Welcome to the 12th Annual Meeting of the Society for the Neurobiology of Language

SNL 2020 (Virtual Edition) - October 21-24

Dear Colleagues,

We are excited to announce the Twelfth Meeting of the Society for the Neurobiology of Language and its first virtual version on October 21-24, 2020.

While all the wonderful opportunities to personally meet, listen to talks, discuss posters, and exchange the latest scientific ideas will be virtual, we have made sure that there are ample options for you to do so over coffee or drinks in the virtual SNL world!

This virtual SNL meeting has also made it possible to reach out to members near and far, and most importantly interested new members and all of those members who normally cannot travel long distances to be part of our exciting meeting.

During the four days of our virtual meeting, you will be able to enjoy an exciting program with Keynote talks by Jenny Crinion (University College London), Elissa Newport (Georgetown University), and Hugues Duffau (CHU Montpellier) spanning topics from aphasia therapy, ECoG, to language acquisition. We have some exciting Symposia lined up, providing us the latest insights into longitudinal studies on the brain dynamics of language acquisition, sleep and language learning, and linguistic levels of representation. Together with the Slide and Poster sessions and the Student Session, *Growing Up in Science*, we really have lots of exciting speech and language science to look forward to.

We are extremely pleased to announce the winner of this year's Distinguished Career Award, Karen Emmorey, for her outstanding contributions to the field of the neurobiology of language, generously sponsored by Language, Cognition and Neuroscience. We also look forward to the Early Career Award talk by Gesa Hartwigsen, and the very first Dissertation Award talk by Laura Gwilliams, both awards generously sponsored by Brain and Language to acknowledge young and thriving scientists in the field for their contribution to the neurobiology of language.

We would like to acknowledge our sponsors and exhibitors: *Neurobiology of Language* (The MIT Press) (Gold Sponsor); *Brain & Language* (Elsevier) (Awards Sponsor); *Language, Cognition & Neuroscience* (Routledge) (Awards Sponsor); Rogue Research Inc. (Silver Sponsor); The Basque Center on Cognition, Brain and Language (BCBL) (Meeting Sponsor); UC Davis (Meeting Sponsor); and Brain Vision, LLC (Exhibitor).

We are looking forward to seeing you all online for an exciting meeting with lots of scientific exchange and time to catch up!

Sonja A. Kotz
Chair, Society for the Neurobiology of Language

Thank you for attending SNL 2020 (Virtual Edition)

Zoom Webinar links appear on the session's page and the Schedule of Events.

Schedule of Events

Opening Remarks
Sonja Kotz, SNL Chair

Keynote Lectures

Jennifer Crinion	Modulating speech recovery after aphasic stroke: Brain and behaviour
Elissa Newport	Developmental plasticity and language reorganization after pediatric stroke
Hugues Duffau	A meta-networking theory of brain functions: lessons gained from stimulation mapping in awake patients

Award Talks

Karen Emmorey	Hand it to sign languages
Gesa Hartwigsen	Adaptive neuroplasticity in the language network
Laura Gwilliams	Towards a mechanistic account of speech comprehension

Business Meeting

Student Session
Growing Up in Science

Symposia

Symposium 1	Sleep and consolidation during language learning
Symposium 2	Capturing developmental brain dynamics: methods for longitudinal language research
Symposium 3	Linguistic levels of representation: Challenges at the interfaces

Slide Sessions

- Slide Session A
- Slide Session B
- Slide Session C
- Slide Session D

Poster Sessions

- Poster Session A
- Poster Session B
- Poster Session C
- Poster Session D
- Poster Session E
- Poster Session F
- Poster Session G
- Poster Session H

Closing Remarks
Sonja Kotz, SNL Chair, and Matt Lambon-Ralph, incoming SNL Chair

Sponsors and Exhibitors

Schedule of Events

All times displayed in Pacific Daylight Time (PDT) America/Los Angeles.

Date	Time	Event
Wednesday October 21	8:15 - 8:30 am	Opening Remarks *Join Zoom Webinar* Sonja Kotz, Chair SNL
	8:30 - 9:30 am	Keynote - Jennifer Crinion *Join Zoom Webinar*
	9:30 - 10:00 am	Coffee Break *Go to Gather.Town*
	10:00 am - 12:00 pm	Symposium 1 *Join Zoom Webinar* Sleep and consolidation during language learning
	12:00 - 1:00 pm	Poster Session A *Go to Gather.Town*
	3:00 - 4:00 pm	Poster Session B *Go to Gather.Town*
	4:00 - 5:30 pm	Slide Session A *Join Zoom Webinar*
Thursday October 22	8:00 - 10:00 am	Symposium 2 *Join Zoom Webinar* Capturing developmental brain dynamics: methods for longitudinal language research
	10:00 - 10:30 am	Coffee Break *Go to Gather.Town*
	10:30 - 11:30 am	Poster Session C *Go to Gather.Town*
	11:30 am - 1:00 pm	Slide Session B *Join Zoom Webinar*
	4:00 - 5:00 pm	Keynote - Elissa Newport *Join Zoom Webinar* Developmental plasticity and language reorganization after pediatric stroke
	5:00 - 5:30 pm	Coffee Break *Go to Gather.Town*
	5:30 - 6:30 pm	Poster Session D *Go to Gather.Town*
Friday October 23	7:00 - 8:00 am	Poster Session E *Go to Gather.Town*
	8:00 - 9:00 am	Keynote - Hugues Duffau *Join Zoom Webinar* A meta-networking theory of brain functions: lessons gained from stimulation mapping in awake patients
	9:00 - 9:30 am	Coffee Break *Go to Gather.Town*
	9:30 - 10:15 am	Early Career Award Talk - Gesa Hartwigsen *Join Zoom Webinar* Adaptive neuroplasticity in the language network
	10:15 - 10:45 am	Dissertation Award Talk - Laura Gwilliams *Join Zoom Webinar* Towards a mechanistic account of speech comprehension
	11:30 am - 12:30 pm	Business Meeting *Join Zoom Webinar*
	12:30 - 1:30 pm	Student Session *Join Zoom Webinar* Growing Up in Science

	4:00 - 5:00 pm	Slide Session C *Join Zoom Webinar*
	6:00 - 7:00 pm	Poster Session F *Go to Gather.Town*
Saturday October 24	6:00 - 7:45 am	Slide Session D *Join Zoom Webinar*
	7:45 - 8:00 am	Coffee Break *Go to Gather.Town*
	8:00 - 10:00 am	Symposium 3 *Join Zoom Webinar* Linguistic levels of representation: Challenges at the interfaces
	10:30 - 11:30 am	Distinguished Career Award Talk - Karen Emmorey *Join Zoom Webinar* Hand it to sign languages
	11:30 am - 12:30 pm	Poster Session G *Go to Gather.Town*
	4:00 - 5:00 pm	Poster Session H *Go to Gather.Town*
	5:00 - 5:30 pm	Closing Remarks *Join Zoom Webinar*

Opening Remarks

Wednesday, October 21, 8:15 am PDT *Join Zoom Webinar*

SNL Chair, Sonja Kotz, welcomes SNL members to the first-ever virtual SNL meeting. Sonja will give an overview of what to expect at SNL 2020 (Virtual Edition).

Coffee Breaks

Wednesday, October 21, 9:30 am PDT
Thursday, October 22, 10:00 am PDT
Thursday, October 22, 5:00 pm PDT
Friday, October 23, 9:00 am PDT
Saturday, October 24, 7:45 am PDT

"Coffee Breaks" are scheduled throughout SNL (Virtual Edition). Like coffee breaks at the in-person SNL meetings, they offer attendees an opportunity for social interaction, networking and connecting with colleagues. Join your fellow researchers in the Gather.Town lobby to discuss the session or catch up with old friends. BYOC (Bring your own coffee)!

Keynote Speaker: Jennifer Crinion

Wednesday, October 21, 2020, 8:30 – 9:30 am, PDT *Join Zoom Webinar*

Modulating speech recovery after aphasic stroke: Brain and behaviour

Speaker: Jennifer Crinion, University College London

Speech production is dependent both on regional changes within the left inferior frontal cortex (LIFC) and also on modulation between and within anatomically distinct but functionally connected brain regions. Interregional changes are particularly important in speech recovery after stroke, when neural plasticity changes underpinning behavioural improvements are observed in both ipsilesional and contralesional frontal cortices. It is increasingly understood that recruitment of LIFC, including Broca's area is necessary to allow learning of a speech task. However, the neural mechanisms underpinning plasticity within this region and other language and cognitive control regions in temporal and parietal cortex, are not well understood. In this talk I will outline recent studies ongoing in our lab where we use functional magnetic resonance imaging to simultaneously identify neural changes within speech systems in both healthy adults and people with aphasia in response to transcranial direct current stimulation (tDCS) applied to LIFC and aphasia treatment interventions. Together, these findings shed light on the interactions between the major frontal-temporal-parietal network nodes underpinning speech plasticity, offering a potential framework from which to optimize future interventions to improve speech function after stroke.

About Jennifer Crinion

Jennifer Crinion is a Professor of Cognitive Neuroscience at the Institute of Cognitive Neuroscience, University College London. From 2016 she is supported by a Wellcome Senior Clinical Fellowship. She joined the Institute of Cognitive Neuroscience when awarded an MRC Clinical Scientist Fellowship in 2008 and has been co-lead of the Neurotherapeutics Group since 2014. Jenny first qualified as a speech and language therapist (SLT) from University College London and received a PhD in Cognitive Neuroscience from Imperial College London in 2005.

Her clinical research program is dedicated to understanding the neural mechanisms of aphasia and how lesioned brains respond to different and novel treatment interventions. This requires integration of both research and clinical infrastructures, which as an academic SLT at University College London/Hospitals, UK she is well placed to do so. The translational cognitive neuroscience approach is multi-pronged (neuroimaging, behaviour, non-invasive brain stimulation) investigating the neural mechanisms underlying variability in treatment response and factors that relate to aphasia outcomes. Clinically, she is also a consultant SLT at the National Hospital of Neurology and Neurosurgery, University College London Hospitals responsible for the delivery and strategic development of a national specialist Aphasia Clinic and since 2019 its first NHS Intensive Comprehensive Aphasia Rehabilitation Programme for chronic stroke patients. By understanding the mechanisms of recovery her goal is to develop new treatment approaches and predict which is best for each person living with aphasia, so we can improve outcomes and long-term prognosis.

Keynote Speaker: Elissa Newport

Thursday, October 22, 2020, 4:00 – 5:00 pm, PDT *Join Zoom Webinar*

Elissa Newport's Keynote Address is generously sponsored by *Neurobiology of Language* (The MIT Press).

Developmental plasticity and language reorganization after pediatric stroke

Speaker: Elissa Newport, Center for Brain Plasticity and Recovery, Georgetown University

It is well known that the adult human brain is highly lateralized for language, with the left hemisphere primarily responsible for sentence production and comprehension and the right hemisphere primarily responsible for suprasegmental aspects of language such as the expression of emotion and intonation. It has also long been hypothesized that there is a high degree of plasticity for language in early life, allowing young children to acquire language successfully by using other cortical regions for linguistic functions when the normal left hemisphere language areas are damaged. Are both of these claims true? If so, how do they fit together, and what are the principles and constraints on developmental plasticity and long-term functional organization? Which areas of the brain are capable of controlling language functions, and how well do they do this? If language is 'reorganized' to atypical regions, what happens to other cortical and cognitive functions?

We address these questions by focusing on long-term outcomes in a well-defined population of children with a single major injury at birth (perinatal arterial ischemic stroke to the middle cerebral artery). We study older children and young adults who have had a perinatal stroke to the left hemisphere brain areas ordinarily subserving language, or to the homologous right hemisphere areas ordinarily subserving the processing of emotion and spatial cognition. We are using a battery of behavioral tasks and fMRI to examine their processing and neural activation for language materials (sentence comprehension, emotional prosody) and for visual-spatial materials (line bisection, block configuration). We are also testing their healthy same-aged siblings and, in order to understand the early developmental status of these functions in the brain, a separate group of healthy children from ages 5 to 10. We believe that our results provide insights into both the striking lateralization of language functions in healthy adults and also the remarkable ability of the young brain to reorganize these functions in specific and highly constrained ways.

About Elissa L. Newport

Elissa L. Newport, Ph.D., is Professor of Neurology, Rehabilitation Medicine, Psychology, and Linguistics, Co-Director of the Ph.D. Concentration in Cognitive Science, and Director of the Center for Brain Plasticity and Recovery at Georgetown University. She moved to Georgetown in 2012, after 24 years at the University of Rochester, where she was the George Eastman Professor of Brain and Cognitive Sciences and served for 12 years as Department Chair. Her primary research interests are in language acquisition in healthy children and recovery of language after pediatric stroke. Her research has been funded by the NIH since 1980. She has received the NIH Claude Pepper Award of Excellence, the APS William James Lifetime Achievement Award for Basic Research, the Benjamin Franklin Institute Medal for Computer and Cognitive Science, the Norman A. Anderson Lifetime Achievement Award from the Society for Experimental Psychology, and this year the American Psychological Association Distinguished Scientific Contribution Award. She has been a member of the National Academy of Sciences since 2004.

Keynote Speaker: Hugues Duffau

Friday, October 23, 2020, 8:00 – 9:00 am, PDT *Join Zoom Webinar*

A meta-networking theory of brain functions: lessons gained from stimulation mapping in awake patients

Speaker: Hugues Duffau, MD, PhD, Department of Neurosurgery and INSERM U1191, Montpellier University Medical Center, France

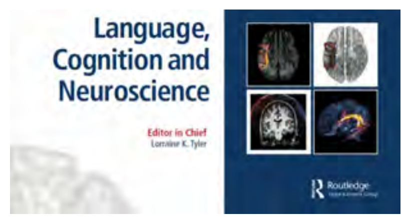
In the traditional literature, brain processing was mainly thought in a localisationist framework, in which one given function was sustained by a discrete, isolated cortical area, and with a similar cerebral organization across individuals. However, this static view of brain functioning does not explain numerous observations of functional recovery following cerebral damages. Here, the goal is to revisit such a classical modular and inflexible model by evolving toward a dynamic organization of neural circuits, which allows postlesional cerebral adaptive phenomena able to maintain neurological and cognitive functions. Indeed, recent data provided by serial mappings performed in patients who underwent awake surgery for glioma infiltrating eloquent structures have provided new insights into the organizational principles of anatomo-functional architecture. First, intraoperative electrical mapping enables the realization of real-time structural-functional correlations both at cortical and subcortical levels, supporting a network distribution of the brain, and resulting in the reappraisal of cognitive models – notably regarding movement, language, executive functions and emotional processing. Second, combination of neuropsychological assessments and functional neuroimaging before and after operation(s) demonstrates that it is possible to achieve massive resections of “critical” regions without eliciting permanent sequelae, thanks to remodelling of cerebral circuits. Third, repeated surgeries in cases of tumor relapse show functional remapping in the same patients over time. Based upon these recent data on brain connectome, the aim is to challenge the outdated localisionnist view, and to propose an alternative meta-networking theory. This model holds that complex behaviors arise from the spatiotemporal integration of distributed but relatively specialized networks underlying conation and cognition. Dynamic interactions between such circuits result in a perpetual succession of new equilibrium states, opening the door to considerable interindividual behavioral variability and to neuroplastic phenomena. Indeed, a meta-networking organization underlies the uniquely human propensity to learn complex abilities, and also explains how postlesional reshaping can lead to some degrees of functional compensation in brain-damaged patients, even though white matter connectivity constitutes a main limitation of such neuroplasticity. The major implications of this approach are discussed, both in fundamental neurosciences as well as for clinical developments.

About Hugues Duffau

Hugues Duffau (MD, PhD) is Professor and Chairman of the Neurosurgery Department in the Montpellier University Medical Center and Head of the INSERM 1191 Team "Plasticity of the central nervous system, human stem cells and glial tumors" at the Institute of Functional Genomics, University of Montpellier (France). He is an expert in the awake cognitive neurosurgery of slow-growing brain tumors, as low-grade gliomas, a routine which he has developed since more than twenty years. His fundamental approach is centered on the concepts of the brain connectomics and neuroplasticity, breaking with the traditional localizationist view of cerebral processing. For his innovative work in neurosurgery and neurosciences, he was awarded Doctor Honoris Causa six times, and he was the youngest recipient of the prestigious Herbert Olivecrona Award from the Karolinska Institute in Stockholm. He has written four textbooks and over 430 publications in international journals ranging from neurosurgery to fundamental neurosciences, including cognitive sciences and brain plasticity for a total of more than 34,000 citations and with an h-index of 99. He gave more than 560 invited lectures and was invited as a visiting professor in more than 50 institutions. He is member of Editorial boards of many journals (as Brain and Language, Neurosurgery or Neuro-oncology) and ad-hoc reviewer for around 100 journals (over 950 reviews) including: New England Journal of Medicine, Lancet Oncology, Nature Medicine, Nature Reviews Neuroscience, Nature Reviews Neurology; Annals of Neurology, Brain, Cerebral Cortex, Trends in Cognitive Science, Current Biology, etc. He is member of many societies, such as the French Academy of Medicine, the French Academy of Surgery, the World Academy of Neurological Surgery, the Young Neurosurgeons Award Committee of the World Federation of Neurosurgical Societies, the Scientific Committee of the European Association for Neurooncology.

2020 Distinguished Career Award

Karen Emmorey



Saturday, October 24, 10:30 – 11:30 am, PDT *Join Zoom Webinar*

The Society for the Neurobiology of Language is pleased to announce the 2020 Distinguished Career Award winner: **Karen Emmorey**.

The Distinguished Career Award is generously sponsored by *Language, Cognition and Neuroscience*.

Hand it to sign languages

Speaker: Karen Emmorey, Distinguished Professor, San Diego State University, California

Sign languages and the deaf and hearing people who use them have taught us a tremendous amount about the neurobiology of language. Only by studying sign languages can we understand what is universal to all human languages and what properties depend on the auditory-vocal or visual-manual modalities. Further, some questions are best answered with sign languages, such as whether iconicity (motivated form-meaning mappings) impacts neural representation or processing. Bimodal bilinguals (those who know a spoken and a signed language) offer unique insights into language representation and control because their two languages do not share phonological features or an orthography. Deaf bilinguals also provide insights into the neurobiology of reading because they reveal alternative paths to skilled reading. This talk will provide a personal walk through these issues, highlighting some of what we have learned and what exciting questions remain.

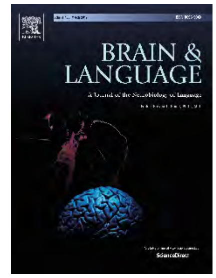
About Karen Emmorey

Dr. Karen Emmorey is a Distinguished Professor at San Diego State University where she is the Director of the Laboratory for Language and Cognitive Neuroscience. During her career she has made many outstanding contributions to our understanding of the neurobiology of language. Trained as a linguist at the University of California, Los Angeles, Dr. Emmorey started her career studying voice recognition, morphemic parsing, and prosody. She then moved to the Salk Institute, San Diego, where she quickly became one of the main figures leading the development of sign language research, not only from a linguistic perspective but also from neurobiological and psycholinguistic perspectives. Her research, consistently funded by grants from the National Institutes of Health and the National Science Foundation, has brought users of sign languages into the mainstream of behavioral and neuroscience research for what they tell us about how language is organized in the brain; about the constraints and plasticity associated with language in a visual modality; and about the consequences of bilingualism for hearing individuals who both sign and speak. Her contributions to all these areas have been novel and transformational.

Dr. Emmorey has authored over 300 peer-reviewed publications and 4 books (including "Language, cognition, and the brain: Insights from sign language research", cited over 1,000 times). She has served as Chair of the Linguistics section of the American Association for the Advancement of Science in 2018 and was recognized as a Fellow of the Linguistics Society of America in 2019.

Dr. Emmorey's impact is not limited to her own research. She is a strong and energetic leader who has acted as a supervisor and mentor to a large number of researchers and students, both deaf and hearing. She brings a special collaborative energy to her research so that researchers, as well as members of her research communities, are brought into the center of her research program. The Society for the Neurobiology of Language is extremely lucky that she brought this energy and leadership to bear during her term as Chair of SNL (2017/18). We congratulate Dr. Emmorey as an extremely well-qualified recipient of the SNL Distinguished Career Award 2020.

2020 Early Career Award



Gesa Hartwigsen

Friday, October 23, 9:30 – 10:15 am, PDT *Join Zoom Webinar*

The Society for the Neurobiology of Language is pleased to announce the 2020 Early Career Award winner: **Gesa Hartwigsen**

The Early Career Award is generously sponsored by *Brain and Language*.

Adaptive neuroplasticity in the language network

Speaker: Gesa Hartwigsen, Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany

Language is organized in large-scale networks in the human brain. In this talk, I discuss rapid short-term reorganization and adaptive plasticity in the healthy and lesioned language network. Combining neurostimulation with neuroimaging, I will show that focal perturbation of key language areas may be compensated by a stronger contribution of homologous regions, neighbouring regions for other specialized language functions or domain-general areas.

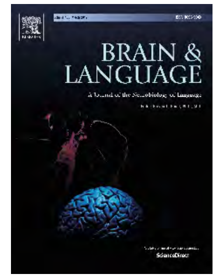
These mechanisms of adaptive systems plasticity are summarized in a model on the flexible redistribution in neural networks for cognition. Moving beyond the language network, I will further outline our recent work on the process-specific overlap and dissociation in the neural networks underlying semantic processing, attention and social cognition. These data provide insight into hemispheric asymmetries for key cognitive functions in the human brain.

About Gesa Hartwigsen

Gesa Hartwigsen received her PhD in Psychology from Kiel University in 2010. After completing post-doctoral research at the Language and Aphasia Laboratory, University of Leipzig, she was appointed as Assistant Professor for Biological Psychology at Kiel University in 2013. She joined the Department of Neuropsychology at the Max Planck Institute for Human Cognitive and Brain Sciences (MPI CBS) in Leipzig as a group leader in 2015. In 2019, she was appointed as an Independent Research Group Leader at the MPI CBS, supported by the Lise Meitner Excellence Program of the Max Planck Society.

Dr. Hartwigsen's research program is centred on the investigation of neuroplasticity in the language network across the adult life span. During her PhD studies, she established multifocal neurostimulation approaches to demonstrate that the right hemisphere makes an essential contribution to efficient language processing in the healthy brain. Soon after, she developed her own research program to study flexible interactions in the language network. Her work combines multiple neurostimulation approaches with neuroimaging and electroencephalography to probe interactions and adaptive plasticity at the neural network level. Dr. Hartwigsen recently offered a model on the interaction of domain-specific language regions with domain-general areas. Her key assumption is that compensation for perturbation of a language area can either be achieved within the network or across networks via flexible redistribution of functions. Her interdisciplinary research agenda is funded by the Max Planck Society and the German Research Foundation. Dr. Hartwigsen has already published over 60 papers in high-ranking journals and is regularly invited to present her work at different international institutions and conferences. Her strong neurostimulation background and her interest in systems neuroplasticity provide unique perspectives and new insights into the neurobiology of language. We congratulate Gesa for this impressive research and contribution to our field.

2020 Dissertation Award



Laura Gwilliams

Friday, October 23, 10:15 – 10:45 am, PDT *Join Zoom Webinar*

The Society for the Neurobiology of Language is pleased to announce the recipient of the NEW 2020 Dissertation Award: **Laura Gwilliams**

The Dissertation Award is generously sponsored by *Brain and Language*.

Towards a mechanistic account of speech comprehension

Speaker: Laura Gwilliams, New York University; NYU Abu Dhabi; University of California, San Francisco

Humans understand speech with such speed and accuracy, it belies the complexity of transforming sound into meaning. The goal of my research is to develop a theoretically grounded, empirically tested and computationally explicit account of how the brain achieves this feat. In this talk, I will first present an analytical framework — informed by machine-learning and classic statistics — which allows neural signals to be decomposed into an interpretable sequence of operations. Next, utilising this framework, I will overview a set of magneto-encephalography studies that describe (i) what linguistic representations the brain uses to bridge between sound and meaning; (ii) how those representations are combined to form hierarchical structures (e.g. phonemes into morphemes; morphemes into words); (iii) how information is exchanged across structures to guide comprehension from the bottom-up and the top-down. Overall, this body of work showcases the utility of combining theoretical linguistics, machine-learning and cognitive neuroscience for developing empirically- and performance-optimised models of spoken language processing.

About Laura Gwilliams

Laura Gwilliams received her PhD in Psychology with a focus in Cognitive Neuroscience from New York University in May 2020. Currently she is a post-doctoral researcher at UCSF, using MEG and ECoG data to understand how linguistic structures are parsed and composed while listening to continuous speech. The ultimate goal of Laura's research is to describe speech comprehension in terms of what operations are applied to the acoustic signal, which representational formats are generated and manipulated (e.g. phonetic, syllabic, morphological), and under what processing architecture.

Dr. Gwilliams' PhD research focused on questions of phonemic representation in lexical contexts, on ambiguity, and on sentence level phenomena in online processing. For example, using an innovative combination of psychophysics and MEG, Laura tackled how ambiguously perceived phonemes inform lexical-level processing in an influential article published in the Journal of Neuroscience. The work makes a significant contribution to when in time, where in the brain, and how ambiguous representations are maintained versus 'discarded' to facilitate categorical level processing. Further and quite impressive are her quantitative and data analytic skills that go far beyond what most researchers attain. In fact, she has developed her own integrative approach to cognitive neuroscience, which spans advances in data analysis, theory, and computational modeling – showcased in her recent paper on phoneme sequence processing of naturalistic speech. Furthermore, together with Jean-Remi King, Laura provided machine-learning and data analysis tools for M/EEG that serve multiple labs at NYU. Most impressively she has written a sole authored paper in Philosophical Transactions, which informs the community in an incredibly differentiated manner about the integration of contemporary linguistic theory with the sketch of a computational model, while also encompassing the latest neuroscience data on morphological processing. We congratulate Laura on these impressive achievements.

Honorable Mention

Reem Al Yahya, MRC Cognition and Brain Sciences Unit, University of Cambridge, UK; King Fahad Medical City, Saudi Arabia
Esti Blanco-Elorrieta, New York University; Harvard University
Gabriela Meade, San Diego State University; University of California, San Diego
Sarah Solomon, University of Pennsylvania

SNL Business Meeting

Friday, October 23, 11:30 am PDT *Join Zoom Webinar*

Join the SNL Board of Directors for the Annual Business Meeting. SNL leadership will review what the Society has accomplished in 2020 and discuss the outlook and priorities for 2021. The Business Meeting is an opportunity for SNL members to ask questions of the SNL Board and bring up issues of concern to the general membership.

You may send questions before the start of the Business Meeting to info@neurolang.org.

Student Session

Friday, October 23, 12:30 – 1:30 pm, PDT *Join Zoom Webinar*

SNL presents a session specially designed for student members.

Growing Up in Science

Speaker: Sonja Kotz, SNL Chair
Interviewer: Esti Blanco-Elorrieta,
SNL Student/Postdoc Representative

Have you ever wondered what the big fish struggled with as a graduate student? What they struggle with now? What they wish they knew when they were young? This event will be a conversation featuring personal narratives of becoming and being a scientist. You will hear the unofficial story behind the success story of what it takes to become the Chair of SNL. There is a Q & A following the presentation.

About Sonja Kotz

Sonja Kotz is a trained linguist and translational cognitive neuroscientist, investigating prediction and cognitive/motor control in speech, language, and music in healthy and patient populations. In her research she utilizes a wide range of behavioral and neuroimaging methods (M/EEG, s/f/rsMRI, TMS). In more recent investigations on the evolution of speech and music, she also applies behavioral and electrophysiological measures in comparative studies. She heads the section of neuropsychology at Maastricht University, the Netherlands, and holds a number of honorary professorships (Manchester, Leipzig, and Lisbon). She currently chairs the Society for the Neurobiology of Language and is the past president of the European Society for Cognitive and Affective Neuroscience. She is a senior/associate editor for several journals (e.g. Neurobiology of Language, Neuroimage, Cortex, Plos One, Time and Time Perception) and has/is chairing cognitive neuroscience panels for multiple grant agencies in Europe, including the European Research Council (ERC). You can find out more about her lab and team at www.band-lab.com.

Symposium 1

Wednesday, October 21, 2020, 10:00 am - 12:00 pm, PDT *Join Zoom Webinar*

Sleep and consolidation during language learning

Organizer: Tali Bitan[1,2]; [1]University of Haifa, [2]University of Toronto

Presenters: Kimberly Fenn, Laura Batterink, Tali Bitan, Gareth Gaskell, Rebecca Gomez

While the important role of sleep in the consolidation of non-linguistic declarative, motor and perceptual skills was shown in numerous studies, there is an ongoing debate on which types of tasks are influenced, and the specific sleep components involved. During the last decade there is a growing number of studies examining similar questions in the linguistic domain, with different methodologies and populations. We will present studies showing the effect of night sleep and daytime naps on learning vocabulary, grammar and speech perception, in adults, children and toddlers, using behavioral, polysomnographic and neuroimaging methods. These studies highlight variables such as age and other individual differences that modulate the effect of sleep beyond the tasks at hand. Altogether they show the effects of sleep on various aspects of consolidation, including stabilization and protection against subsequent degradation; enhanced performance on trained stimuli; and extraction of hidden regularities evident in generalization to novel stimuli.

Talks

The Role of Sleep in the Consolidation of Synthetic Speech Learning

Kimberly Fenn[1]; [1]Michigan State University, US

In this talk, I will discuss ongoing work investigating sleep-dependent consolidation of generalized perceptual learning of synthetic speech. Synthetic speech is a distorted speech signal that requires listeners to map new acoustics onto existing linguistic categories. Importantly, learning is generalized, meaning that listeners never experience the same stimulus more than once. Thus, learning represents a change in the way that listeners perceive stimuli. In a series of studies, we have shown that a waking day degrades performance, but a night of sleep can restore lost performance. Sleep also protects against subsequent degradation. These effects of sleep are specific for generalized learning; rote learning does not benefit from sleep. Furthermore, a daytime nap can prevent waking degradation of performance and this stabilization is related to NREM 2 spindle activity during the nap. Implications for theories of sleep-dependent consolidation and second language acquisition will be discussed.

Interactive effects of slow-wave and REM sleep on grammar and vocabulary learning

Laura Batterink[1]; [1]Western University, Canada

Sleep plays an important role in memory consolidation, and the natural cyclical alternation between slow-wave and REM sleep appears to optimize the consolidation of many different types of memories. In particular, slow-wave sleep may function to consolidate new item memories, while REM may facilitate the integration of new memories into pre-existing memory networks. In two studies using two artificial language learning paradigms, we tested whether interactions between slow-wave and REM sleep contribute to two key aspects of language learning – grammar and vocabulary. In the first study, we found evidence that both slow-wave sleep and REM sleep synergistically facilitate the extraction of a novel hidden grammar rule. In the second study, we found that the consolidation of vocabulary words depends on the presence of REM after slow-wave sleep. Together, these results suggest that the cyclic succession of slow-wave and REM sleep actively contributes to the consolidation of diverse aspects of language.

Age and prior knowledge affect consolidation of regularities in a novel language

Tali Bitan[1,2]; [1]University of Haifa, Israel, [2]University of Toronto, Canada

We examined the effects of sleep, age and individual differences in prior knowledge on consolidation of morpho-phonological regularities in an artificial language. We found that while performance of 9-10-years-old children improved after the end of training, this was not affected by sleep. In contrast, as a group adults did not show offline improvement after training, but sleep had a protective effect against subsequent decay during wake. These more robust effects of consolidation in children may explain their ability to achieve more native-like proficiency when learning a second language. However, a second study showed that adults are not a unified group. Some participants did improve during the first night after training, and this was predicted by good phonological awareness prior to training. These results suggest that similar to hippocampus-dependent episodic memory, when learning linguistic regularities, associated with fronto-striatal mechanisms, prior knowledge may facilitate faster consolidation, and thus explain higher attained proficiency.

Making space for group and individual differences in language learning

Gareth Gaskell[1]; [1]York University, UK

A wealth of evidence has assessed how language users differ in their acquisition profile. Often in these studies, learning of a particular aspect of language is thought of as a single dimension allowing “good learners” to be distinguished from “poor learners” either at a group or an individual level. I will explore the potential for explanatory power in a shift from a single dimension of learning to (at least) two dimensions, namely encoding and consolidation. With this framework in mind, I will describe recent behavioural, polysomnographic and diffusion tensor imaging evidence on language learning in 8-12 year-old children with or without autism. We find that substantial variability can be captured in terms of encoding ability, but that some subtle differences are better captured as consolidation and/or forgetting, particularly when looking over longer timescales. Individual and group differences in sleep quality appear to be associated with aspects of the consolidation dimension.

Developmental change in the effects of sleep on new language learning in toddlers

Rebecca Gomez[1], Lucia Sweeney[1]; [1]The University of Arizona, US

A growing body of work in early childhood demonstrates a crucial role for naps in language acquisition. Exactly how sleep supports new language-learning may change as children develop and as their brains support more mature memory processes. We report developmental change demonstrating an increase in the precision of nap-dependent memory consolidation. Our published data with 15-month-olds suggests that sleep promotes generalization after exposure to an artificial language, potentially due to loss of detail. According to new data, by 18 months, sleep appears to stabilize memory such that infants remember specific details of the language. Moreover, infants recognize a grammatical rule in the language presented in completely novel vocabulary. Thus, at 15-months, sleep promotes generalization potentially due to loss of detail. By 18-months, sleep promotes a stable and specific representation, flexible enough to apply to new vocabulary. Taken together, our findings reflect a shift in sleep-dependent retention of new language learning.

Symposium 2

Thursday, October 22, 2020, 8:00 - 10:00 am, PDT *Join Zoom Webinar*

Capturing developmental brain dynamics: methods for longitudinal language research

Organizers: Maaike Vandermosten[1], Milene Bonte[2]; [1]KU Leuven, [2]Maastricht University

Presenters: Maaike Vandermosten, Rogier Kievit, Lucy Whitmore, Martin Reuter, Marcus Kaiser

The brain undergoes continuous structural and functional changes when we learn to understand and use language. These changes may yield crucial insights on typical development as well as on atypical development in language disorders, even before diagnostic symptoms can be observed. Capturing these developmental and learning-induced dynamics is extremely challenging however, as changes occur interactively across multiple levels, including (social) environmental, behavioral, structural and functional brain changes. Studying this interplay of factors calls for both an interdisciplinary and longitudinal approach. This symposium brings together researchers with different theoretical and methodological backgrounds to discusses state-of-the-art MRI analysis and statistical approaches and their application to longitudinal research within the language domain.

Talks

A direct measure of cortical change across (a)typical reading development

Maaike Vandermosten[1], Than Vân Phan[1], Pol Ghesquière[1], Jan Wouters[1]; [1]KU Leuven

During development, non-linear and regional changes in the brain occur. However, brain dynamics in relation to learning to read are not well understood. In the current study, we analyzed longitudinal T1 MRI data to investigate the brain development of children with developmental dyslexia and with typical reading skills, from the early to late years of primary school (5-12 years old). The structural brain change was quantified by the local morphological differences between a pair of brain images at two different time points, while considering the global head growth. Our results on cortical development during primary school using the proposed measure showed that different brain regions co-develop during early years versus late years of primary school. In addition, we found that children with dyslexia show similar brain changes as typical readers in the left reading network but different neurodevelopment in the right hemisphere, which could be a compensatory mechanism.

Into the great beyond: Estimating growth trajectories across the lifespan using random effects models

Rogier Kievit[1]; [1]University of Cambridge

Longitudinal models are becoming increasingly commonplace tools to capture lifespan changes. These models, especially when incorporating random effects components capturing individual differences in change, can better capture lifespan developmental trajectories in language abilities. A more recent class of models known as dynamic measurement models (McNeish, Dumas & Grimm, 2019) allow us to take things one step further: Using these models, we can extrapolate, in a principled manner, the likely growth trajectory, including the ‘capacity’, or end point for individuals. We describe these techniques, how they can be used to formalize developmental concepts such as equifinality and multifinality, and provide empirical examples to illustrate the value for lifespan language studies.

Making the most of longitudinal MRI to understand learning reading and language development

Lucy Whitmore[1], Kathryn Mills[1], Anna van Duijvenvoorde[2]; [1]University of Oregon, [2]Leiden University

Understanding how learning processes are both supported by and shape the developing brain requires taking an individual differences approach within a longitudinal framework. We discuss how longitudinal studies of typical brain development, as well as the variability that exists in specific measures of the brain obtained through MRI, can help inform studies designed to measure learning processes such as reading and language. We address issues regarding how to distinguish between typical brain maturation processes that support learning processes from brain changes resulting from acquired knowledge and skills.

Unbiased Longitudinal Analysis of Brain MRI in FreeSurfer

Martin Reuter[1,2,3]; [1]German Center for Neurodegenerative Diseases, Bonn, [2]Harvard Medical School, Boston, [3]Massachusetts General Hospital, Charlestown

When processing longitudinal imaging data, care needs to be taken to avoid inducing processing biases into an automated pipeline, e.g. by mapping follow-up images to the baseline scan. Here I present potential sources of bias and ways to avoid them. Furthermore, I describe the unbiased longitudinal pipeline in FreeSurfer – an open source software package to analyse brain MRI, including extensions to fibre tracking and subfield segmentation. Our dedicated longitudinal methods demonstrate increased test-retest reliability and sensitivity to disease effects compared to standard independent processing, permitting researchers to detect subtle longitudinal changes (e.g. drug effects) or work with substantially smaller sample sizes in a cost effective way.

Changing Connectomes: How Structural and Functional Connectivity Changes are linked to Cognitive Development

Marcus Kaiser[1,2]; [1]Newcastle University, UK, [2]Shanghai Jiao Tong University, China

Our work on connectomics over the last 15 years has shown a small-world, modular, and hub architecture of brain networks [1]. These network features allow for efficient processing of information in neural networks. Recent studies have highlighted how brain network organization is linked to cognition, intelligence, and language skills. Describing experimental and computational studies, I will discuss the key factors that are linked the maturation of brain networks [2]. I will highlight how network organisation is linked to cognition, with language skills as one example, and how developmental changes lead to cognitive deficits. Finally, I will outline a framework of modelling how brain networks in individuals change over time [3]. Such models can inform interventions in order to improve cognition. [1] Kaiser. Changing Connectomes. MIT Press, 2020. https://mitpress.mit.edu/books/changing-connectomes [2] Kaiser. Trends in Cognitive Science, 2017. [3] Peraza et al. Alzheimer's & Dementia: Diagnosis, Assessment & Disease Monitoring, 2019.

Symposium 3

Saturday, October 24, 2020, 8:00 - 10:00 am, PDT *Join Zoom Webinar*

Linguistic levels of representation: Challenges at the interfaces

Organizer: Arianna Zuanazzi[1]; [1]Department of Psychology, New York University, New York, US

Presenters: Yulia Oganian, Laura Gwilliams, Arianna Zuanazzi, Andrea E. Martin, Simona Mancini, Petra Hendriks

Speech comprehension relies on segmenting a continuous acoustic signal into discrete linguistic units that are combined to form representations across different levels of complexity (e.g., phonemes, morphemes, words or phrases, meanings). Previous research has mainly investigated how such units are computed and represented within each level. However, it remains unclear (1) what information contained in simpler units (e.g., phonemes) is employed to derive more complex objects (e.g., morphemes); (2) how features from different representational levels (e.g., phonetic and morphological features) interact with one another; (3) whether similar operations are performed at all levels of complexity (e.g., morphological, syntactic and semantic composition). This symposium will bring together research programs that specifically investigate how information across levels is exchanged and integrated. Thus, students and faculty interested in different language domains and in different scientific approaches (such as linguistic theory, computational models, behavior and neurophysiology) will find this symposium relevant and timely.

Talks

Transformation from acoustic to phonemic representations in human auditory cortex

Yulia Oganian[1]; [1]Department of Neurological Surgery, University of California, San Francisco, San Francisco, US

Speech processing relies on the transformation of an acoustic signal to linguistic categories. A central debate concerns the extent to which auditory cortical areas in medial and lateral superior temporal gyrus (STG) contribute to this transformation, or whether they contain linguistically agnostic spectro-temporal representations of speech sounds. To advance this debate, we characterize local cortical encoding of spectro-temporal, phonemic and syllabic structure of natural speech throughout the entire STG, using high resolution intracranial electrocorticography recordings. We find that medial STG is dominated by spectro-temporal representations, whereas representations in lateral STG are geared towards the phonemic and syllabic structure of speech. I will demonstrate this principle on two examples: The representation of speech syllable structure based on the amplitude envelope of speech, and the representation of vowel formants and categories. Overall, our results suggest that lateral STG contains specialized neural populations, each representing distinct linguistic features in speech.

Continuous phoneme sequences are rapidly transformed into discrete (sub)lexical units

Laura Gwilliams[1,2]; [1]Department of Psychology, New York University, New York, US, [2]NYU Abu Dhabi Institute, Abu Dhabi, UAE

Listeners experience speech as a sequence of words. However, the true acoustic input is a continuously varying signal that blends speech sounds into one another. In this study we ask how the brain: (i) simultaneously processes overlapping acoustic-phonetic information; (ii) keeps track of the relative order of phonemic units; (iii) maintains phonetic information long enough to interface with (sub)lexical representations. Magneto-encephalography was recorded while participants listened to natural stories. Overall, our results suggest that the continuously unfolding speech input is jointly encoded with elapsed processing time, thus both ensuring non-overlapping representations of neighboring phonemes and an implicit encoding of relative order. Phonetic processing is initiated earlier as a function of local predictability within a word, and is sustained until lexical ambiguity is sufficiently resolved. These results provide critical insight into how rapid phoneme sequences are processed, and how phonemic units interface with (sub)lexical representations.

Behavioral and neural representation of word class expressed through suffixes

Arianna Zuanazzi[1]; [1]Department of Psychology, New York University, New York, US

In English, and in other languages that use affixation, word class (i.e., noun, verb, adjective, etc.) is determined either by the root (e.g., “joy” is a noun) or, in morphologically complex words, by derivational suffixes (e.g., “joyful” is an adjective). Behavioral, neuroimaging and neuropsychological research on word class have controversially debated whether different word classes engage dedicated neural representations and processes; however, previous research has mainly focused on relatively morphologically simple words (i.e., without affixes). In this talk, I will discuss how word class expressed through derivational suffixes is encoded at the behavioral and neural level during speech comprehension and I will provide evidence that suffix features (e.g., word class ambiguity) contribute to the characterization of word class. Our results have broad implications for understanding how meaning is composed at the word level and how more complex syntactic structures (i.e., phrases) are formed.

Building models of language that are faithful to linguistic structure and brain activity

Andrea E. Martin[1,2]; [1]Max Planck Institute for Psycholinguistics, Nijmegen, NL, [2]Donders Centre for Cognitive Neuroimaging, Radboud University, Nijmegen, NL

Great advances have been made in computational and neurobiological models of language, yet how constituent parts like words and morphemes are bound together into compositional structures like phrases and sentences remains underspecified. In this talk, I argue that a neurophysiological computation system cannot achieve the compositional structure that is exhibited in human thought and language if it were to rely on coding schemes that are widespread in contemporary artificial intelligence and computational cognitive science. I show via simulation and experimentation that a particular instantiation, tensor products, clashes with human behavior, and I discuss how multiple model instantiations can produce established neural responses to language. I highlight how computational models can increase their explanatory force by including the system properties that are implicated by human behavior, and I describe one way to instantiate the expressive power of human thought and language in a neural system.

From features to relations: processing mechanisms at the syntax-discourse interface

Simona Mancini[1]; [1]Basque Center on Cognition, Brain and Language, San Sebastian-Donostia, ES

Features are fundamental descriptions of linguistic objects that allow the detection of regularities both within and across linguistic domains. A variety of aspects associated with our perception of the world can be conveyed by features: the time and the temporal organization of an event (i.e. tense and aspect features), as well as the cardinality, discourse roles and gender of an event's participants (i.e. number and person features), to name a few. During language comprehension, featural information extracted from the linguistic input is analyzed to form many distinct types of syntactic relations, whose interpretation involves the interaction between different levels of representation, such as between syntax and discourse. In this talk I will show how distinct types of features and the relations they are involved in are differentially processed, providing behavioral, electrophysiological and neuro-anatomical evidence for common and feature-specific mechanisms at work at distinct interface levels.

Interpreting pronouns at the grammar-pragmatics interface

Petra Hendriks[1]; [1]Center for Language and Cognition Groningen, University of Groningen, Groningen, NL

In many languages, children show acquisition delays in their comprehension of specific linguistic forms compared to other linguistic forms. For example, 5-year-old English-speaking children still have difficulty comprehending pronouns like 'him' correctly, contrasting with their adult-like comprehension of reflexives like 'himself' already at age 4 (the so-called Delay of Principle B Effect). A prominent explanation for this pattern is that, while reflexive interpretation merely requires the application of syntactic and semantic principles or constraints of the grammar, pronoun interpretation additionally requires a pragmatic operation. Here, we discuss the implications and challenges of the assumption that this pragmatic operation is an operation of perspective taking. This process of perspective taking essentially uses the same information as the more basic grammatical processes, but is more complex because it combines the process of semantic interpretation from the listener's perspective with the process of syntactic generation from the speaker's perspective.

Slide Session A

Wednesday, October 21, 2020, 4:00 - 5:30 pm, PDT [*Join Zoom Webinar*]

Bi-directional relations of semantic and syntactic neuro-cognitive development in children 6- to 7.5-years-old

Neelima Wagley[1], James R. Booth[1]; [1]Vanderbilt University

The present study examined the longitudinal relations of brain and behavior from 6 to 7.5 years old to test the bootstrapping account of language development. Prior work suggests that children's early lexical knowledge predicts later grammatical achievements (e.g. semantic bootstrapping) and grammatical knowledge facilitates acquisition of lexical meanings (e.g. syntactic bootstrapping). Yet, little is known about the dynamics underlying semantic and syntactic development as children enter elementary school. Around this age, children are developing more specialized brain networks and are learning to comprehend more complex language and text.

We tested how semantic and syntactic behavioral skills influences the development of brain regions implicated in these processes, i.e. the left posterior middle temporal gyrus (pMTG) and inferior frontal gyrus (pars opercularis, IFGop), respectively. Vice-a-versa, we tested how these brain regions influence the development of children's semantic and syntactic behavioral skills. We implemented a cross-lagged panel design by measuring semantic and syntactic processing behaviorally and in the brain when children were 5.5-6.5 years old (Time 1) and again at 7-8 years old (Time 2). Participants completed two auditory sentence processing tasks during fMRI, a semantic plausibility judgement (N=26) and a grammaticality judgment (N=30). Semantic and syntax skills were measured behaviorally using CELF-5 standardized assessments. All analyses controlled for T1 autoregressive effects and phonological working memory. A series of preregistered and exploratory hierarchical regression analyses indicated bi-directional influences, but with greater support for syntactic bootstrapping. Across the models tested, semantic skills at T1 explained 2-8% of the variance in IFGop activation for syntax at T2. Conversely, syntactic skills at T1 explained 5-22% percent of the variance in pMTG activation for semantics at T2. Parallel models in which brain activation at T1 predicted behavior at T2 yielded little to no evidence in favor of either mechanism, likely because of the modest change in behavior across this time period. Taken together, results suggest a close relationship between lexical and grammatical development in children ages 6-7.5 years old. However, there was more robust evidence for syntactic bootstrapping, suggesting that acquisition of phrase structure in school age children allows the more effective learning of word meanings. This complements behavioral studies showing the greater importance of lexical knowledge in bootstrapping grammatical development in younger children.

Predictive Neural Language Models Capture Language Processing in the Brain

Martin Schrimpf[1], Idan Blank[1,2], Greta Tuckute[1], Carina Kauf[1], Eghbal Hosseini[1], Nancy Kanwisher[1], Joshua Tenenbaum[1], Evelina Fedorenko[1]; [1]MIT, [2]UCLA

The ability to share ideas through language is our species' signature cognitive skill, but how this feat is achieved by the brain remains unknown. Here we tested the long-standing hypothesis that the human brain's language system is functionally optimized to use predictive processing for efficient meaning extraction (e.g., Levy, 2008; Smith & Levy, 2013; Kuperberg & Jaeger, 2016). To do so, we asked whether artificial neural network models of language ('models' below) built to predict words given context capture human brain activity during language comprehension. We tested 43 language models spanning major model classes—embedding models, recurrent networks, and attention-based 'transformer' architectures—against three neural datasets, including fMRI (Pereira et al., 2018; Blank et al., 2014) and intracranial electrocorticographic (ECoG) recordings (Fedorenko et al., 2016), by presenting the same stimuli to models that were shown to humans. We then fit a linear regression from the model activations to the corresponding human measurements on a subset of the stimuli, and evaluated model predictions on held-out stimuli by computing Pearson's correlation. We further normalized these correlations by the extrapolated reliability of the particular dataset, which places an upper bound ("ceiling") on the correlation between the neural measurements and any external predictions. We found that the most powerful generative transformer models (GPT-2, Radford et al., 2019) accurately predict neural responses, in some cases achieving near-perfect predictivity relative to the noise ceiling. In contrast, simpler word-based embedding models (e.g., Pennington et al., 2014) only poorly predict neural responses (<10% predictivity). Model predictivity scores are consistent across datasets, establishing the generality of model representations. Critically, the ability of each model to predict neural data is strongly correlated with its performance on the next-word-prediction task, but not other linguistic tasks, like grammaticality judgments or sentence similarity judgments, suggesting that optimizing for predictive representations may be a critical shared objective of biological and artificial neural networks for language. Beyond neural representations, we tested the models' ability to predict behavioral outputs in the form of self-paced reading times (Futrell et al., 2018). We found that specific models predict human reading times accurately and, across models, behavioral predictivity correlates with both the corresponding neural predictivity and next-word prediction performance. Finally, we explored the relative contributions to brain predictivity of two different aspects of model design: network architecture and training experience, to begin to test different hypotheses about how the brain's language network might have arisen through a combination of evolutionary and learning-based optimization. Intriguingly, certain model architectures alone, with random weights, produce representations that capture neural and behavioral linguistic responses and closely track the representations with learned weights across datasets. Together, these results suggest that a drive for online prediction, and the functional computation of meaning that can support prediction, fundamentally shapes the architecture of language processing in the human brain. In addition, the finding of strong correspondences between ANNs and human representations opens the door to using the growing suite of tools for neural network interpretation to test hypotheses about the human mind.

Dissociating syntactic processing and semantic composition in the left temporal lobe: MEG evidence from Standard Arabic

Suhail Matar[1], Julien Dirani[1], Alec Marantz[1,2], Liina Pylkkänen[1,2]; [1]New York University, [2]NYUAD Research Institute

INTRODUCTION. Decades of research have painted a confusing picture of the neural basis of syntactic processing, usually implicating one or more of these regions: the left posterior temporal lobe (LPTL; e.g., Flick & Pylkkänen, 2020), anterior temporal lobe (LATL; Brennan et al., 2012), inferior frontal gyrus (LIFG; Zaccarella & Friederici, 2017), and angular gyrus (LAG; Pallier et al., 2011). This confusion is largely due to the elusiveness of a grammatical design that varies syntactic structure independently of other, chiefly semantic, variables. This MEG study achieves such a design in Standard Arabic: the same noun-adjective pairs ('chair purple'), coupled with an orthographically-contiguous definiteness manipulation ('chair purple'; 'the-chair the-purple'; 'the-chair purple'), represent the same concept but with varying degrees of syntactic complexity (respectively corresponding to: indefinite phrase: 'a purple chair'; definite phrase: 'the purple chair'; sentence: 'The chair is purple.'). We expected a region processing syntax to respond differently to the simpler indefinite phrases compared to the bulkier definite phrases and sentences. Single-word controls ('chair'/'purple') addressed definiteness-based accounts. Additionally, previous literature implicates the LATL in basic semantic composition, outlining its sensitivity to conceptual specificity. Unlike English, head nouns in Arabic appear first, so we manipulated their conceptual specificity ('chair' vs. 'throne') to determine whether the expected elimination of a composition effect for conceptually-specific nouns ('throne') is independent of the head's position. Lastly, because LATL effects occur early (~250ms), we hypothesized that they are facilitated by orthographic/morphological salience. Thus, we compared adjectives of high vs. low morphological typicality, expecting the latter to eliminate composition effects. METHODS. Twenty-one participants read noun-adjective pairs and single-word tokens, as above, in a serial presentation (600ms between words). Task items followed one-third of trials: participants read a sentence containing a gap, mentally substituted it with the preceding token, and evaluated the resulting sentence for grammaticality and plausibility. We source-localized MEG data to obtain signed estimates of single-trial activation on the cortex. We then built statistical regression models, using model comparison to assess how much adding each factor of interest improves the models. To control error rates, we performed cluster-based permutation tests. Syntactic analyses focused on the LPTL, LATL, LIFG, and LAG, with test-windows extending from 100-500ms after word onset. Semantic analyses focused on the LATL and its right-hemispheric homologue, 150-350ms post-adjective. RESULTS. Syntactic structure differences elicited a significant effect for two-word tokens only in the LPTL ($p=0.0032$; 270-360ms post-adjective). The underlying pattern shows more positivity for the syntactically simple indefinite phrases compared to definite phrases and sentences; the effect is eliminated in single-word tokens, ruling out other, non-syntactic interpretations. Semantically, significant effects emerged in the LATL ($p=0.0016$; 230-350ms post-adjective); morphologically typical adjectives elicited semantic composition effects: more positivity for two-word tokens compared to single adjectives. The effects disappear for morphologically untypical adjectives, except for low-specificity nouns with definite adjectives. CONCLUSION. Using a straightforward, basic composition design, we show the LPTL's involvement in syntactic processing. We also implicate morphological salience in the LATL's semantic composition effects, and determine that head nouns' conceptual specificity effects occur regardless of noun position.

Long-range sequential dependencies precede syntactically-rich vocalizations in humans

Tim Sainburg[1], Anna Mai[1], Timothy Q Gentner[1]; [1]University of California, San Diego

As sequential distances between elements in human language increase, the mutual information (MI) between them decays following a power law. This power-law relationship has been variously attributed to human language syntax, semantics, and discourse structure. However, the vocalizations of numerous phylogenetically distant species including humpback whales and songbirds also demonstrate similar long-range statistical dependencies. These observations support the hypothesis that the long-range statistical dependencies found in human speech may occur independently of linguistic structure. To test this hypothesis, we computed MI over several child speech corpora (6 months – 12 years) to determine whether long-range relationships are present in human vocalizations prior to the production of syntactically-rich speech. We compare these to non-linguistic behavioral sequences in both humans and nonhumans. We computed MI over words and phonemes for 9 corpora of natural speech from English speaking children included in the PhonBank and CHILDES repositories. All data included here were transcripts of spontaneous speech from typically-developing children aged 6 months to 12 years. Utterances in each transcript were analyzed both as sequences of words and sequences of phonemes. Sequence distributions were treated independently across speakers to account for individual variation in lexical acquisition. For each corpus, we calculated sequential MI relative to chance over the elements of the sequence dataset (i.e., words or phonemes), and fit the MI decay using either (1) a power-law model, (2) an exponential decay model, or (3) a composite of (1) and (2), following the methods outlined in Sainburg et al. (2019). Context-free languages exhibit power-law decays in MI while Markovian processes exhibit exponential decays. The composite model captures the sequential organization of human speech, in which exponential decays dominate the organization of speech elements within words and at short distances, while longer-range dependencies follow a power-law decay. We also perform the same MI analysis on corpora of non-linguistic behaviors, including Drosophila and zebrafish movement sequences and human cooking. At the earliest time point we can reliably measure (6 months of age), MI decay for both phonemes and words show above chance long-range statistical relationships best-fit by the adult-like composite model. That is, the MI decay in vocal sequences produced by pre-lingusitic infants follows a power-law at long distances and an exponential decay at shorter distances, just as it does in adults. This observation contradicts the notion that the adult-like power lay decay is generated solely by either human language syntax, semantics, or discourse structure. Indeed, we find similar patterns of above-chance long-range relationships in non-linguistic sequences, suggesting that this structure reflects more basic underlying processes and mechanisms. We propose that the hierarchical organization of human language evolved to exploit pre-existing long-range structure present in much larger classes of non-linguistic behavior, and that the cognitive and neural capacity to model long-range hierarchical relationships preceded language evolution.

Slide Session B

Thursday, October 22, 2020, 11:30 am – 1:00 pm, PDT *Join Zoom Webinar*

Neural mechanism underlying speech production during delayed auditory feedback

Muge Ozker Sertel[1], Werner Doyle[2], Orrin Devinsky[1], Adeen Flinker[1]; [1]Department of Neurology, New York University Langone Health, [2]Department of Neurosurgery, New York University Langone Health

Monitoring the vocal output during speech production allows the detection and correction of vocalization errors in real-time, however the neural mechanism underlying this auditory feedback control of speech is poorly understood. We obtained electrocorticography recordings from human subjects while they read aloud words and sentences during delayed auditory feedback. Subjects slowed down their speech rate to compensate for the delay and this behavioral effect was stronger for sentences. Neural responses in superior temporal, supramarginal, inferior frontal and dorsal prefrontal regions were both enhanced in amplitude and extended in duration for large delays reflecting the error signal caused by altered feedback and the subsequent longer articulation. Response enhancement was stronger across the speech network for sentences when delayed feedback had a stronger disruptive effect on speech. Our results highlighted dorsal precentral gyrus as a critical region for auditory feedback control of speech, which showed selective response enhancement during slowed down speech and was recruited much earlier compared to other vocal motor sites. Furthermore, our subjects performed an auditory repetition task, which we used to identify auditory sites that show suppressed responses during speaking compared to listening. Our results revealed that sites that show stronger auditory suppression also show stronger response enhancement to delayed feedback, providing evidence for a shared mechanism between speech-induced auditory suppression and sensitivity to altered feedback in humans.

Speakers' and listeners' brains show different time lags when tracking the speech envelope

Alejandro Perez[1], Robin A.A. Ince[2], Matthew H. Davis[1], Philip J. Monahan[3,4,5]; [1]MRC Cognition and Brain Sciences Unit, University of Cambridge, UK, [2]Institute of Neuroscience and Psychology, University of Glasgow, UK, [3]Centre for French & Linguistics, University of Toronto Scarborough, Canada, [4]Department of Linguistics, University of Toronto, Canada, [5]Department of Psychology, University of Toronto Scarborough, Canada

Introduction Even without face to face contact, speakers and listeners show increased inter-brain synchronisation during speech. Since there is a coupling between the listener's cortex and the slow modulations in the speech envelope, and the speaker is also hearing their own speech, then, this inter-brain coupling could be a simple by-product of concomitant brain entrainments to speech sounds. Here we measure the timing of speech envelope tracking for speakers and listeners. Specifically, we assessed whether the lagged covariation of brain activity and speech envelope peaks with different timings for the speaker as compared to the listener. Methods We designed a paradigm in which subjects: (i) listen to natural speech, (ii) produce natural speech and (iii) listen to the playback of their own speech all while electroencephalographic (EEG) brain activity was recorded. The lagged relationships between the EEG recordings and the audio envelope in the 2-10 Hz frequency range were calculated using a mutual information measure (MI). 15 English speakers (11 females; $\bar{x}$ age = 21 years, sd = 1.6 years, range = 19-26 years) took part in the study. Independent components (IC) showing strongest speech tracking over the range -400 to 400 ms were identified. The exact lag inside the interval showing the peak MI value was taken for each participant and condition. Results When participants are listening to speech (self-listening or listening to others), the maximal MI values are on average 117 ms (sd: 125) after the headphones deliver the audio; however, in the case that participants are producing speech, maximal MI values occur approximately 25 ms (sd: 32) before the audio onset. A Wilcoxon Signed-Ranks Test indicated that latency of the peak values for the Listening conditions was significantly delayed than for the Speech Production condition (Z=3.01, p=.0026 and Z=3.05, p=.0023 for Self-Listening and Listening, respectively). Also indicated that peak value for Speech Production was significantly earlier than zero lag (Z=-2.39, p=.0085). Dipole localisations for the maximally ICs showing brain-speech MI processes were similar for the two listening conditions. Both are left-lateralised to parieto-temporal areas of the cortex. Dipole localisation during Speech Production suggests a qualitatively different pattern of brain activity, with two clusters in left-posterior and middle central brain regions. Conclusion Here we show that the timing of speech envelope tracking is different for speakers and listeners. For listeners, the maximal coupling between brain activity and speech take place with positive delays (brain activity following speech). For speakers, neural tracking of self-produced speech is strongly attenuated even compared to later playback of the same speech due to the effect of efferent copy. Hence, maximal speech envelope tracking occurred prior to verbalisation, represented as negative delays between brain activity and speech. In combination, these effects should lead to a substantial delay between brain activity in speakers and listeners during conversation rather than the instantaneous coupled interbrain activity seen during speaking and listening. We therefore conclude that between brains coupling is not wholly dependent on a shared physical stimulus.

Natural language encoding models for fMRI reveal distinct patterns of semantic integration across cortex

Shailee Jain[1], Amanda LeBel[1], Alexander G. Huth[1]; [1]The University of Texas at Austin

Encoding models are a powerful computational tool for modeling language processing in the brain. These models learn to map features extracted from stimuli to the elicited fMRI responses. Previous research used encoding models to investigate word-level processing in cortex by representing each stimulus word with an embedding vector. The learned weights were then used to find words that maximally activated each voxel, revealing word-level selectivity. While this provides insights on how semantic selectivity is organized across the cortex, word-level models treat each word in a phrase independently, ignoring the effects of context, phrase structure, and syntax. One solution to this issue is using language model (LM) based encoding models. LMs are artificial neural networks that learn to predict the next word by developing a representation of the preceding phrase. To build an encoding model, we extract this phrase-level representation for each stimulus word. Hence, these models serve as useful candidates to study phrase-level processing in the brain. Here we used a 12-layer transformer LM (GPT) and data from an fMRI experiment with 3 subjects (1 female) listening to 13 hours of naturally spoken narrative English language stimuli. Encoding models were built using ridge regression and performance was measured by testing predictions on a held-out dataset. The phrase-level model significantly outperformed the word-level model in nearly all brain areas, highlighting the importance of context for natural language representations in the brain. The learned weights were then used to find phrases that were predicted to maximally activate each voxel, revealing phrase-level selectivity. This computational model predicts voxel response as a function of the words constituting a phrase. However, different brain areas are known to integrate over different amounts of information. To investigate these differences, we used encoding models to assess how sensitive each voxel was to constituent words in a phrase. This was done as a function of each word's position relative to the most recent word. We found that most voxels were much more sensitive to changes in recent words than words further in the past. Yet we also found substantial differences across brain areas. Overall, voxels in the right hemisphere integrate information over more words than the left hemisphere, but voxels in the prefrontal cortex showed substantial heterogeneity in both hemispheres. Finally, we compared this new measure of phrase-level information integration across brain areas that are selective for the same broad semantic category, such as "places". This revealed significant differences between areas; for example, voxels near the parahippocampal place area (PPA) had small integration windows, while voxels in the retrosplenial cortex (RSC) had longer windows and were particularly sensitive to prepositional phrases involving places. These results paint a more detailed, nuanced, and accurate picture of language selectivity across cortex than previous computational models. Further, examining phrase-level selectivity reveals differences among brain areas in the same semantic network, leading to a better understanding of how these areas work together to extract meaning from natural language.

Bottom-up neural entrainment and top-down cortical tracking cooperate around syllable P-centers to ensure speech intelligibility. A combined EEG-tACS study.

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Talk Cancelled Congratulations on the new addition to the Strauß family.

Slide Session C

Friday, October 23, 2020, 4:00 – 5:00 pm, PDT *Join Zoom Webinar*

Neural indicators of articulator-specific sensorimotor influences on infant speech perception

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Speech perception is multisensory from early in life. Pre-lingual infants match visual and auditory speech for both native (Patterson & Werker, 2003) and non-native (Danielson et al.. 2017) speech, suggesting that infants are sensitive to audio-visual congruencies. The finding that infants match non-native audio-visual speech that they haven't experienced before suggests that specific experience (i.e. that infants learn to associate multisensory speech input through experience) is not required for this sensitivity to emerge. Speakers adjust the movements of the unaffected articulators to compensate for somatosensory perturbations (e.g., Tremblay et al., 2003), but also, somatosensory inputs to the perceiver's own articulator have been reported to alter the perception of the concordant speech sounds (e.g., Ito et al., 2009). Interestingly, recent behavioural evidence shows that at 6-months of age, when the native phonological system is still being established, sensorimotor information influences speech perception in an articulator-specific manner (Bruderer et al., 2015; Choi et al., 2019). These studies suggest a potential link between speech perception and speech production systems that precedes active babbling. To further probe the relation between speech perception and production systems early on in ontogeny, the current study examines the neural dynamics underlying phonetic perception with and without articulator-specific oral-motor influences. We tested 3-4 months-old English-exposed infants, an age at which infants discriminate native and non-native phonetic distinctions (Werker & Tees, 1984; Peña, Werker & Dehaene-Lambertz, 2012) and do not yet babble. Infants heard sequences of four syllables, while their neural responses were measured using electroencephalography (EEG). Previous studies have shown that a mismatch response between the standard trials and the deviant trials is elicited when infants perceptually distinguish phones that cross the phonetic boundary (Dehaene-Lambertz & Dehaene, 1994). In Experiment 1, we tested infants' discrimination of the bilabial /ba/ – dental /da/ contrast, and the dental /da/ – retroflex /Da/ contrast, while infants passively listened to the syllables. We identified an ERP discriminative response to both distinctions in a cluster of left-anterior-sensors 450-710ms following the critical stimulus onset. In Experiment 2, infants participated in the same EEG task as in Experiment 1 while their tongue-tip movement was restricted with a teething-toy. We hypothesized that if there is a specificity in the relationship between the oral-motor articulator influence and speech perception, then the tongue-tip movement restriction would selectively impair the event-related-potential (ERP) response to phonetic category changes between the dental and the retroflex sounds, but not between the bilabial and the dental sounds. We observed an ERP discriminative response from 290-490ms in a cluster of left-central-posterior sensors only to the /ba/-/da/ category change, demonstrating that restricting infants' tongue-tip movement selectively diminished the ERP responses to the /da/-/Da/ phonetic contrast. These findings extend the previously reported behavioural results by providing electrophysiological evidence for articulator specific auditory-sensorimotor integration in pre-lingual infants. This work further suggests that the speech production and perception systems may be linked even prior to the onset of babbling when direct production experience begins.

Visual speech cues aid speech motor areas encoding phonemes in noise

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Introduction: Speech motor system plays a compensatory role in speech perception under adverse conditions via sensorimotor integration. Although it is evident that lip movements facilitate speech perception in noise, it remains unknown whether visual information could promote neural representations of syllables in noise. And the modulatory effect of visual cues on the functional connectivity of the speech processing network was also not fully studied. We hypothesized that visual speech information would enhance neural representations of speech in speech motor areas and modulate the connectivity between speech motor regions and sensory areas. Methods: In this fMRI study, 24 young Chinese adults discriminated 4 syllables (/ba/, /da/, /pa/, /ta/) in speech-spectrum noise at three SNRs (-8, 0, 8 dB) with visual valid (corresponding lip movement) and visual invalid (still lip picture) information. Anatomical ROI-based multivoxel patterns analysis (MVPA) was used to assess the neural representations of syllables, and generalized psychophysiological interactions (gPPI) was used to investigate the condition effect on the functional connectivity. Results: Participants performed better when visual cues were valid and SNR increased. BOLD signal was higher in bilateral visual cortices and bilateral posterior middle temporal gyri under the visual valid condition. Unprecedentedly, MVPA showed that the Broca's area (pars opercularis) and the left supramarginal gyrus exhibited better phoneme categorization when valid visual cues were provided. Furthermore, PPI analysis showed weaker functional connectivity between left supramarginal gyrus and bilateral premotor cortices under the visual valid condition. Conclusions: Our findings suggest that visual speech cues promote speech perception in noise by sharpening speech representations in speech motor and sensorimotor integration areas related to articulatory prediction and phonological decision, but reducing the functional connectivity between them in the dorsal stream of speech processing. Our results provide novel evidence on the functional contribution of visual speech in facilitating speech perception in noise and highlight a key role of the speech motor system in audiovisual integration of speech.

Neural encoding of phonological sequences in the human brain

Matthew Leonard[1], Emily Stephen[1], Lingyun Zhao[1], Edward Chang[1]; [1]University of California, San Francisco

As natural speech unfolds rapidly in time, listeners must extract meaningful linguistic units like words, which are composed of specific sequences of phonemes and syllables. Often, there are no clear acoustic markers that indicate where one word ends and another begins. How does the brain segment a continuous speech stream into perceptually-meaningful chunks that are perceived as distinct whole words? Here, we recorded high-resolution neural activity directly from the human cortical surface while listeners heard a continuous speech stimulus that could be perceived as multiple words (e.g., "/…seɪseɪseɪseɪ…/", which can be heard as "say" or "ace"). They indicated which word they were hearing at every point during the experiment, allowing us to examine neural activity associated with distinct word percepts from an identical acoustic stimulus. Crucially, the task leverages a classic psycholinguistic phenomenon, in which the distinct percepts differ in the perceived order of the consonants and vowels, e.g., "say" (/s-eɪ/) versus "ace" (/eɪ-s/) (Warren, 1968), where the brain must select the specific window over which to bind the input. We show that neural populations primarily in the superior temporal gyrus respond with different activity patterns depending on which word is perceived. Some neural populations encode specific words, while others encode a more general phonological sequence order (e.g., CV vs VC; "say/day" vs "ace/aid"). Furthermore, many neural populations encode word perception for both 1- and 2-syllable sequences (e.g., "/…sɜrtɛnsɜrtɛnsɜrtɛn…/, which can be heard as "certain" or "tensor"), demonstrating representation of abstract, word-level phonological units, independent of length. Perceptual word encoding occurs most strongly in neural populations that are weakly tuned to acoustic-phonetic features like vowel formants, demonstrating that flexible, context-specific representations of sub-word speech content are a mechanism for binding input across time. In addition, neural populations tuned to speech envelope features encode word percepts by varying the peak timing of the neural response, suggesting that both amplitude and temporal codes are used to represent words. Together, these results provide a direct demonstration of neural computations that underlie the perception of word-level phonological sequences during continuous, connected speech.

Slide Session D

Saturday, October 24, 2020, 6:00 – 7:45 pm, PDT [*Join Zoom Webinar*]

Functional organisation for verb generation in children with developmental language disorder

Saloni Krishnan[1,2], Salomi Asaridou[1], Gabriel J. Cler[1], Harriet J. Smith[1,3], Hannah E. Willis[1], Máiréad Healy[1], Dorothy V. M. Bishop[1], Kate E. Watkins[1]; [1]University of Oxford, [2]Royal Holloway, University of London, [3]MRC Cognition and Brain Sciences Unit, University of Cambridge

Developmental language disorder (DLD) is characterised by difficulties in learning one's native language for no apparent reason and occurs in 7% of children. DLD increases the risk of academic underachievement, unemployment, and social and emotional problems. Our understanding of the brain basis of DLD is limited. Previous fMRI studies have yielded inconsistent results, perhaps as a consequence of small sample sizes, heterogeneity in the populations studied, and the tasks used to study neural activity. An important step for the field is to develop a basic understanding of how variation in language ability patterns with functional organisation. As part of the Oxford BOLD study (boldstudy.wordpress.com), we assessed brain activity in 10- to 15-year-olds for a simple language task, overt verb generation (e.g., saying "fly" in response to an image of a kite). We monitored in-scanner performance, and only included those participants with >75% accuracy. Our final sample included 67 typically-developing (TD) children, 50 with DLD, and 26 with a history of speech-language problems (who do not fully meet our criteria for DLD). This is the largest investigation of the functional neural basis of DLD to date. Our pre-registered hypotheses (osf.io/r2fc5/) were that those with DLD would have: (i) reduced activity in the left inferior frontal gyrus (LIFG); (ii) abnormal striatal activity, and (iii) reduced task-related laterality in frontal cortex. First, performance of this simple language task evoked activity in children with DLD in the same regions and to a similar level as in TD children. We found no evidence for group-level differences in activity in LIFG (pars triangularis) and striatal brain regions in DLD and TD children. Second, our results revealed that atypical laterality was not associated with language proficiency or a diagnosis of DLD. Given the large size of our sample, this suggests that previously reported differences were false positives. In a follow-up analysis, we contrasted a subset of the DLD group with the lowest verb generation accuracy (50-83.3%, N=14) with a subset of TD children who performed the task with high accuracy (100%, N=14). This revealed sub-threshold differences in the LIFG and caudate nuclei bilaterally; these areas had reduced activity in the low-performing DLD group consistent with previous studies. These findings confirm the importance of monitoring and controlling for task performance in studies of DLD. We also conducted a planned whole-brain analysis including all our participants (N=143), using language and verbal memory factors as continuous variables. These factors were computed from a range of standardised tests assessing participants' grammatical, vocabulary, narrative, list learning and working memory abilities. This analysis revealed that 1) higher language proficiency was associated with greater task-related activity in the LIFG (pars orbitalis) and the supramarginal gyrus, and 2) better verbal memory ability was associated with greater task-related activity in the left hippocampus, left cerebellum, and ventral sensorimotor cortex bilaterally. This work suggests a lack of sharp dividing lines between TD and DLD brains. Modelling continuous language variation in large samples might yield greater insight into the brain basis of DLD than using dichotomous categories.

Form-invariant conceptual coding of words and sentences: Evidence from multivariate fMRI

Paul Hoffman[1], Andres Tamm[1], Rafael Lemarchand[1], Aliff Mohd Sharif[1]; [1]University of Edinburgh

The mapping between form and meaning is not constant. Meaning can change while form remains the same, as in case of ambiguous words like "bark". Conversely, meaning can remain constant while form changes radically, as the same sentiment can be expressed in many different ways. Brain areas involved in conceptual semantic processing should show activation patterns that respect the underlying meaning of stimuli rather than their form. Previous studies have demonstrated such form-invariance across modalities (e.g., similar patterns for pictures of objects vs. their names) but there is less evidence for form-invariant concept coding within the language domain. We will present data from two multivariate fMRI studies that provide such evidence. Study 1 investigated the neural representations of homonyms, whose meaning changes while their form remains constant. 23 participants were presented with word pairs consisting of a homonym target paired with a contextual cue that primed one of its meanings. We tested whether multi-voxel activation patterns could discriminate between presentations of the same homonym in different contexts (e.g., bark following tree vs. bark following dog). Three regions of interest in the left-hemisphere semantic network displayed this effect at FDR-corrected $p<0.05$: ventral anterior temporal lobe (ATL), posterior middle temporal gyrus (pMTG), inferior frontal cortex (IFG; BA47). A weaker effect in the angular gyrus (AG) did not survive correction for multiple comparisons. Thus, activation patterns in the semantic network changed according to the underlying conceptual significance of stimuli, even when their surface form remained the same. These effects were only observed when participants made semantic judgements, and not phonological judgements, to the stimuli. Study 2 used sentence stimuli to investigate cases where form changes while meaning remains (relatively) constant. 26 participants were presented with sentences describing four distinct events (e.g., “the student pondered the problem”). Each event could be described using four different sentence forms, varying in their lexical items and syntactic structures (c.f., “the issue was considered by the pupil”). We trained multivariate classifiers to discriminate between the four events, each time training on one set of sentence forms and testing generalisation to a new set of sentences. Left ATL, pMTG, IFG and AG showed above-chance classification that generalised across both lexical items and syntactic structures (all significant at FDR-corrected $p<0.05$). In other words, these regions coded the conceptual content of the events independently of the sentence forms used to describe them. In contrast, none of these regions could successfully discriminate between different syntactic structures, independent of the events being described. Only pMTG patterns discriminated between different lexical items used to describe the same events. Searchlight analyses revealed a left-biased but bilateral pattern of event decoding across the whole brain, with accuracy highest in the left-hemisphere semantic network but frequently above chance in right-hemisphere homologues. Taken together, these studies provide new evidence that brain regions implicated in semantic processing code the conceptual significance of language stimuli, decoupled from their surface properties.

Word frequency and prediction: spatiotemporal MEG signatures during sentence reading

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The processing mechanisms that underlie sentence reading are greatly affected by the lexical characteristics of the input (e.g. lexical frequency, predictability, position in the sentence, length). For example, highly frequent words are processed faster and with less effort than less frequent words. There is a well-documented discrepancy between the electrophysiological and eye-tracking literature as to whether frequency and context (or predictability) have additive or interactive effects on processing. It is unclear whether word frequency influences processing when input is predictable. Despite the complex interaction between these attributes, much of the previous work lacks the required temporal and/or spatial resolution to provide a comprehensive account of how they influence word processing, largely due to averaging over time and space. The current work aimed to better define the effects of lexical frequency and predictability on stages of neural processing. Data were analysed from 102 participants in which magnetoencephalography (MEG) was recorded while they read sentences and word-lists. Data were part of the larger MOUS dataset (Schoffelen et al., 2019). Participants read 240 sentences, 50% of which were presented as intact sentences and 50% of which were presented as scrambled sentences (word-lists). Stimuli were counterbalanced so that no participant read both versions (sentences/word-lists). Data were bandpass filtered (1-20Hz). Artefacts were removed. Source activity was reconstructed for 382 cortical parcels using an atlas-based parcellation scheme. For each parcel, principal component analysis was performed and the five strongest components were selected for further analysis. Sentence/word-list time series were shifted +/-50ms in steps of single samples. Time-shifted time series were entered into 5-fold cross-validated multiset canonical correlation analysis to achieve spatiotemporal alignment across subjects, thereby boosting the stimulus-specific signal and reducing intersubject variability (Arana et al., 2020). The extent to which predictors of interest (index/perplexity/entropy/frequency/index*frequency) were encoded in the MEG signal evoked by single content words (from sentences/word-lists) was quantified in a model comparison scheme, using 5-fold cross-validated ridge regression, using the change in explained variance as test statistic. Index (word position), perplexity (surprise about current word; log10 transformed), entropy (constraints on possible continuations) and frequency (log10 transformed) each significantly predicted the MEG signal (in addition to the variance explained by all other predictors; maximum statistic corrected, $p<.05$). More variance was explained in sentences compared to word-lists ($p<.025$) by index (258-417ms in left anterior temporal, inferior frontal and bilateral orbitofrontal parcels), perplexity (50-58ms in left middle temporal gyrus, MTG; 392-475ms in bilateral orbitofrontal and left MTG parcels), entropy (450-458ms in a left occipitotemporal parcel) and frequency (267ms in a right frontal parcel). After multiple comparisons correction, the index*frequency interaction did not significantly predict MEG signal. Instead we report uncorrected exploratory analyses of the spatiotemporal dynamics of the interaction. We demonstrate that lexical frequency and predictability (quantified with index/perplexity/entropy) independently effect word processing. Frequency significantly influences both early and later stages of word processing, both with and without sentence context. We provide a novel illustration of the complex spatiotemporal dynamics of the frequency*index interaction, which previous work has lacked the spatial and/or temporal dynamics to do.

A Hierarchy of Linguistic Predictions During Natural Language Comprehension

Micha Heilbron[1,2], Kristijan Armeni[1], Jan-Mathijs Schoffelen[1], Peter Hagoort[1,2], Floris P. de Lange[1]; [1]Donders Institute, [2]Max Planck Institute for Psycholinguistics

Language comprehension requires the rapid transformation of complex, ambiguous stimulus streams into distinct linguistic representations. It is often claimed that this process relies on routine prediction to guide the interpretation of incoming information. While there are well-documented effects of linguistic predictability on brain responses, the exact role of prediction in language comprehension remains disputed. First, some critics question the pervasiveness of linguistic prediction, pointing out that apparent prediction effects might instead reflect other processes like semantic integration – or that they could be a by-product of artificial, 'prediction-encouraging' experiments. Second, even among proponents of predictive processing, the nature of predictions remains disputed: do people predict single words or entire distributions? And are predictions lexical, or rather syntactic or semantic – or might prediction occur at each linguistic level, all the way down to individual speech sounds? Here, we address both issues by probing the effects of prediction across multiple linguistic levels during natural language comprehension. We analyse both EEG (19 participants, 1 hour per participant) and source-localised MEG (3 participants, 10 hours per participant) recordings of people listening to audiobooks, and use a state-of-the-art neural language model (GPT-2) to quantify predictions in a fine-grained, contextual fashion. First, we establish clear evidence for predictive processing, confirming that brain responses to words are modulated by word predictability. This effect is present over and above a strong baseline of non-predictive factors (such as acoustics and semantic congruency) and was best explained by a probabilistic account, suggesting that the brain is generating graded, distributional predictions rather than discrete 'best guess' predictions. Next, we asked at which level(s) of representation prediction occurs. To this end, we factorised the lexical predictions from GPT-2 into distinct linguistic dimensions using techniques from computational linguistics. This revealed dissociable signatures of predictions at different levels: syntactic and phonemic predictions modulated early frontal and temporal responses, while semantic predictions modulated later, more distributed responses. Finally, we asked how these levels interact: are predictions at different levels independent or do they align and form a single multi-level hierarchical prediction? To answer this question, we compared two models of phoneme prediction: a single-level model, which computes phoneme predictions based on short sequences of phonemes and a fixed lexical prior, and a hierarchical model, which computes phoneme predictions using a contextual prior derived from higher-level lexical predictions. Neural responses to phonemes were best explained by the hierarchical model, suggesting that phoneme-level predictions are informed by word-level predictions, effectively incorporating prior contexts up to hundreds of words long. Altogether, this work underscores the ubiquity of prediction in language processing, and demonstrates that linguistic prediction is not implemented by a single system but occurs throughout the language network, together forming a hierarchy of linguistic predictions across all levels of analysis.

Implicit Statistical Learning in Fast Periodic Visual Stimulation

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Research on the neural underpinnings of linguistic representations has recently received a methodological boost with an approach that capitalises on the principle of neural entrainment by combining Fast Periodic Visual Stimulation (FPVS) and electrophysiological recordings (e.g., Lochy, Van Belle, & Rossion, 2015). In this paradigm, streams of visual stimuli (i.e., base stimuli, e.g., consonant strings) that are presented at a frequency rate F, are interleaved with oddballs (i.e., stimuli from another category, e.g., words), which are periodically inserted at fixed intervals (i.e., every n items), appearing thus at a slower frequency rate (F/n). Neural entrainment is indexed by a response at the base stimulation frequency, while an additional neural response at the pre-defined oddball stimulation frequency reflects the brain's ability to discriminate between the two types of stimulus categories, and is selective to the dimension that differentiates the oddball from the base stimuli. The present study investigated (a) whether such category-selective response can be generated by incidental implicit learning even when base and oddball stimuli are of the same kind, and (b) whether it can be modulated by stimulus familiarity. Skilled readers (N = 30; native Italian speakers) were asked to monitor the color change of a central fixation cross while exposed to sequences of four types of linguistic items with decreasing familiarity: (1) existing Italian words (e.g., ombra, shadow); (2) pronounceable, but not attested letter strings (e.g., barmo, swhoad); (3) unpronounceable consonant strings (e.g., qnlvd), and (4) strings of non–alphabetic characters that share low-level visual features with letters. Crucially, these sequences were made of stimuli belonging to the same category, in which the only distinction between base and oddball items was the frequency of individual tokens within a stream. Stimuli were presented at a frequency rate of 6Hz, with oddball items inserted every fifth item (i.e., 6/5 = 1.2Hz). Since individual base tokens appeared four times more often than their oddball counterparts, a neural entrainment to oddball items would reflect an effect of token frequency, while a response in any of these categories would index which level of stimulus familiarity (i.e., whole-word level, co-occurring letter clusters, letters, letter features) can give rise to such implicit statistical learning. Results revealed a significant response at the oddball frequency and its harmonics in all conditions, suggesting the emergence of two distinct classes of items purely informed by token frequency. Cross-condition comparisons indicated that the effect is independent of stimulus familiarity, and arises across a wide span of stimuli, from non–alphabetic characters that were never experienced to fully fledged, frequent words. The implications of our findings are twofold. On a theoretical level, we observe an online neural index of fast implicit statistical learning, a mechanism that might account for the bootstrapping of linguistic categories. On a methodological level, we show that sensitivity to statistical regularities can contaminate any category-selective response in FPVS-oddball designs calling for future studies to take this phenomenon under serious consideration.

Poster Session A

Neurocognitive correlates of broad & local context cues during natural language comprehension

Poster A1 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session A.

Presenter Note: If you cannot visit us during the poster session, please feel free to reach out to us at shohini@umd.edu or @shohini_tahini on Twitter.

Shohini Bhattasali[1], Philip Resnik[1]; [1]University of Maryland, College Park

Introduction: Context guides comprehenders' expectations during language processing. The expectation can be based on information from the immediately preceding words (local) or previous sentences and paragraphs (broad). Information-theoretic surprisal (Hale, 2001; Levy, 2008) can be utilized to capture both types of contextual cues. This measure tells us how unexpected the word is given the preceding context and reflects cognitive processing effort. In this study, we use surprisal to look at how use of local and broader context are involved in processing using an analysis of fMRI timecourses collected during naturalistic listening. Our goal is to investigate how the relationship between a word and its immediate context versus the wider topic influences language processing. Lexical surprisal calculated from an LSTM (long short-term memory) language model is used to capture effects of local context (van Schijndel & Linzen, 2018). For broader topical context, a new metric, topical surprisal (Bhattasali & Resnik, 2020) is used. It is defined using the weighted average of a word's probability given a topic, where weights are the (posterior) probability the context is about that topic; topics can be defined and probabilities estimated using a topic model (LDA; Blei et al., 2003). Methods: Participants (n=51) listened to The Little Prince's audiobook for 1h38mins. Participants' comprehension was confirmed through multiple-choice questions (90% accuracy,SD = 3.7%). The LSTM language model was trained on 90 million words of English Wikipedia (Gulordava et al., 2018). Using the wrapper for Mallet LDA (McCallum, 2002) in the Gensim toolkit (Rehurek & Sojka, 2010), we estimated a 100-topic model using the Brown corpus (Francis & Kučera, 1964). We compute topical surprisal for each of the 6,243 non-function words in the audio sample using the paragraph containing the word as its context. Additionally, we entered four regressors of non-interest into the GLM analysis (SPM12): word-offset, word frequency, pitch, intensity. Results: The whole-brain main effects were FWE-corrected (T-score>5.3). Regression analyses localized the activation patterns for local and broad context to different areas. The peak activation for lexical surprisal (instantiating local context) was observed in bilateral ATL, along with a small cluster in left STG. Significant clusters for topical surprisal (instantiating broad context) were seen in the right Precuneus and right MTG.. Conclusion: Our lexical surprisal results corroborate previous findings by Willems et al., (2015), Brennan et al., (2016), Shain et al., (2020) for bilateral ATL and by Willems et al. (2015), Lopopolo et al. (2016), Shain et al. (2020) for STG. Our topical surprisal results are supported by prior work on context and discourse-level phenomena (Bhattasali & Resnik, 2020; Maguire et al. 1999; Raposo et al., 2013; Whitney et al., 2009; Xu et al., 2005) and further supports this measure as a cognitively plausible metric associated with distinct neural substrates from lexical surprisal. Overall the neurocognitive correlates for lexical surprisal and topical surprisal suggest utilizing local and broad contextual cues during language processing recruit different brain regions and illustrate that various regions of the language network functionally contribute to processing different dimensions of contextual information during comprehension.

Topic Areas: Computational Approaches, Meaning: Discourse and Pragmatics

Machine Learning-Based Multimodal Prediction of Language Outcomes in Chronic Aphasia

Poster A2 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session A.

Sigfus Kristinsson[1], Wanfang Zhang[2], Chris Rorden[3], Roger Newman-Norlund[3], Alexandra Basilakos[1], Leonardo Bonilha[4], Grigori Yourganov[5], Feifei Xiao[2], Argye Hillis[6], Julius Fridriksson[1]; [1]Center for the Study of Aphasia Recovery, University of South Carolina, Columbia, SC, USA, [2]Department of Epidemiology and Biostatistics, University of South Carolina, Columbia, SC, USA, [3]Department of Psychology, University of South Carolina, Columbia, SC, USA, [4]Department of Neurology, Medical University of South Carolina, Charleston, SC, USA, [5]Advanced Computing and Data Science, Cyberinfrastructure and Technology Integration, Clemson University, SC, USA, [6]Department of Neurology and Physical Medicine and Rehabilitation, Johns Hopkins School of Medicine; Department of Cognitive Science, Johns Hopkins University, Baltimore, MD, USA

Introduction Several recent studies have leveraged a multimodal neuroimaging approach to examine how patterns of brain damage and structurally and functionally intact cortical and subcortical regions correspond to aphasia severity to gain further understanding of the neurobiological substrates of aphasia.1-3 Following this line of work, the current study used machine learning approaches to predict aphasia severity and specific language measures based on a multimodal neuroimaging dataset. Methods A total of 117 individuals with chronic left-hemisphere stroke were included in the study. Aphasia was assessed with the WAB-R4, and specific subtests served as dependent variables in the analyses. Neuroimaging data included task-based functional magnetic resonance imaging (fMRI), diffusion-based fractional anisotropy (FA)-values, cerebral blood flow (CBF), and lesion-load data. As a primary analysis, we constructed support vector regression (SVR) models predicting language measures based on (i) each neuroimaging modality separately, (ii) lesion volume alone, and (iii) a combination of all modalities. Prediction accuracy across models was subsequently statistically compared. Finally, we extracted topographical information about predictors (modality and brain region) of language measures. Results Prediction accuracy across modalities and language measures varied substantially (predicted vs. empirical correlation range: r = 0.30 to 0.6; see Table 1). The multimodal prediction model yielded the most accurate prediction in all cases except one (Naming; multimodal vs. FA-model accuracy: 0.57 vs. 0.59, p = .360). Accuracy of the multimodal prediction model was >0.55 for other language measures. Statistical superiority in favor of the multimodal model was achieved in 24/30 model comparisons (p-value range: <.001 to .036; see Table 2). Topographical information revealed an extensive neural network supporting speech and language processing, implicating lesion-, structural-, and functionally-based measures across brain regions. WAB score CBF FA fMRI Lesion-load Lesion-volume Multimodal AQ 0.54 (401.72) 0.56 (388.64) 0.42 (465.73) 0.52 (420.31) 0.55 (389.48) 0.66 (317.37) Fluency 0.49 (6.86) 0.62 (5.58) 0.43 (7.42) 0.51 (6.63) 0.57 (6.03) 0.62 (5.49) Spontaneous Speech 0.52 (19.38) 0.57 (17.98) 0.48 (20.77) 0.49 (19.99) 0.55 (18.34) 0.64 (15.48) Naming 0.39 (7.47) 0.59 (5.71) 0.30 (8.18) 0.40 (7.47) 0.43 (6.99) 0.57 (5.85) Repetition 0.45 (7.53) 0.48 (7.43) 0.33 (8.62) 0.52 (7.02) 0.50 (7.04) 0.55 (6.66) Auditory Comprehension 0.41 (2.66) 0.46 (2.41) 0.32 (2.90) 0.55 (2.14) 0.45 (2.38) 0.61 (1.89) Table 1. Accuracy of prediction models (SVR) for all language measures. WAB score CBF FA fMRI Lesion-load Lesion-volume AQ 0.0046 0.0074 0.0001 0.0001 0.0134 Fluency 0.0052 0.3827 0.0015 0.0019 0.1331 Spontaneous Speech 0.0070 0.0182 0.0012 0.0004 0.0334 Naming 0.0027 0.3561 0.0001 0.0004 0.0189 Repetition 0.0341 0.0364 0.0002 0.1663 0.1663 Auditory Comprehension 0.0002 0.0011 0.0001 0.1119 0.0042 Table 2. Hotelling-Williams test comparing prediction accuracy of the multimodal to single-modality prediction models. Conclusions Our results indicate that a prediction model incorporating several different neuroimaging modalities yields, in most cases, more accurate prediction of aphasia severity and specific language measures compared to any single-modality prediction model. These results suggest that different neuroimaging modalities carry complementary information that can be integrated to more accurately depict how brain damage and remaining functionality of intact brain tissue translate into language function in aphasia.

Topic Areas: Computational Approaches, Methods

The Role of Procedural Learning for Emergent Reading: Insights from Côte d'Ivoire

Poster A3 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session A.

Joelle Hannon-Cropp[1], Benjamin Zinszer[1,2], Axel Seri[3], Elise Kouadio[4], Fabrice TANOH[4], Sayako Earle[1], Kaja Jasinska[1,5,6]; [1]University of Delaware, [2]Swarthmore College, [3]Centre de Recherche et d'action pour la Paix, [4]Université Félix Houphouët-Boigny, [5]Haskins Laboratories, [6]University of Toronto

Introduction: In low- and middle income countries, such as Ivory Coast, the age of school enrollment is highly variable. Children may begin schooling, and therefore begin learning to read, as late as 12 years of age. Yet little is known about learning to read in later childhood. Some models suggest that the cognitive and linguistic systems which support reading are differentially supported by procedural and declarative memory (PM, DM; Ullman, 2004). PM supports the discovery of structure (e.g. phonology, syntax), including in phonological awareness (PA; i.e. knowledge about the segmental nature of speech), a vital skill for emergent reading (Quam et al., 2018). DM supports the arbitrary mapping of form and meaning including vocabulary, which increases in importance with skilled reading (Harm & Seidenberg, 2004). PM appears to reach maturity around age ten (Finn et al., 2016) and younger children rely on skill learning supported by PM (Mayor-Dubois, Zesiger, Van der Linden, & Roulet-Perez, 2016). We posit that, even for older first time readers, PA is still vital to emergent reading. If older emergent reading relies on PA, which is supported by PM, then emergent reading should be linked to PA and PM regardless of the age of the learner. Methods: Forty-five children in rural Ivory Coast, aged 9-15 years (M=11.24, SD=1.36) participated in French language (PA, vocabulary), literacy assessments (letter, word, nonword reading), and a measure of PM, a version of the Serial Reaction Time task (SRTT; Nissen & Bullemer, 1987) adapted for administration on children in Ivory Coast. SRTT; children respond to an image appearing in locations determined by either a random or sequential pattern. RT for random versus sequential was measured. Results: Older children (i.e. older than 10 years) had higher PM, lower PA, and lower reading scores. Older children also started school later and repeated grades more often than younger children. Higher PA, but lower PM, were associated with better letter reading, irrespective of the child's age. The effect of PA on reading was dependent on PM (β= 0.03, $t(33)$ =3.45, p=0.002); for children who had lower PA scores (one SD below mean), higher PM was associated with poorer reading. However, for children with higher PA scores (one SD above mean), higher PM was associated with better reading. Conclusions: PA has a reciprocal relation to reading such that PA will also improve as reading becomes more skilled (Wagner & Torgesen, 1987), despite better PM, older children were at a disadvantage for reading and PA. Environmental factors, such as older age at starting school and more grade repetitions, may have impacted PA for older children who start school later and are held back more. Children with better PA, however, demonstrate the predicted relation between PM and reading, supporting the hypothesis that PM is important for emergent reading. Further, the relevance of PM to reading does not depend on the child’s age. Understanding age-dependent contribution of PM to literacy provides insight regarding learning to read at different ages.

Topic Areas: Development, Reading

Lexical, morphological and syntactic abilities at the discourse level: comparing elicitation methods

Poster A5 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session A.

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Language assessment in persons with aphasia (PWA) includes the analysis of their discourse using different tasks, such as the description of pictures, the explanation of procedures and storytelling. Studies have shown that the discourse output varies depending on the task used, with storytelling eliciting the most informative and lexically diverse speech, while procedural tasks produce the lexically and syntactically poorest output (Alyahya et al., 2020, Brain; Stark, 2019 AJSLP). This study focuses on the lexical, morphological and syntactic productivity of PWA and neurotypical individuals using 4 tasks: storytelling, in which a tale like cinderella is narrated after showing a pictured book; procedural speech, in which participants are requested to explain how to make a sandwich; sequential picture description, requiring participants to describe a series of pictures representing an event (e.g a kid breaking a window with a ball); and single-picture description, where a single image is presented with several characters and actions depicted (e.g. a cat stuck in a tree). These tasks require the implementation of different cognitive processes and can lead to different characteristics in the elicited discourse. Concretely, procedural discourse is not based on visual support and may rely more on procedural memory and planning; storytelling may depend on episodic memory and spatiotemporal processes; while picture description may be constrained by the visual nature of the stimuli. Discourse samples from 117 monolingual English speaking PWA and 117 age, education and gender-matched control participants were extracted from Aphasia Bank (MacWhinney et.al., 2011, Aphasiology). For each elicitation task, we analyzed the number of open- and closed-class words for lexical productivity and the quantity of regular/irregular inflected verbs for morphological productivity. The percentage of syntactically incorrect sentences, sentence complexity ratio and the number of embedded sentences were analyzed for syntactic production. Demographic variables, mean length of utterance and duration of speech sample were used as covariates in a series of repeated-measures ANCOVAs with group and elicitation task as predictors. Preliminary analyses showed group and task differences. Controls outperformed patients in all variables and across all tasks. Storytelling produced the highest scores on measures of lexical diversity, followed by single picture description, sequential picture description and procedural discourse. A similar pattern emerged in the analysis of morphology and in the analysis of syntactic production. The advantage of single relative to sequential pictures may reside in the greater variety of elements that are visually available to the participant, which may prime production. Overall, these findings suggest that a thorough assessment of the lexical, morphological and syntactic aspects of discourse should rely on the combination of different elicitation tasks. Additional measures are being examined to provide a finer-grained analysis of lexical (lexical density), morphological (regular/ irregular inflection) and syntactic productivity (agreement and coreference relations). Also, further analysis is underway to test potential differences between fluent and non-fluent patients.

Topic Areas: Disorders: Acquired, Meaning: Discourse and Pragmatics

Regional atrophy predicts change in naming performance in primary progressive aphasia: A longitudinal study

Poster A6 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session A.

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Introduction Cross-sectional investigations of brain-behavior relationships in primary progressive aphasia (PPA) typically attribute poor performance to dysfunction of regions that appear grossly atrophied or that are reduced in size or cortical thickness relative to the brains of healthy individuals. However, true quantification of atrophy requires comparison of each individual's brain images over time. Here, we used longitudinally-collected data to examine both atrophy and language decline over time to more directly connect brain and behavior changes. Methods We analyzed data from two studies. Participants included 63 individuals with primary progressive aphasia (32 female; mean age= 66.9, standard deviation=7.35 years; variant: 25 logopenic, 26 non-fluent/agrammatic, 11 semantic, 1 unclassified). All had concurrently-collected behavioral assessment and magnetic resonance imaging (MRI) at two timepoints (mean=338.67, standard deviation=211.39 days apart). Object naming performance was evaluated with the 60-item (n=25) or 30-item (n=39) Boston Naming Test (BNT; Kaplan, Goodglass, & Weintraub, 1983; Mack et al., 1992); scores were normalized to the same scale. Neuroimaging analysis utilized T1-weighted MRI collected with the same imaging parameters at both timepoints. Each anatomical scan was segmented into regions of interest (ROIs) via atlas-based analysis in the MRI Cloud platform (www.mricloud.org). The two scans for each individual were compared using DiffeoMap to quantify change in each ROI as measured by the Jacobian determinant (<1 indicates shrinkage in that region; >1 indicates expansion). Using stepwise forward regression minimizing Akaike information criterion (AIC), we evaluated relationships between naming performance change and change in 13 left hemisphere ROIs commonly associated with language (middle frontal gyrus; dorsolateral prefrontal cortex; pars operculais, pars orbitalis, and pars triangularis of inferior frontal gyrus; supramarginal gyrus; angular gyrus; superior, middle, and inferior temporal gyri; superior and middle temporal poles; and fusiform gyrus) and their right hemisphere homologues. The model also included the number of days between timepoints; a measure of overall baseline atrophy (cerebral/intracranial volume at the first timepoint); and sex, as women showed significantly greater naming decline than men ($t(54.93)=-2.45$, $p=.017$). Results The final model selected six factors to predict change in BNT ($F(6,56)=13.2$, $p<.001$, Adjusted $R^2= 0.541$). Male sex ($t=2.95$, $p=.005$); fewer days between timepoints ($t=-4.23$, $p<.001$); less volume loss over time in: left supramarginal gyrus ($t=2.26$, $p=.028$), left middle temporal pole ($t=2.26$, $p=.028$), and left fusiform gyrus ($t=1.57$, $p=.122$); and greater volume loss over time in the right fusiform gyrus ($t=-4.61$, $p<.001$) were associated with slower decline (less negative change) on the BNT. Discussion We identified areas where change in volume (atrophy) is associated with change in naming performance by examining data collected longitudinally. Increased atrophy over time in several left hemisphere regions commonly associated with naming (left supramarginal gyrus, left middle temporal pole, and left fusiform gyrus) was associated with increased decline in naming performance. Increased right fusiform atrophy was instead associated with reduced decline, possibly because PPA often affects the left hemisphere first. Those who experience bilateral atrophy (likely those with semantic variant) have low initial BNT scores, limiting opportunity to observe further decline.

Topic Areas: Disorders: Acquired, Language Production

Utility of Estimated Hypoperfusion in Predicting Naming Performance Post Stroke

Poster A7 [Poster PDF] [Poster Tour] Visit me at [Gather.Town] in the Broca room during Poster Session A.

Lisa D. Bunker[1], Alex Walker[1], Richard Leigh[1], Erin Meier[1], Emily Goldberg[1], Bonnie L. Breining[1], Colin M. Stein[1], Delaney M. Ubellacker[1], Argye Hillis[1]; [1]Johns Hopkins University School of Medicine Department of Neurology

Lesion metrics are often used to predict language performance/recovery in poststroke aphasia. Considering various metrics, lesion volume (independent of location) has been shown to predict general language performance, including naming. However, acute lesion variables besides volume may provide additional predictive power in capturing language impairments. Hypoperfusion (i.e., compromised blood flow causing dysfunction in tissue surrounding the infarct, the ischemic penumbra) may possibly contribute to performance deficits in the acute stage. Although typically estimated using perfusion-weighted imaging (PWI), not all patients can have PWI acutely. However, the area of hypoperfused or dysfunctional tissue beyond the infarct can be estimated on fluid-attenuated inversion recovery (FLAIR) sequences (typically obtained clinically) since blood vessels supplying regions of hypoperfusion typically lack a flow void, making them hyperintense. We examined the association between dysfunctional tissue, (estimated by quantifying extent of FLAIR hyperintense vessels; FHVs), and other lesion/demographic characteristics on naming performance following acute stroke. Seventy-four participants with acute left hemisphere ischemic stroke (39 female; mean[SD] age=61.2[11.9] years) completed the Boston Naming Test (BNT) within 48 hours of acute clinical MRI scans including diffusion-weighted images (DWI) and FLAIR. Lesion volumes were obtained from traced DWI. We estimated volume of hypoperfused tissue by scoring images for presence of FHVs. Six areas (viz., territories of anterior cerebral artery, posterior cerebral artery, and middle cerebral artery [MCA] divided into MCA-temporal, MCA-frontal, MCA-parietal, and MCA-insular) were scored from 0-2 with 0=0 FHVs, 1=1-2 FHVs on ≤2 slices, and 2=3+ FHVs. Scores for each area were summed for a total maximum score of 12. Total FHV scores were multiplied by 16000 to estimate the affected volume (mm3; per studies correlating FHV to hypoperfusion on PWI). Lesion volumes were subtracted from transformed FHV scores to determine the penumbra volume. Penumbra volume was added to infarct volume to estimate total volume of dysfunctional tissue (VDT). Correlations and regression analyses were completed to examine relationships between infarct volume, VDT, and demographic variables on BNT scores. BNT scores correlated with both lesion volume ($r=-0.38;p=0.002$) and VDT ($r=-0.37;p=0.0025$). In the multivariable regression model, lesion volume and VDT accounted for 37% of the variability in naming scores ($F[7, 57]=4.87;p=0.0002$) with hypoperfusion in MCA-parietal and insular regions being significantly associated independent of lesion volume (p's<.05). Naming accuracy did not correlate with age ($r= 0.21;p=0.09$), but did with education ($r= 0.32;p=0.0098$). Thus, education was added to the multivariable regression model, which accounted for 47% of the variance ($F[8, 54]=6.05;p<0.00001$). BNT scores were best accounted for by education, infarct volume, and hypoperfusion in the MCA-parietal and insular regions, which were all independently associated (all p's<0.05). As expected, variability in naming was best predicted by a combination of variables: lesion volume, hypoperfusion in MCA-insular and MCA-parietal areas, and education. Naming accuracy was independently associated with hypoperfusion in these regions after controlling for lesion volume. Findings suggest that it is important to consider dysfunctional tissue beyond infarct when identifying areas where acute

damage contributes to language deficits: perfusion deficits should be included when predicting behavior from acute lesions.

Topic Areas: Disorders: Acquired, Language Production

Spared functional connections relate to core language abilities in chronic left-hemisphere stroke survivors

Poster A8 [Poster PDF] [Poster Tour] Visit me at [Gather.Town] in the Broca room during Poster Session A.

Presenter Note: Thank you for your interest in my poster! If you have any questions or comments, feel free to reach out to W. Tyler Ketchabaw at wtk10@georgetown.edu

W. Tyler Ketchabaw[1], Candace van der Stelt[1], Andrew DeMarco[1], Elizabeth Dvorak[1], Elizabeth Lacey[1,2], Sarah Snider[1], Peter Turkeltaub[1,2]; [1]Georgetown University, [2]MedStar National Rehabilitation Hospital

Introduction: Post-stroke aphasia is caused by damage to local brain processors as well as disconnection of brain networks. Additional research is needed to characterize which connections in the brain are important for good clinical outcome when spared from lesion damage or newly integrated into the language network after reorganization. Connectomics presents one method of interrogating brain-wide network structure by dividing gray matter into nodes and measuring connectivity between each node pair or "edge". While most connectomics studies in aphasia have investigated structural connections or global properties of large-scale functional networks, less work has focused on how functional connectivity (FC) of individual edges relates to outcomes for specific language abilities (Yourganov et al., 2018). Here we examine edgewise FC in chronic stroke survivors (CSSs) and matched controls (MCs) to identify edges where FC relates to core language domains after stroke. Methods: Thirty-three CSSs (>6 months post-left-hemisphere stroke) underwent behavioral assessment from which four tests were selected as representative of core language functions: the Philadelphia Naming Test (naming); Western Aphasia Battery Yes/No Questions subtest (comprehension); Pseudoword Repetition (phonology); and Pyramids and Palm Trees (semantic knowledge). CSSs and 32 MCs underwent anatomical scans and resting-state fMRI (rs-fMRI). Lesions underwent automatic segmentation (Pustina et al., 2016), and the anatomical scans were parcellated using the Lausanne 2008 parcellation (Hagmann et al., 2008), yielding 116 nodes in right hemisphere (RH) and 117 in left hemisphere (LH). rs-fMRI data were coregistered to parcellated anatomical data and average time series were extracted from each node and correlated with every other node, resulting in functional connectomes for each participant. To find edges where stronger FC predicted better performance, edges with positive connectivity in MCs were modeled in separate GLMs, using lesion size and standardized CSS connectivity (relative to MCs) as predictors of each of the four domains. Edges where FC positively related to performance (at $P < .005$, unc.) were examined with post-hoc t-tests for differences in FC between CSSs and MCs. Results: Of 22,509 edges with positive FC, 41 were significantly positively related to language performance across the four domains. Naming was related to FC of intrahemispheric edges in both hemispheres as well as interhemispheric edges, while comprehension and phonology were mainly related to FC of intra-left hemispheric edges and interhemispheric edges. FC in only 1 edge related to semantic knowledge, a connection within right inferior frontal gyrus. FC was numerically lower in CSSs than MCs in 35 of the 41 edges implicated in language outcomes, with 9 of these edges significantly weaker in CSSs than MCs ($P < .005$, unc.). There were no edges with significantly greater FC in SCCs compared to MCs. Summary: Functional connectivity in CSSs relates to performance in core language domains, even when controlling for lesion size. In most cases, FC is reduced compared to controls, suggesting that relationships with behavioral outcomes are primarily driven by disconnection or network dysfunction due to lesions. Examining disruptions in FC may help to explain patterns of deficit and preserved ability observed in stroke survivors.

Topic Areas: Disorders: Acquired, Computational Approaches

Poststroke brain plasticity in sensory aphasia

Poster A9 [Poster PDF] Visit me at [Gather.Town] in the Broca room during Poster Session A.

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In this study, we tested neural network rearrangements against the background of restoration of the speech function sensory component in patients with sensory aphasia according to fMRI data got during hospitalization and after undergoing therapy. The study involved patients with isolated sensory aphasia (10 men, 5 women; right-handers; average age 61.9±9.8 years; the average number of days between studies - 42.6 ±12.8; severity of aphasia (on a 10-point scale) - 5.6±1.18 points at admission), and healthy volunteers (8 men, 7 women; right-handers; average age 65.9±9.7 years). We examined all patients on a 10-point scale of neuropsychological symptoms. At discharge, patients had an increase in the impressive component of speech and a decrease in the severity of aphasia. Patients underwent fMRI scanning twice. The scanning procedure included the collection of structural and functional data with the use of auditory-speech stimulation using phonemes, as well as fMRI without a task that assesses changes in the functional connectivity of brain areas against the background of an increase in the indicators of the impressive component. Auditory-speech stimulation was an oddball paradigm: the block contained 10 Russian syllables (330 MS, 85 dB). Syllables with an oppositional phoneme were used: "BA" - as standard, "PA" - deviant (presented with a frequency of 20% within the block). MRI was performed on a MAGNETOM AVANTO 1.5 T (Siemens, Germany). FMRI data were analyzed using the SPM12 package and the CONN TOOLBOX software package on the MATLAB r2012b platform (MathWorks, Natick, MA, USA). When constructing an fMRI contrast of MMN in a healthy group, bilateral activation regions were identified in the STG and the right IFG. In the group of patients, activation was observed only in the STG on the right at admission, and upon discharge, additional activation areas were identified in the left STG and the right IFG. Pair-wise comparison of MMN activation maps of a group of patients at admission and discharge resulted in a significant increase in activation in BA 44. Then the resulting activation gain region was used as a region of interest (ROI) to assess its functional connectivity according to resting-state fMRI data. There was a decrease in the total number of connections between this area and other areas of the brain when re-examined. There was a tendency to increase functional connectivity between the ROI and the right cerebellum, while functional connectivity with the left cerebellum decreased. In addition, the indicators of functional connectivity between the region of interest and the BA 40 increased, and decreased between the region of interest and the right premotor cortex. The decrease in the number of ROI connections against the background of the auditory-speech system function recovery can presumably be attributed to an increase in the efficiency of the neuronal (speech) network by removing redundant connections. The pattern of interaction with the cerebellum may reflect the role of this structure in speech perception, which needs further research.

Topic Areas: Disorders: Acquired, Speech Perception

Neuroplasticity in post-stroke aphasia: A systematic review and meta-analysis of functional imaging studies of reorganization of language processing

Poster A10 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session A.

Presenter Note: https://langneurosci.org/aphasia-neuroplasticity-review

Stephen M. Wilson[1], Sarah M. Schneck[1]; [1]Vanderbilt University Medical Center

Recovery from aphasia is thought to depend on neural plasticity, that is, functional reorganization of surviving brain regions such that they take on new or expanded roles in language processing. We carried out a systematic review and meta-analysis of all studies published between 1995 and early 2020 that have described functional imaging studies of six or more individuals with post-stroke aphasia, and have reported analyses bearing on neuroplasticity of language processing. Each study was characterized and appraised in detail, with particular attention to three critically important methodological issues: task performance confounds [1, 2], contrast validity [3], and correction for multiple comparisons [4]. We identified 86 studies describing a total of 561 relevant analyses. We found that methodological limitations related to task performance confounds, contrast validity, and correction for multiple comparisons have been pervasive. We drew empirical conclusions primarily from the subset of analyses that had no major limitations and relatively few other limitations. Only a few claims about language processing in individuals with aphasia are strongly supported by the extant literature: first, left hemisphere language regions are less activated in individuals with aphasia than neurologically normal controls, and second, in cohorts with aphasia, activity in left hemisphere language regions, and possibly a temporal lobe region in the right hemisphere, is positively correlated with language function. There is modest, equivocal evidence for the claim that individuals with aphasia differentially recruit right hemisphere homotopic regions, but no compelling evidence for differential recruitment of additional left hemisphere regions or domain-general networks. There is modest evidence that left hemisphere language regions return to function over time, but no compelling longitudinal evidence for dynamic reorganization of the language network. Progress in understanding neuroplasticity in post-stroke aphasia will depend on addressing the important methodological issues identified. Collaborative studies with large sample sizes that carefully investigate the complex relationships between structural damage, functional activity, and language outcomes will be necessary to uncover the neural changes that support recovery from aphasia. References: [1] Binder et al. NeuroImage 2005; 27: 677-93. [2] Geranmayeh et al. Brain 2014; 137: 2632-48. [3] Wilson et al. Hum Brain Mapp 2018; 39: 3285-307. [4] Eklund et al. PNAS 2016; 113: 7900-5.

Topic Areas: Disorders: Acquired, Methods

Microstructural Properties of the Cerebellar Peduncles in Children with Developmental Language Disorder

Poster A11 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session A.

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Children with developmental language disorder (DLD) struggle to learn their native language for no apparent reason. While DLD is a common disorder, with prevalence estimated at 7%, we know relatively little about what characterizes the brains of children with DLD. In the current study, we examined the link between cerebellar connectivity and variation in language learning abilities in children aged 10-15 years. Cortico-cerebellar circuits, alongside cortico-striatal systems, have been shown to contribute to complex sensorimotor skill learning, such as that involved in the acquisition of spoken language. Furthermore, a growing literature suggests that the cerebellum is involved in higher-order cognitive functions, including working memory. Children with DLD typically present with co-occurring motor-speech deficits, as well as atypical performance in procedural memory tasks which may also depend on the cerebellum. In this work we used diffusion-weighted imaging to assess microstructural properties of the cerebellar peduncles, which constitute the main input and output fiber pathways of the cerebellum. Data were acquired from 77 typically developing children (TD), 58 children with DLD, and 27 children with history of speech-language problems (HSL) as part of the Oxford BOLD study (boldstudy.wordpress.com). We used probabilistic tractography to identify the middle (MCP), and inferior (ICP) and superior cerebellar peduncles (SCP) in each hemisphere by applying a published protocol (Bruckert et al. 2019, Cerebellum). Mean fractional anisotropy (FA) values for each tract were extracted and entered in a beta regression using generalized linear mixed models with group, hemisphere (in ICP and SCP) and their interaction as fixed effects, and subjects as random effects. We found a significant effect of group in the ICP such that mean FA in this peduncle was lower in children with DLD compared with TD; the HSL group was not significantly different to either group. The group effect remained significant after controlling for whole brain FA, age, sex, and motion (during scan acquisition). In order to gain a better understanding of the microstructure underlying the FA differences in the ICP, we examined mean radial diffusivity (RD), an index of myelination, and axial diffusivity (AD), an index of axonal integrity. Differences were driven by significantly lower AD in the DLD group compared with the TD group. FA in the ICP was not associated with the level of impairment in language or verbal memory factors, which captured children's performance on standardized language and memory tests. Tracing studies have shown that the ICP carries fibers from the inferior olivary nucleus, the vestibular nuclei, as well as spinocerebellar fibers, transmitting sensory information to the cerebellum. Consequently, the observed group differences in the microstructural properties of the ICP suggest potentially suboptimal transfer of sensory input in children with DLD. In contrast, there was no evidence of differences in children with DLD in the SCP that carries cerebellar outputs to the cerebrum via the midbrain or in the MCP that provides inputs from the cerebrum via the pons. This negative finding contrasts with previous findings in young adults with DLD and expectations of impairment in cortico-cerebellar pathways.

Topic Areas: Disorders: Developmental, Development

Use of olfactory language in a person without smell: A case study of total anosmia

Poster A12 [Poster PDF] Visit me at [Gather.Town] in the Broca room during Poster Session A.

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Much remains to be learned about the link between olfaction and natural language. A longstanding belief is that vision and audition dominate the lesser senses of smell, taste, and touch in human perception and that this hierarchy of the senses is recapitulated in the human brain. English has an impoverished odor lexicon. Congenital anosmia (i.e., no olfaction) presents a unique opportunity to address the question of whether direct first-person experience with a particular sensory modality (e.g., knowledge of odors) is crucial for typical language use for words that load heavily upon olfaction. We examined processing of odor salient words and schemas in a person with total anosmia (P01). We hypothesized that lack of first person experienced odors would exert subtle linguistic effects. We contrasted processing of odor salient and odor neutral words for P01 relative to controls (N=20) in three experiments. In Experiment 1, we examined hierarchical semantic clustering properties for concrete nouns rated along dimensions of Color, Sound, Smell, Positive/Negative Feelings, and Social Interactions. P01's ratings of odor salience (Raw = 1.51, Z = -2.10, percentile = 1.78) were significantly lower than all controls (M = 2.97, SD = 0.69, p < .05*). All other dimensions did not differ. These differences in subjective ratings yielded distinctive semantic distance matrices and clustering properties. A k-means cluster analysis revealed 3 distinct clusters for P01 and 5 distinct clusters for the control group. Chi-squared tests of independence among clusters revealed that P01 did not differentiate words by smell salience [X^2(2)=.1.96, p>.05]. However, controls distinguished words by smell salience [X^2(4)=.50.19, p<.0001], and by pleasant [X^2(4)=.18.21, p=.001] or unpleasant [X^2(4)=.27.68, p<.0001] smell quality. In Experiment 2, we used macroscale language analyses to examine participant descriptions of five odorous scenes (e.g., fish market, bakery). P01 did not differ from controls in type-token ratio (TTR), mean length of utterance – words (MLUw), or mean olfactory salience of content words. In Experiment 3, we asked participants to provide two smell associates for fifteen low-smell stimuli (e.g., chalk). P01's responses (Raw = 2.99, Z = 2.94) were more smell salient than controls (M=1.64, SD = 0.46, p < .01**, 95% CI [97.95, 100.00]). On a cosine similarity measure of stimulus/response word pairs, P01 was indistinguishable from controls. To our knowledge, P01 represents the first single case examining the effects of anosmia on language. In odorous scene description and on measures of cognitive function, P01 did not differ from controls. Among other strategies, P01 may leverage indirect cues from language and observe the reactions of others to build an accurate representation of olfactory language. However, on sensitive measures of olfactory language, differences emerged. We attributed these differences to P01's anosmia, although other causes cannot be excluded. Further research will benefit from a larger sample size as well as examination of the effects of later life anosmia (e.g., secondary to brain injury or dementia). In conclusion, our findings contribute to the growing body of literature demonstrating flexible representation and use of modality salient language in context of sensory deprivation.

Topic Areas: Disorders: Developmental, Multisensory or Sensorimotor Integration

Individuals with autism spectrum disorders (ASD) have a reduced ability to track mental states of others during language comprehension

Poster A13 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session A.

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Social and communicative impairments have long been argued to be a core deficit in autism spectrum disorders (ASD) (Baron-Cohen et al., 1985; Happe, 1993; Tager-Flusberg et al., 2003). However, many early findings of neural differences between ASD and neurotypical (NT) individuals during social/communicative tasks have been shown to be non-robust or artifactual, and several recent studies report similar activations between the two populations (Dufour et al., 2013; Rosenthal et al., 2019; Jouravlev et al., 2020). One possibility is that the basic functional architecture of social cognition is intact in ASD individuals, and the commonly used paradigms are too crude to detect differences in more subtle aspects of social reasoning. Here, we leverage the so-called “Social-N400” ERP effect (Rueschemeyer et al., 2015; Jouravlev et al., 2019) to probe the ASD individuals’ sensitivity to co-listeners’ mental states. In NTs, the Social-N400 effect obtains when another individual is present not privy to some contextual information and would thus be confused by a sentence that is nonsensical without the context. Although the sentence makes sense to the experimental participant, they exhibit an N400 (indicating comprehension difficulty; Kutas & Federmeier, 2011) as if they were empathizing with the other individual’s confusion . Nineteen ASD participants (and 19 matched NTs) processed sentence pairs while their ERPs were recorded. The first (context) sentence in each pair was presented over the headphones, and the second (target) sentence, which contained the critical word, was presented visually. The target sentence was (a) plausible (The bird had a little beak.), (b) implausible (The girl had a little beak), or, critically, (c) plausible only in the context of the first sentence (The girl dressed up as a canary for Halloween.). Each participant completed the task in two sessions: joint (with a confederate in the room reading the sentences), or alone (with a confederate engaged in another task).If participants are sensitive to the confederate’s inability to comprehend the target sentences in the context-dependent condition, they should exhibit the Social-N400 in the joint condition. Although the Social-N400 (=Context-Dependent–Plausible in the joint session) was present in both groups, its magnitude was significantly reduced in ASD individuals. The standard N400 (=Implausible–Plausible) was comparable between the groups, ruling out the possibility that the Social-N400 reduction is due to general comprehension difficulty or due to mere presence of another individual. Thus, although ASD individuals appear to track mental states of other individuals present during a linguistic exchange, they do so to a lesser extent than NTs. These results suggest that in spite of generally similar neural architecture of social cognition, ASD individuals differ in how they engage these mechanisms during communication, perhaps especially so in situations with real humans (cf. observing social stimuli on a computer screen).

Topic Areas: Disorders: Developmental, Meaning: Discourse and Pragmatics

Examination of Common and Unique Brain Regions for Atypical Reading and Math: A Meta-Analysis

Poster A14 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session A.

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The single deficit model indicates that each neurodevelopmental disorder is due to a single underlying cognitive deficit. However, the prevailing single deficit model provides an inadequate account of atypical neuropsychological development. Reading and math are complex and require the integration of multiple components, including domain-general (e.g., language) and domain-specific (e.g., number sense) mechanisms.

The multiple deficit model accounts for multiple predictors contributing to disorders and shared risk factors possibly accounting for comorbidity. This model is supported by the behavioral literature which have outlined shared and distinct features in disorders of reading and math (e.g., Cirino, Child, & Macdonald, 2018). Yet, it remains unclear whether such shared and distinct features are underlain by corresponding activity in the brain. In isolation, there is evidence that both Reading Disabilities (RD) and Math Disabilities (MD) have been associated with underlying differences in neurobiology relative to typically developing (TD) learners. While some work has been done to compare typical reading and math functional neurobiology (Pollack & Ashby, 2018), there are no published meta-analyses comparing RD and MD. The purpose of this study is to identify consistencies across studies regarding common and unique brain regions/networks for individuals with RD and MD compared to TD individuals. A systematic search of the literature, utilizing multiple databases, identified 4,505 research items. Items including journal articles, dissertations, and conference proceedings were hand-sorted, using article titles. 557 items were then closely read to determine eligibility, employing the following criteria: 1) represented original research; 2) included at least one measure of functional whole brain imaging; and 3) included at least one group of participants identified with RD or MD. A hand search was also conducted and resulted in the addition of 97 articles for review. This process yielded 130 studies that were double coded. Coordinates that directly compared TD with RD or MD were entered into GingerALE (Brainmap.org). An activation likelihood estimate (ALE) meta-analyses was conducted to examine common and unique brain regions for reading and math across studies. Imaging results are reported using a family wise error (FWE) correction of $p < .05$. Overall, there were more studies that examined RD (n=104) than MD (n=26). The RD studies sampled elementary students to adults; however, the majority of the MD studies included elementary students and included no high school students. Across studies, areas of overlap for reading and math included middle temporal gyrus, angular gyrus, declive, insula, precuneus, and superior temporal gyrus for TD >Atypically Developing (AD) comparisons. For AD>TD comparisons there were no overlapping brain regions. Preliminary results indicate that there were differences across brain activation in how typically and atypically individuals process language and math tasks. Particularly, there were similarities in brain activation of language areas across reading and math for TD individuals that was not present for atypical individuals. These findings may have theoretical and practical implications for researchers and educators. The results highlight that the role of language may be considered in the development and interpretation of intervention studies for students with learning disabilities.

Topic Areas: Disorders: Developmental, Development

Neural sensitivity to close phonological neighbors is consistent across the lifespan

Poster A15 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session A.

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Producing spoken language is often associated with age-related decline. Compared to younger adults, older adults have more pauses, hesitations, and slips of the tongue during spoken language, and older adults' word-retrieval is often slower, less accurate, and associated with more retrieval failures. While prior work has suggested that retrieval difficulties may be phonologically based, it is unclear whether there are age-related differences in the organization of phonological information per se or whether age-related difficulties may arise from accessing that information. Here we investigated the influence of close phonological neighbors on the neural and behavioral bases of word naming. Phonological neighbors have long been shown to affect word processing. Prior work has shown that when a word with an initial voiceless stop has a contrasting initial voiced stop neighbor, Voice Onset Times (VOTs) are longer. Higher phonological neighborhood density (PND) has also been shown to facilitate word retrieval, has been associated with longer VOTs, and results in less neural activation, suggesting facilitation. Here we investigated the influence of close phonological neighbors, sometimes termed "minimal pairs", or real words that differ in a single phonetic unit, such as the voicing of the initial consonant (e.g., cape – gape, which begin with voiceless and voiced velar stops, respectively). We included an across the lifespan sample to investigate potential age-related differences (N=53, ages 22-78, mean age = 46.92, 35 Females). Participants underwent an fMRI session in which they overtly read words that had a real minimal pair neighbor (minimal pair words), words that did not have a real minimal pair neighbor (non-minimal pair words), and filler items. Importantly, the minimal pair neighbor was never presented. We hypothesized that phonological similarity (i.e., words that have a minimal pair neighbor) would lead to reduced activation in left hemisphere language regions. Moreover, based on previous results from our lab, we hypothesized that this sensitivity to basic phonological characteristics would be consistent across the lifespan. fMRI results revealed that all words elicited activation in typical language regions including bilateral superior temporal gyri, bilateral precentral gyri, left frontal gyri, and bilateral ventral visual processing regions. In addition, non-minimal pair words elicited greater activation than minimal pair words in left orbital frontal cortex, suggesting increased processing demands for words without a close phonological neighbor. Moreover, preliminary analyses suggest that there were no age differences in these effects. These results suggest that having a close phonological neighbor facilitates language production, and although aging is associated with increases in language production difficulty, sensitivity to phonological features is stable across the lifespan.

Topic Areas: Language Production, Phonology and Phonological Working Memory

Preserved language performance in typical aging is associated with increased resting-state functional connectivity despite grey matter loss

Poster A16 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session A.

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Healthy older adults commonly report increased difficulties with language production (e.g. more tip-of-the-tongue states, Burke et al., 2004), probably related to functional and structural changes within specialized brain networks. However, it remains unclear whether these age-related changes comprise a deterioration of language functional networks, a reorganization of these networks, and/or a different dynamics with other domains (e.g. the domain-general frontoparietal Multiple-Demand system, as shown by Hoffman and Morcom, 2018, during semantic tasks). In the current study we examined age-related differences in language functional networks at rest, in relation to participants' language performance. Twenty-three young adults (28±4 years old) and 24 healthy older adults (70±4 years old) were recruited. Both groups were French monolinguals, matched for gender (Younger group: 13 women; Older group: 11 women), level of education (years of education, younger group: 14±2; older group: 13±4) and global cognition (MMSE, younger group: 28.74±1.01; older group: 29.0±1.06). We assessed participants' language performance (GREMOTs battery, Bézy et al., 2016), volumetric grey matter differences (i.e. voxel-based morphometry); seed-based functional connectivity, using the left inferior frontal gyrus as a seed; and between-network connectivity (i.e. between language network and the Multiple-Demand system), in both groups. We expected lower lexical and syntactic performance in the group of older adults. We also expected greater atrophy, and less extended connectivity maps in older adults, correlated with lower language performance (fluency tasks and syntactic tasks). On the contrary, we predicted higher connectivity between the language network and the Multiple-Demand system in older adults, correlated with better language performance. Older adults had widespread grey matter atrophy, including bilateral fronto-temporal areas. Surprisingly, they did not differ from the younger group during the language assessment, and grey matter loss was not correlated with language performance. Contrary to what was expected, seed-based analyses showed larger connectivity maps in typical aging: the left inferior frontal gyrus was positively correlated with three clusters in older adults (precuneus, left angular gyrus and left temporal pole), while negatively correlated in younger adults. Finally, the older group had greater connectivity between the language network and the Multiple-Demand network compared to the younger group, and the strength of this connectivity was positively correlated with phonemic and grammatical fluency scores in this group. The discrepancy between atrophy and language performance supports the idea that language relies on a distributed functional network, rather than individual structures, which enables several functional compensations (Ansado et al., 2013). At a functional level, current results show extra intra- and inter-network connections during typical aging, both during seed-based and between-networks analyses. This could explain why older adults' performance during language assessment was not lower than younger adults, despite significant atrophy. References Ansado, J. et al. Eur. J. Neurosci. 37, 1887–1895 (2013) Bézy, C. et al. (De Boeck supérieur, 2016) Burke, D. M. et al. Curr. Dir. Psychol. Sci. 13, 21–24 (2004) Hoffman, P. et al. Neurosci. Biobehav. Rev. 84, 134–150 (2018)

Topic Areas: Language Production, Control, Selection, and Executive Processes

Baseline cortical anatomy predicts response to combined HD-tDCS and speech therapy intervention in primary progressive aphasia

Poster A17 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session A.

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Primary progressive aphasia (PPA) is a debilitating syndrome marked by progressive loss of language skills resulting from neurodegenerative disease. There are no current effective treatments for PPA. Noninvasive brain stimulation, such as transcranial direct current stimulation (tDCS), when paired with language therapy, has demonstrated the ability to enhance language outcomes in aphasia patients. However, there is known variability in tDCS responsiveness, which is not well understood. In a blinded, within-group crossover pilot study, PPA patients (N=12) underwent a two-week intervention of high-definition-tDCS (HD-tDCS) paired with constraint-induced language therapy (CILT). HD-tDCS applies focal, direct current via electrodes on the scalp that modulates cortical excitability. CILT utilizes mass practice and different levels of difficulty scaled to individual ability, while constraining nonverbal communication. We assessed whether baseline cortical thickness or volume of regions involved in language function predict tDCS-induced naming improvements, measured by the Western Aphasia Battery-naming subtest, at 0-weeks (immediately) and 6-weeks post-intervention. Multi-level linear regression using backward-fitted models were performed separately to assess whether cortical thickness or volume of left-hemisphere language regions predict change in naming difference scores from baseline to 0- and 6-weeks post-intervention. Cortical thickness of the pars opercularis explained 37.8% of the variance in change in performance at 0-weeks post-intervention following active stimulation ($F(1,10)=6.08$, $p=0.03$, R2Adjusted=0.32), where greater thickness ($\beta=0.62$) significantly predicted naming gains ($p=0.03$). At 6-weeks post-intervention following active stimulation, thickness explained 83.3% of the variance in change in performance ($F(4,6)=7.46$, $p=0.02$, R2Adjusted=0.72), where greater thickness of the middle temporal gyrus (MTG; $\beta=0.92$) and less thickness of the posterior superior temporal gyrus (pSTG; $\beta=-2.02$) significantly predicted maintenance of naming gains (p's<0.02). Cortical thickness did not predict naming gains in sham at either time-point (p's>0.05). Cortical volume was not predictive of 0-week performance for active stimulation ($p>0.05$). However, cortical volume in sham explained 68.2% of the variance in change in 0-week performance ($F(3,8)=5.71$, $p=0.02$, R2Adjusted=0.56), where greater volume of pars orbitalis and MTG, and less volume of pSTG, significantly predicted immediate naming gains (p's<0.03). Volume for 6-week active, explained 84.2% of the variance in change in performance ($F(4, 6)=8.01$, $p=0.014$, R2Adjusted=0.74), where greater volume of pars triangularis ($\beta=0.76$) and MTG ($\beta=0.71$), but less volume of pSTG and anterior-STG ($\beta=-0.57$, $\beta=-0.70$) significantly predicted naming gains (p's<0.05). Volume did not significantly predict 6-week sham naming performance ($p>0.05$). The findings that frontal cortical thickness predicted tDCS-induced naming gains at 0-

weeks and expanded to temporal areas at 6-weeks in active but not sham suggests that a broader network of regions may help to maintain treatment gains. The result that cortical volume predicted 0-week naming performance in sham may indicate the behavioral therapy response for immediate gains, rather than the added benefit of stimulation. Collectively, thickness and volume were predictive of treatment gains in active but not sham at 6-weeks post-intervention, suggesting that pairing HD-tDCS with CILT may be important for maintenance of treatment effects. These data suggest tDCS-induced gains are influenced by degree and location of atrophy. Future research is needed to make clearer inferences about the nature of these relationships.

Topic Areas: Language Therapy, Disorders: Acquired

Combined rTMS and constraint induced language therapy reveals interactions between language and motor systems: A case study

Poster A18 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session A.

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Neuropsychological studies have shown the involvement of motor areas in language functions, especially in semantic processing of action verbs. However, the exact manner and anatomical underpinnings of this involvement are under debate. Here, we report data from a patient who participated in an ongoing clinical trial assessing the efficacy of repetitive transcranial magnetic stimulation (rTMS) of the right pars triangularis to treat aphasia following a left-hemispheric stroke. In addition to language improvements, the patient showed unexpected improvements in right hemiparesis, providing us with the opportunity to investigate relationships between language and motor systems. The participant (P01) was a 56-year-old male native English speaker who suffered from a single left-hemispheric stroke 8 years prior, resulting in a large, left peri-sylvian ischemic infarct involving the frontal lobe, insula, supramarginal and superior temporal gyri. At baseline, P01 presented with Broca's aphasia along with hemiparesis in his contralesional right arm and hand. Performance on a neuropsychological battery was assessed at baseline, and post-treatment at 1 week (T0), 3 months (T3), and 6 months (T6). Critically, the battery included an assessment of verb production. Treatment consisted of 10 semi-consecutive sessions of 1-Hz inhibitory rTMS at 90% resting motor threshold delivered to the right pars triangularis for 20-min, which was immediately followed by 1-hour of constraint-induced language therapy (CILT). The clinical trial investigates whether rTMS paired with CILT confers better outcomes when compared to CILT alone (sham rTMS). P01 was randomized to receive real rTMS. P01's verb production improved from baseline (17.4% correct) at T0 (41.7% correct), but this improvement was not maintained at T3 and T6 (18.1 and 15.3% correct, respectively). Strikingly, P01 self-reported reduced hemiparesis after the second treatment session, and expressed increasing improvements in functional use across the remaining sessions. For example, the patient reported chopping onions and celery and washing hair using his right upper extremity, which he had not been able to do. We measured his right-hand grip strength (after treatment session 6, 8, 10) and finger-tapping speed (after session 8, 10), which are predictors of motor stroke recovery. We obtained consent to acquire motor data collected in a different study, which provided a baseline measure. P01 showed an increase in both right-hand mean grip strength (13.3N at baseline to 45.3N after session 10) and finger-tapping speed (25.5times/min at baseline to 40.3times/min after session 10). The improvement maintained at least for 2 weeks post-treatment, based on right-hand grip strength data from a separate study (mean 45N). However, at T3 and T6, these improvements had subsided (self-reported and confirmed by experimenter observation). The co-occurrence of improved verb production and motor function at immediate, but not long-term, follow-up testing after rTMS therapy provides some support for the functional overlap between action-related language and motor systems. Importantly, the unexpected motor recovery points to potential network effects of rTMS, which may depend on white-matter pathways connecting language and motor systems. Carefully controlled future experiments with large sample sizes have the potential to both inform hypotheses regarding grounded cognition and develop novel approaches to post-stroke rehabilitation.

Topic Areas: Language Therapy, Multisensory or Sensorimotor Integration

Inferior frontal cortex and temporo-parietal junction in sentence comprehension

Poster A19 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session A.

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Introduction: The role of the left inferior frontal cortex (LIFC; Broca's area) in sentence comprehension is controversial. Here, we tested comprehension of canonical sentences in left hemisphere stroke patients. Effects of damage to LIFC, and to left temporoparietal junction (TPJ) – another area associated with sentence comprehension – were examined using lesion-deficit mapping. To control for lexical and executive processing, we included a number of other tasks as covariates in a lesion-symptom mapping analysis. Methods: We tested 67 chronic left-hemisphere stroke patients in sentence sensibility (SS), lexical decision (LD), semantic similarity judgement (SSJ), auditory word recognition (AWR), and digit span (DS) tasks. The SS task consisted of simple declarative sentences presented auditorily, along with nonsense sentences that were grammatical yet semantically nonsensical (e.g., The dog boiled on the ceiling). Participants made a binary decision as to whether the sentence made sense or not. LD consisted of written words and pseudowords which the participant must judge as either a real word or not. SSJ consisted of a target word and two choice words, and the participant must choose which of the two words most closely matches the target word in meaning. AWR (part of the Western Aphasia Battery) consists of saying a word aloud to the participant, who must then point to the object in the room that matches the word. For DS, lists of numbers are read aloud to the participant, who must then reproduce them either forwards or backwards. Voxel-based lesion-symptom mapping was used within two regions of interest (ROI), LIFC and TPJ. Four of the tasks (LD, SSJ, AWR, DS) were directly compared to the SS task by including them as covariates to examine the relative contribution of the LIFC and TPJ in the different cognitive processes that are important for sentence comprehension (i.e., single word recognition, semantics, verbal short-term memory). Multiple comparisons were controlled for using 5000 permutations (voxelwise $p = 0.0005$, clusterwise $p = 0.05$). Results: ROI analysis in TPJ and LIFC showed that impairment in the SS task (without covariates) was associated with TPJ, but not LIFC, damage. ROI analysis of LIFC revealed that, with SSJ as a covariate, damage to LIFC predicted a decline in SSJ, but not SS, performance. ROI analysis of TPJ, with DS and LD covariates, demonstrated that TPJ damage predicted lower SS performance. Discussion: While both the SS and SSJ tasks require semantic retrieval, the SSJ also requires significant cognitive control, as participants must choose among competing distractor words. Damage to LIFC being associated with worse SSJ performance points to a role for LIFC in cognitive control, an important, yet domain-general, part of sentence comprehension. LIFC does not appear to be necessary for comprehension of simple declarative sentences. TPJ damage being associated with worse performance for SS relative to LD and DS suggests that the TPJ is involved in explicit semantic retrieval or higher-order combinatorial processes at the semantic or syntactic level.

Topic Areas: Meaning: Lexical Semantics, Meaning: Combinatorial Semantics

Away from arbitrary thresholds: using statistics to improve artifact rejection in ERP

Poster A20 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session A.

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Traditionally, artifacts are handled one of two ways in ERP studies: (1) rejection of affected segments via threshold criteria or manual inspection and (2) correction via e.g. regressing out the EOG or ICA. Threshold-based rejection is problematic because of the arbitrariness of the chosen limits and particular threshold criterion (e.g. peak-to-peak, absolute, slope, etc.), resulting in large researcher degrees of freedom (cf. Simmons et al. 2011). Moreover, most threshold-based methods are sensitive to other parts of the processing pipeline: absolute thresholds are sensitive to low-frequency drift, while peak-to-peak thresholds are sensitive to low-frequency drift and trial length. Manual rejection may suffer from low inter-rater reliability and is often done without appropriate blinding. Additionally, rejections are typically done for an entire trial, even if the ERP measure of interest (e.g. mean amplitude 300-500ms post stimulus onset) isn't impacted by the artifact in question (e.g. motion artifact at the end of the trial). Finally, fixed thresholds cannot distinguish between non-artifactual extreme values (i.e. those arising from brain activity and which have some 'signal' and some 'noise') and truly artifactual values (e.g. those arising from muscle activity or the electrical environment and which are essentially pure 'noise'). These aspects all become particularly problematic when analyzing EEG recorded under more naturalistic conditions, such as free dialogue in hyperscanning or virtual reality. By using modern, robust statistical methods, we can avoid setting arbitrary thresholds and allow the statistical model to extract the signal from the noise. To demonstrate this, we re-analyzed data from Tromp et al. 2017, which used a multimodal virtual-reality N400 paradigm. We created two versions of the dataset, one using traditional threshold-based rejection (±75µV), and one without artifact rejection, and examined the mean voltage at 300-500ms post stimulus onset. We then analyzed the data with two different Bayesian mixed-effects models: (1) with a Gaussian likelihood, analogous to traditional statistical analysis and (2) with a Student-t likelihood, analogous to a robust statistical model. The robust model yielded similar effect size estimates for the clean and dirty data, but slightly different estimates of the residual variation and, unsurprisingly, different estimates of the number of outliers (as expressed in the nu parameter, the degrees of freedom from the Student-t likelihood). The non-robust model meanwhile showed different estimates of the effect and of the residual variation between the clean and dirty data. In other words, the robust model worked equally well with or without artifact rejection and did not require any arbitrary thresholds. The standard, non-robust model was sensitive to the degree of data cleaning. This suggests that robust methods should become the standard (cf. Wilcox 2010, 2012) in ERP analysis, regardless of data cleaning procedure.

Topic Areas: Methods, Computational Approaches

Structural asymmetry of the Arcuate Fasciculus is not associated with functional lateralization for language, nor with handedness

Poster A21 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session A.

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Structural asymmetries in language-related white matter tracts have been proposed to be one of the factors underlying functional language lateralization. Among the major association tracts within the language system, the Arcuate Fasciculus (AF) was found to be extremely lateralized to the left hemisphere (Catani et al., 2005, 2007; Matsumoto et al., 2008) and was extensively examined for a relationship with handedness and functional language lateralization (Allendorfer et al., 2016; Vernooij et al., 2007, Ocklenburg et al., 2014). However, it was suggested that asymmetry of the in vivo AF is not always reliably detected and depends on the chosen tractography pipeline (Bain et al., 2019). The goal of the present study was to reconstruct white matter tracts in healthy participants with different degree of handedness using a novel hybrid tractography algorithm that combines the strengths of both probabilistic and deterministic tractography (Cabeen & Toga, 2020) and to test whether there is a correlation between macrostructural and microstructural metrics of the AF, on the one hand, and functional language lateralization measures and handedness, on the other hand. Fifty healthy Russian participants (20 right-handed, 20 left-handed and 10 ambidexters; 18 males; mean age= 24.38 years) underwent 3T functional magnetic resonance imaging (fMRI) to assess language lateralization and diffusion tensor imaging (DTI). The DTI images were preprocessed in the FSL library and the tracts reconstruction was performed in the Quantitative Imaging Toolkit (Cabeen et al., 2018); mean volume values were extracted for the left and the right AF. Language-related functional activations were registered using a sentence completion task.

Laterality indices (LIs) for functional maps were calculated with LI-Toolbox in SPM; for the AF - using a formula (left - right) / (left + right). Handedness quotient for each participant was calculated using the Edinburgh Handedness Inventory (Oldfield, 1971) and ranged from -100 to +100. The significant correlation between functional LIs (fMRI) and handedness scores were found (r = 0.391, p =0.005). However, there was no significant correlation between anatomical LIs of the AF (DTI) and functional LIs (fMRI) (r = 0.113, p = 0.434), nor between anatomical LIs of the AF (DTI) and handedness scores (r = 0.137, p = 0.341). Instead, the majority of participants (94% - 47 out of 50) regardless of their handedness and functional lateralization for language revealed left dominance of the AF. Thus, the present study demonstrated an overall significant leftward asymmetry of the arcuate fasciculus regardless of degree of handedness or functional language lateralization using a novel hybrid tractography algorithm for tracts reconstruction. We failed to find any correlations between anatomical lateralization and other two metrics: functional lateralization and degree of handedness. We provide evidence that structural asymmetry of the AF does not correlate with “language lateralization” registered with fMRI. However, it is strikingly in line with the robust knowledge about left-hemisphere language dominance in 96% of population, based on the Wada-test (Rasmussen & Milner, 1977). These findings have important implications for the clinical evaluation of language function and suggest serious reconsidering of fMRI-based language lateralization assessment.

Topic Areas: Methods, History of the Neurobiology of Language

No impact of the structural properties of the corpus callosum on handedness: evidence from the constrained spherical deconvolution approach

Poster A22 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session A.

Victor Karpychev[1], Tatyana Bolgina[1], Svetlana Malytina[1], Olga Dragoy[1,2]; [1]National Research University Higher School of Economics, [2]Federal Center for Cerebrovascular Pathology and Stroke

Language lateralization is a classic example of functional asymmetry of the human brain (Berretz et al, 2020). Left-hemispheric language lateralization is more represented in right-handed (about 95%) compared to left-handed participants (about 75%) (Sommers et al., 2015; Knecht et al., 2000b). Both the direction and the degree of handedness are often used as a proxy for language lateralization (Schmitz et al., 2017; Ooki, 2014). Handedness, in turn, was shown to be affected by the structural properties of the corpus callosum (CC), which plays a crucial role in interhemispheric communication (Danielsen et al., 2020). However, previous studies used postmortem examinations, the delineation of the CC midsagittal surface, and diffusion tensor imaging (DTI) to examine the impact of the structural properties of the CC on handedness (Cowell & Gurd, 2018; Luders et al., 2010). All these methods have limitations regarding the estimation of the structural properties of the CC. In this work, we implemented the more advanced Constrained Spherical Deconvolution (CSD) approach (Farquharson et al., 2013; Dell'Acqua, 2010), to study the association between the volume of the CC, measured with the CSD, and the handedness. Forty neurological healthy individuals participated in the study (15 males, 25 females, mean age = 24.7, SD = 5.1, range = 18 – 37 years). Handedness quotient (HQ) of each participant was estimated using the Edinburg inventory (Oldfield, 1971). Twenty participants with scores from +45 to +100 were classified as right-handed, 20 participants with scores from -100 to -45 were classified as left-handed. Diffusion-weighted images (DWIs) were acquired using single-shot spin echo EPI sequence with TR=13700 ms; TE=101ms; b-value=1500 s/mm2. For the CSD-based reconstruction, the damped Richardson-Lucy algorithm was applied with the fiber response of 1.5*10^(-3) mm2/s^(−1) and 400 iterations in StarTrack software (https://www.mr-startrack.com). The CC was reconstructed in the TrackVis software (http://trackvis.org). A one-way ANOVA was used to examine the differences between the CC volumes of the right-handed and the left-handed participants. We built two general linear models to evaluate the relation between the absolute/non-absolute HQ values and the CC volume. The mean CC volume for the right-handed participants was 287.27 cm3 (SD = 51.79 sm3), while for the left-handed participants it was 272.8 cm3 (SD = 45.18 cm3). There was no significant difference found in the CC volume between the right-handed and the left-handed people (F(1,38)=.37, p=.54). Additionally, the CC volume was associated with neither non-absolute HQ values (β= 347.4, SE= 448.81, t(38)= .77, p=. 44) nor with the absolute values (β=64.06, SE= 98.46, t(38)= . 65, p=. 51). Our results yielded a non-significant difference in the CC volume between the groups of the right-handed and left-handed participants. Also, no association between the CC volume and the absolute/non-absolute values of HQ was found, which suggests the absence of the direct impact of the structural properties of the CC on both the direction and the degree of handedness. Nevertheless, additional neuroimaging studies directly measuring lateralization indexes are needed to draw a conclusion about the impact of the structural properties of the CC on language lateralization.

Topic Areas: Methods, Multisensory or Sensorimotor Integration

The practicalities of implementing a longitudinal study of recovery from aphasia

Poster A23 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session A.

Jillian L. Entrup[1], Sarah M. Schneck[1], Caitlin Onuscheck[1], Deborah F. Levy[1], L. Taylor Davis[1], Wayneho Kam[1], Maysaa Rahman[1], Emma Willey[1], Annie Burchfield[1], Michael de Riesthal[1], Howard S. Kirshner[1], Stephen M. Wilson[1]; [1]Vanderbilt University Medical Center

In this "sandbox series" presentation, we describe some of the challenges we have faced in implementing a research project investigating the natural history of recovery from aphasia after stroke, and the solutions we have found. We welcome input from groups with related research interests, and we hope that our experiences will be informative for other researchers. The overall goals of our project are to better characterize the nature and neural correlates of recovery from aphasia after stroke. We recruit and evaluate all left hemisphere stroke patients at the bedside 2-5 days post-stroke, then attempt to collect follow-up behavioral and neuroimaging data at 1 month, 3 months and 12 months post-stroke. First, recruitment is always a challenge for clinical research. We have succeeded in identifying potentially eligible patients by daily reviewing the electronic medical records of all patients on the stroke service, by having one team member attend a "stroke huddle" each day, and by having two team members with effort shared between research and the acute care clinical team. Second, the consent process is critical. We have learned how to approach consent with sensitivity at an overwhelming moment in the lives of patients and families. Surrogate consent is frequently necessary, because many patients who will go on to have persistent aphasia cannot consent in the acute period. Third, to ensure MRI safety, we have developed a comprehensive process for obtaining and assessing all relevant medical records of each individual who will be scanned. Fourth, we found that only about half of patients willing to participate in follow up sessions are willing and able to be scanned, so we started visiting these patients' homes throughout our region to acquire follow-up language assessments. This has greatly increased our sample size and the representativeness of our cohort. Fifth, to minimize the burden of testing on patients, we use validated behavioral and imaging protocols that are optimized for efficiency; in particular, we developed the Quick Aphasia Battery [1] and adaptive language mapping paradigms [2]. Sixth, to ensure data integrity, an interdisciplinary team is essential. Licensed speech-language pathologists carry out all patient interactions, a neurologist characterizes each stroke from a medical perspective, and a neuroradiologist oversees interpretation of imaging findings. All interactions are videotaped, high quality audio recordings are made, and we have developed a project-specific relational database to securely store study data. Patients are provided with three options as to the extent of data sharing they are comfortable with; fortunately, most patients have consented to freely share their data with other researchers through the AphasiaBank database, which will maximize the value of our dataset. Finally, our project has of course been dramatically affected by the coronavirus pandemic. We rapidly reconfigured our behavioral evaluation for administration over Zoom, and although we have been unable to collect imaging data since March, we have been able to continue to collect data on trajectories of recovery from aphasia. References: [1] Wilson et al. PLoS One 2018; 13: e0192773. [2] Wilson et al. Hum Brain Mapp 2018; 39: 3285-307.

Topic Areas: Disorders: Acquired, Methods

Rhythm discrimination in adults who stutter

Poster A24 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session A.

Emily Garnett[1], Jeremy Taigman[1], Devin McAuley[2], Soo-Eun Chang[1]; [1]University of Michigan, [2]Michigan State University

Stuttering is a neurodevelopmental disorder characterized by involuntary disruptions in the rhythmic flow of speech. There is accumulating support for the role of the basal ganglia thalamocortical (BGTC) network in stuttering, in particular in connections between the basal ganglia, supplementary motor area (SMA), and ventral premotor cortex (vPMC). Regions within the BGTC are critical in planning complex movement routines, including speech, that are internally timed and initiated, rather than in response to external cues. People who stutter show difficulty with tasks that require precisely timed movements in speech and non-speech tasks involving rhythm and timing, results that are corroborated by attenuated functional connectivity among these BGTC regions. Previous research has shown that children who stutter show worse rhythm discrimination ability than fluent peers, particularly for complex rhythms (Wieland et al., 2013). This difference is less understood between adults who stutter (AWS) and fluent peers. We investigated performance on an auditory rhythm discrimination task in AWS compared to controls, and the effects of musical training experience and working memory on performance. We expected AWS to perform worse than controls, particularly for complex rhythms than simple rhythms, and that musical experience and working memory scores would modulate group differences. Participants were 44 AWS (8 F) and 43 controls (23 F) who were native speakers of English with no reported speech, language, hearing, or cognitive disorders, except for stuttering in the stuttering group. Participants provided years of formal music training and completed a working memory task (operation span). In the rhythm discrimination task, participants heard three rhythms: the first two (standard) were always the same and participants decided whether the third rhythm (comparison) was the same or different than the first. Participants completed two blocks of 30 trials consisting of randomized simple and complex rhythms. In simple rhythms, perceptual accents occurred at regular intervals throughout rhythm. In complex rhythms, perceptual accents occurred at irregular intervals, with uneven spacing. Each simple rhythm had a matching complex rhythm, consisting of the same intervals between beats, rearranged in a different order. Rhythm discrimination performance was measured using d', a measure of signal detection, calculated as (hit rate)-(false alarm rate), with $d'=0$ indicating chance performance. Simple rhythms ($M=2.37$, $SD=1.06$) were better discriminated than complex rhythms ($M=1.59$, $SD=.97$) across groups ($t(86) = 9.356$, $p<.001$). The control group and stuttering group exhibited similar discrimination for simple rhythms ($p=.262$). For complex rhythms, there was a tendency for poorer discrimination by the stuttering group ($p=.097$). Regression analyses showed that as years of musical training increased, so did discrimination of simple rhythms in both groups ($p=.001$). For complex rhythms, discrimination performance increased with years of musical training ($p=.004$) and working memory scores ($p<.001$) in both groups. Steeper slopes suggest these effects were stronger in the stuttering group, but there was no significant interaction. These preliminary results suggest further investigation of specific aspects working memory and musical training, as well as examination of individual differences, is warranted to ascertain potential differences in rhythm perception between stuttering and control groups.

Topic Areas: Disorders: Developmental, Perception: Auditory

An Examination of the Neural Bases of Conceptual Combination in Stroke Aphasia

Poster A25 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session A.

Presenter Note: Any questions or comments on this work are appreciated, and can be directed to abbyclem@sas.upenn.edu. We specifically invite viewers to give us suggestions of other measures we might use to assess comprehension or interpretation of these nominal compounds.

Abby R. Clements[1], Bethany Blass[2], Casey Ferrara[3], Krysta Duquette[2], Sharon L. Thompson-Schill[1], Erica L. Middleton[2]; [1]University of Pennsylvania, [2]Moss Rehabilitation Research Institute, [3]University of Chicago

The interpretation of novel noun-noun phrases (nominal compounds) in English is generally achieved by one of two putatively distinct combinatorial processes: (1) attributional—concepts are broken down into features and recombined such that an attribute is mapped from the modifier to the head noun (e.g., zebra tablecloth, a black-and-white striped tablecloth); or (2) relational—a relation between the concepts is identified (e.g., bacon tongs, tongs used to cook bacon). Compounds can be biased, where one combinatorial process dominates in its interpretation, or ambiguous, where the two processes lead to two different potential interpretations (e.g., ant apple, a small apple or an apple covered in ants). Both anterior temporal lobe (ATL) and angular gyrus (AG) have been proposed as a candidate hub for conceptual combination due to their connectivity and activity during comprehension tasks (Baron et al., 2010; Graves et al., 2010), but these studies did not acknowledge the well-established mechanistic distinction between attributional and relational processes. A recent neuroimaging study examining comprehension of novel nominal compounds in neurotypical participants points to ATL and AG as distinct hubs for attributional and relational processes, respectively (Boylan et al., 2017). The aim of the present work is to replicate and extend such findings in a controlled case-comparison design in aphasia, with a focus on the relationship between lesion profile (ATL vs. AG) and conceptual combination ability. To date, two dyads of participants with aphasia (PWA) and fifteen neurotypical age-matched controls have completed the study. Each dyad of PWA was matched on aphasia severity and type but contrasted in lesion profile—ATL lesioned and AG intact, or vice versa. Recruitment for the current study was paused due to the COVID-19 pandemic, and the results reported here are preliminary. The experiment involved the presentation of a large number of biased and ambiguous nominal compounds. At the start of each trial, the nominal compound was presented auditorily and in writing and the participant was asked to generate and describe their interpretation. Next, a cartoon image was presented, and the participant rated the image on a 5-point Likert scale based on how closely it matched their original interpretation. Each image was either (1) a target image, which reflected a combined interpretation of the compound (biased compounds had one possible target image, while ambiguous compounds had two), or (2) a foil image, which showed either the two concepts in separate pictures (non-interacting) or the modifier noun alone. Foils provided an index of the participant's ability to recognize the participating concepts absent any combinatorial processes. PWA responses prior to presentation of the image were coded by two trained coders to identify the generated interpretation on each trial, and image ratings were collected for each trial. Preliminary analyses show no difference within each of the PWA dyads for generating attributive versus relational interpretations or for how highly the images were rated. Additionally, all patients were able to generate both types of interpretations, despite extensive damage to targeted neural regions. Implications for neuroanatomic models of conceptual combination and future directions will be discussed.

Topic Areas: Meaning: Combinatorial Semantics, Meaning: Lexical Semantics

Evidence of inter-related and uniquely communicative skill sets using fMRI

Poster A26 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session A.

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Dialog is at the foundation of human communication. It requires an extensive set of pragmatic skills such as inference, audience design and turn-taking, seemingly beyond the 'core language' (e.g. semantic and syntactic) skills. It remains an open question whether the neural basis of pragmatic skills relates to (1) those of the core language, non-verbal ToM and (2) one another, for instance across production and comprehension. While the evidence from one recent behavioral study supports separating 'social understanding' skills from core language, to our knowledge, none has studied these questions using a neuroscience perspective on individual differences. We employed an individual differences approach with an fMRI study (N=60) preceded by a behavioral study (N=201), where we measured non-verbal ToM, core language skills and two pragmatics skills, in addition to a pragmatic task in the scanner. The behavioral study comprised two novel pragmatic tests, advanced Audience Design (AD) and Prosodic Comprehension of Requests for Response (PC-RR), as well as tests of core language (Author Recognition (AR) (N=201), vocabulary test (vSweSAT), and a Lexical Decision Task (LDT) (N=60)) and non-verbal ToM (Reading the Mind in the Eyes Test (RMET)). Based on the results of AD and PC-RR, 30 low-score + 30 high-score, participants were selected for the fMRI study. In the scanner, participants listened to prerecorded dialogs where speaker meaning was communicated directly or indirectly , based on an established indirect speech act fMRI-experiment, for example 'Why don't your girlfriend like Japanese food?' (direct condition) or 'Did you girlfriend like my vegan noodles?' (indirect condition) followed by 'She is not so used to Asian seasoning' (both conditions). To understand speaker meaning in the indirect condition, speakers had to make pragmatic inferences. We performed whole brain analyses of the fMRI data based on the contrast of indirect vs direct condition. While we mainly tested differences of the high-score vs low-score groups in this contrast (i.e. an interaction analysis), we also tested the correlation of brain activation with the behavioral test performances. The interaction analysis revealed significantly higher activations ($pFWE < 0.001$) for the high-score compared to the low-score group, in the left superior parietal lobe/left supramarginal gyrus and bilateral precuneus, both separated from the core left-lateralized language network. Activity in these areas correlated significantly ($p <= 0.001$) with the two pragmatics tests (including the production test), but not with any of the core language or RMET tests. The PC-RR and AD correlated significantly. These results support (1) that the functional anatomical processes underlying pragmatic inference are segregated from core language processes. As the behavioral results showed no correlation between pragmatic tasks and RMET (2) there is also a neurocognitive separation between pragmatic processes and non-verbal ToM . Finally, (3) there exist interrelations between the three different pragmatic skills we measured, importantly across the divide of comprehension and production. Our conclusion is that pragmatics should not be reduced to an extension of core language processes, ToM processes, or their combination.

Topic Areas: Meaning: Discourse and Pragmatics, Language Production

Naturalistic expository discourse processing in school-aged children and adults

Poster A27 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session A.

Maxime Tulling[1], Suhail Matar[1], Ellie Abrams[1], Ria Mai Geguera[1], Miriam Hauptman[1,2], Alicia Parrish[1], Sarah F. Phillips[1], Liina Pylkkänen[1,2]; [1]New York University, [2]NYUAD Research Institute

INTRODUCTION: Being able to understand discourse and grasp its larger meaning is crucial for the academic success of children. Yet, few studies have investigated the neural architecture involved in the discourse processing of typically developing children (e.g., Dapretto et al., 2005). Also, most naturalistic discourse studies have used event and character-oriented narratives, whose structure and content differ from the specific topic-oriented expository discourse one usually encounters in the classroom. While past studies using narrative discourse found that the right hemisphere plays a dominant role in establishing coherence across sentences, and contextualizing discourse within world knowledge (Dapretto et al., 2005; Xu et al., 2005), the few studies using expository discourse comprehension have reported no such effects (Jacoby & Fedorenko, 2018; Miller et al., 2013). But these studies typically use rudimentary discourse complexity predictors and employ fMRI with its limited temporal resolution. GOALS AND PREDICTIONS: In this study, we combine high temporal resolution magnetoencephalography (MEG) measurements and a comprehensive model of discourse complexity to test whether neural correlates of discourse processing, and specifically establishing coherence, are lateralized across expository discourse in children and adults. Moreover, we investigate whether potential lateralization and sensitivity to discourse complexity interact with age. Previous studies investigating the lateralization of language processing over time found that lateralization increases growing up (Enge et al., 2020; Szaflarski et al., 2006), so we expect an interaction between lateralization of discourse processing and children's age. Additionally, since the ability to form a coherent discourse representation from individual sentences depends on the ability to integrate linguistic information with world knowledge, we expect an interaction between discourse predictors and age in children, such that older children's MEG responses would show more sensitivity to discourse predictors. METHODS: Data collection was temporarily halted due to COVID-19 restrictions. A partial sample of 11 adults (M=31.2, SD=11.8, range=19-53) and 7 children (M=8.6, SD=1.35, range=7-10) listened to 4 three-minute audio segments (YouTube: SciShow Kids) teaching about the human body. For each segment, we built a clause-based hierarchical model of the information conveyed. The tree-like model has the main topic as its root (e.g., goosebumps), with new information about the topic (e.g., its causes (cold weather, fear), or its mechanism) assigned hierarchically to deeper levels. Our predictors of interest are: Discourse Depth (hierarchical level of information in each clause), Discourse Displacement (number of moves within model between two consecutive clauses), and Discourse Length (number of clauses heard so far). We also annotated each clause for marginal predictors, including phonetic, lexical, and syntactic properties. PLANNED DATA ANALYSIS: First, we will regress the MEG sensor data against a statistical model containing the different marginal predictors, in addition to Discourse Length. Within the sensors corresponding to each hemisphere, we will test whether Discourse Displacement and Discourse Depth significantly improve the model's account of the data, and the latency at which this happens relative to clause offset. Second, using a multivariate approach, we will test at which time points, relative to clause offset, we can decode information about our predictors from the data.

Topic Areas: Meaning: Discourse and Pragmatics, Development

Language processing in healthy aging: Replicability and implications for patient studies

Poster A28 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session A.

Presenter Note: Contact pietari.nurmi@aalto.fi for more information.

Pietari Nurmi[1], Anni Forsman[1], Hanna Renvall[1,2], Mia Liljeström[1]; [1]Aalto University, [2]Helsinki University Hospital

Neurophysiological recordings of language and semantic processing provide a direct measure of neural activity, unaffected by changes in the neurovascular coupling that occur with age. They could thus provide a valuable tool for clinical assessments in neurological patients suffering from, e.g., post-stroke aphasia or age-related memory disorders. The majority of the neuroimaging studies so far have focused on group-level phenomena. However, for patients, it is crucial to find experimental tasks robust enough to provide reliable results even at the individual level. Here, we will investigate changes in language and semantic processing using magnetoencephalography (MEG) in healthy volunteers in different age groups. In particular, we will assess how aging affects neuromagnetic evoked responses in basic language processing tasks and how reproducible the effects are between different measurement days. We will measure 25 young (age 22–32) and 25 elderly (age 65–75) Finnish-speaking adults. Each participant will be measured twice on different days with MEG. Structural MRI images will be used for source localization. The measurements have been delayed due to the COVID-19 pandemic, and so far (in July), five participants have been measured. We expect to complete recordings of min. 30 participants by the end of 2020 if the pandemic is kept at bay. We chose three simple tasks addressing different language processing domains, i.e., reading, naming, and listening, feasible for future patient measurements. In a semantic priming task, a written prime word is followed by a semantically related (congruent) or unrelated (incongruent) target word. Previous EEG studies have shown that the N400 effect related to semantically incongruent stimuli is weaker and slower for older subjects (Kutas & Iragui, 1998, Electroencephalography and Clinical Neurophysiology 108, 456–471), and likely affected in patients with Alzheimer's disease (Iragui et al., 1996, Electroencephalography and Clinical Neurophysiology 100, 392–406). Here, we developed an automated approach for assessing the semantic similarity between primes and targets using distributional semantics (word2vec algorithm) and Finnish Wikipedia as the training data (Luotolahti et al. 2015, Proceedings of Depling'15). This approach is cost-efficient and easy to apply to different languages. In the naming task, participants watch photographs of everyday living and nonliving things (Brodeur et al., 2014, PLoS ONE 9, e106953) and either name the object in the picture out loud or look at the image without naming. The listening task consists of attending to spoken words and environmental sounds presented alone or masked by noise. We will assess test-retest reliability for each task using intra-class correlation (ICC), separately for each age group. We will also evaluate the differences in MEG and behavioral results between age groups, as well as individual-level task effects. We expect to find good replicability between different days, and significant aging-related effects in both the MEG responses and behavioral results (e.g., reaction time). The present results in healthy elderly subjects will be crucial for providing baseline information for future clinical studies.

Topic Areas: Meaning: Lexical Semantics, Methods

Linguistic and conceptual processing are dissociated during sentence comprehension

Poster A29 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session A.

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The human mind stores a vast array of linguistic knowledge, including word meanings, word frequencies and co-occurrence patterns, and syntactic constructions. These different kinds of knowledge have to be efficiently accessed during incremental language comprehension. How dissociable are the memory stores and online processing of these different types of knowledge? And do different representations rely on language-specific capacities, domain-general ones, or both? To address these questions, we used representational similarity analysis (RSA; Kriegeskorte et al., 2008) to relate linguistic knowledge and processing and neural data. We used fMRI data from Pereira et al.'s (2018) experiment 3 (n=6, three 2-hour scanning sessions each). Stimuli consisted of 243 sentences spanning a broad range of content areas. Multi-voxel activation patterns were extracted from regions of interest in three large-scale brain networks spanning the association cortex: a) the language-specific network, and two domain-general networks: b) the multiple demand (MD) network that supports goal-directed behaviors, and c) the default mode network (DMN) that supports internally-directed cognition. Participant-specific representational similarity matrices (RSM) for the 243 sentences were constructed for each network. In addition, the sentences were represented in three feature spaces: (i) word-embedding, GloVe (Pennington et al., 2014), approximating lexical semantics); ii) lexical, using features that affect the difficulty of retrieving words from memory (e.g., frequency, age of acquisition); and (iii) syntactic, using features that affect the difficulty of sentence comprehension (e.g., dependency locality, syntactic surprisal). RSMs based on pairwise sentence similarity were used to predict neural RSMs using generalized additive models; the predictive contribution of each feature space was evaluated on held-out sentences (50%) using ablative bootstrap testing of the mean squared prediction error. Based on preliminary analyses, we found that similarity based on word-embeddings significantly explains neural similarity in all three networks (expected given the distributed decoding results reported in Pereira et al., 2018). However, lexical and syntactic similarity only show significant effects in the language-specific network ($p<0.0001$, ablative permutation testing) and not in the MD network or DMN. Under the assumption that the word-embedding space encodes abstract conceptual information in addition to lexical semantics, these results support a distinction between conceptual processing and linguistic-form-based (lexical/syntactic) processing during comprehension. This work provides further evidence that the language network differs functionally from other large-scale cortical networks, and that those networks are not sensitive to linguistic processes (e.g., Blank & Fedorenko, 2017; Shain et al., 2020; Diachek et al., 2020). Thus, to the extent that the MD network or the DMN are active during linguistic tasks, this engagement likely reflects task demands or general conceptual processing evoked by linguistic representations. The current analyses were performed on a single, partitioned dataset, and demonstrate that reliable and independent signal can be obtained from the word-embedding, lexical, and syntactic feature spaces in the language network. In ongoing work, we are pre-registering our analyses and validating our models on a new, unseen dataset. Moreover, we aim to investigate the contributions of individual lexical and syntactic features in richer detail, as well as potential differences among the different language regions.

Topic Areas: Meaning: Lexical Semantics, Computational Approaches

Effect of Bilingual Exposure on Linguistic and Cognitive Recovery Following Pediatric Stroke

Poster A30 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session A.

Presenter Note: Thank you for dropping by! Feel free to reach out at by email at: kaiian.leung@mail.utoronto.ca or via twitter: @kellykileung Future results will be available at: https://osf.io/f2rpv/?view_only=206543625caf4ad097ca5c06ddaa99ca

Kai Ian Leung[1], Noma Dlamini[2], Robyn Westmacott[2], Monika Molnar[1]; [1]University of Toronto, Toronto, Canada, [2]The Hospital for Sick Children, Toronto, Canada

Pediatric stroke, caused by an interruption of normal flow of blood to the brain, either by a blockage or a rupture in the blood vessels, occurs during a sensitive period in development and often affects higher-level cognitive and linguistic processes. Half of children receive one or more learning or psychological diagnoses post-stroke (Williams et al., 2017). A great number of children who suffer stroke come from bilingual or multilingual backgrounds. In typically developing bilingual children, theories of linguistic and cognitive advantages have been confirmed in behavioural studies. Protective effects of bilingualism have also been demonstrated in bilingual Alzheimer's Disease patients (Craik et al., 2010). Atypically developing bilingual children may also be able to benefit similarly from bilingualism's protective effects and its apparent contribution to cognitive reserve. Our research evaluates the effects of bilingual language exposure on the cognitive and linguistic recovery of pediatric stroke patients. Specifically, we assess whether a bilingual vs. monolingual learning environment would affect cognitive and/or linguistic recovery in children post-stroke. In order to do so, we will use 440 records of children with arterial ischemic stroke currently available in the Canadian Pediatric Ischemic Stroke Registry (CPISR). Usually caused by a blockage of blood flow by narrowed arteries or blood clots, arterial ischemic stroke accounts for half of all childhood strokes and the majority of perinatal strokes (Heart and Stroke, 2014). The CPISR database and medical charts will be used to gather variable and performance data, with neuropsychological measures evaluated at 6 months and 1-year post-stroke. Perinatal and childhood arterial ischemic stroke patients aged 0-17 years will be sampled. Children with presumed/recurrent/fetal stroke, preterm birth, prenatal exposure to drugs/alcohol, history of epilepsy, pre-morbid psychological or learning disorder and/or developmental/congenital diseases are excluded to avoid confounding variables. In addition to language background, we'll extract data from this registry on the patient (e.g., age, sex, socio-economic status), linguistic (e.g., language exposure), and neural (e.g., stroke characteristics) variables that affect children's cognition and linguistic processing after stroke and their potential interactions, evaluated using regression analyses. Gaining a better understanding of the cognitive and linguistic recovery post-stroke in bilinguals is relevant, as it is estimated that about half of children around the globe are learning more than one language from early childhood. These findings will be relevant to both clinical and theoretical research, given the scarcity of information concerning atypical bilingual development.

Topic Areas: Multilingualism, Disorders: Acquired

Neuroplasticity during adult second language learning: Brain changes in early stages reflect naturalistic language production

Poster A31 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session A.

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Adult second language (L2) learning requires the reorganization of the mature brain. Previous studies on bilingualism and L2 learning showed the involvement of regions beyond the language network (Friederici, 2012), recruiting brain structures associated with sensori-motor control and domain-general executive function (Li &

Grant, 2016; Abutalebi & Green, 2016). However, L2 learning in an immersive setting and measures of L2 proficiency derived from actual language use have been crucially under-investigated (DeLuca et al., 2019). To address these issues, a large-scale, longitudinal multimodal study was conducted during a controlled, intensive German L2 teaching program within an immersive learning environment. The current diffusion MRI study aimed at identifying early, learning-dependent white matter changes specifically associated with measures of naturalistic L2 use. Fifty-one Arabic native speakers (mean age 24.5 ± 4.4 years, 45 males) with no previous knowledge of German were included in the present study. Structural scans were collected before and after 3 months of learning. Additionally, standardized tests assessing language proficiency and more ecologically relevant measures extracted from written production were collected after 3 months of learning. These quantitative measures of linguistic complexity were divided into syntactic and lexical components. Mean clause length and lemma count were respectively taken for syntactic complexity and lexical diversity. To assess brain changes, high resolution diffusion-weighted MRI scans were acquired, and fractional anisotropy (FA) was computed as a measure of brain microstructural organization. After 3 months of learning, proficiency from standardized tests did not correlate with any brain changes in FA. Yet, the combined effect of learners' syntactic complexity and lexical diversity was positively correlated to FA changes in the deep white matter of the right middle temporal gyrus (MTG). In separate analyses, lexical diversity alone did not reach significant correlations with any brain regions, however, syntactic complexity showed positive correlations to changes in left inferior/middle frontal gyrus (IFG/MFG), left arcuate fasciculus, bilateral ventro-medial prefrontal (vmPFC) and orbitofrontal cortices (OFC), anterior corpus callosum, left sensorimotor area, and bilateral pre-supplementary motor area (pre-SMA). These results suggest that during the early stages of adult L2 acquisition, successful learning requires collective structural changes across the primary language network, sensorimotor integration areas, as well as the reward circuit. Moreover, we demonstrate that objective measures of natural L2 use can provide meaningful insights into early brain changes associated with L2 learning. References: Abutalebi, J., & Green, D. W. (2016). Neuroimaging of language control in bilinguals: neural adaptation and reserve. Bilingualism: Language and Cognition, 19(4), 689–698. DeLuca, V., Rothman, J., Bialystok, E., & Pliatsikas, C. (2019). Redefining bilingualism as a spectrum of experiences that differentially affects brain structure and function. Proceedings of the National Academy of Sciences of the United States of America, 116(15), 7565–7574. Friederici, A. D. (2012). The cortical language circuit: from auditory perception to sentence comprehension. Trends in Cognitive Sciences, 16(5), 262–268. Li, P., Legault, J., & Litcofsky, K. A. (2014). Neuroplasticity as a function of second language learning: Anatomical changes in the human brain. Cortex, 58, 301–324.

Topic Areas: Multilingualism, Language Production

Examining Measures of Individual Variability in ERP Responses and Expanding the Evidence to the L2

Poster A32 [Poster PDF] [Poster Tour] Visit me at [Gather.Town] in the Wernicke room during Poster Session A.

Presenter Note: If you have any questions or you want to discuss any of these topics further, please reach out via email at ifines2@uic.edu If you want to know more about this research and other related projects, you can visit my personal website: https://sites.google.com/view/irenefinestrat/about and the Cognition of Second Language Acquisition Lab website: http://lcsl.las.uic.edu/hispanic-italian/research-groups/cognition-of-second-language-acquisition-laboratory

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The study of individual differences (IDs) in language processing using event-related potentials (ERPs) has become more prominent in recent years. However, we have not yet reached a full understanding of variability in ERP correlates of first (L1) or second (L2) language processing; and methodologically, how we capture those IDs is still a matter of debate. Research conducted by Tanner and colleges (2014, 2019) examining grammatical processing suggests that individuals display either an N400- or a P600-dominant profile, given negative associations between the two effects within individuals. However, Fromont, Royle, and Steinhauer (2020) questioned the validity of these results, arguing that averaging N400 and P600 effects over the same region of interest (ROI) in adjacent time windows may lead to component overlap. Thus, our first goal is to examine whether capturing IDs in ERP response dominance varies based on different measurement approaches. Furthermore, for L1, Tanner (2019) found a strong consistency in brain response dominance across two subject-verb agreement conditions, concluding that response dominance is a trait-like effect that reflects stable IDs. Our second goal is to examine this consistency in L1 brain response dominance across different syntactic and morphosyntactic agreement conditions, and also in the L2. Forty English native speakers, low-intermediate-level learners of Spanish, completed a grammaticality judgment task in English and Spanish as EEG was recorded in two sessions. Target structures assessed processing of phrase structure (PS, n=30), subject-verb agreement (SV, n =30), and noun-phrase number agreement (NP, n =30). Regarding our first goal, participants' L1 and L2 N400 and P600 effect magnitudes were calculated using two approaches. First, replicating Tanner's approach, N400 and P600 effects were calculated over a centro-parietal ROI (C3-Cz-C4-CP1-CP2-P3-Pz-P4) with 300-500 and 500-800ms time windows, respectively for L1 (Tanner, 2019) and with 400-500 and 500-1000ms time windows for L2 (Tanner, Inoue, & Osterhout, 2014). Secondly, we replicated Fromont, et al.'s (2020) approach and calculated N400 magnitudes using a C3-Cz-C4 ROI and a 250-500ms time window, and a P3-Pz-P4 ROI and an 800-1200ms time window for P600 effects. For both L1 and L2, results revealed significant negative correlations between N400 and P600 effect magnitudes for all (PS, SV, NP) conditions, under both analysis approaches (based on Tanner's approach: rs>-.62, ps<.001; based on Fromont et al.'s approach: rs>-.33, ps<.05). Regarding our second goal, we calculated participants' response dominance index (RDIs, Tanner, 2019) separately for the L1 and L2. For both languages, results revealed significant positive correlations between the two morphosyntactic agreement conditions under both analysis approaches (based on Tanner's approach: rs>.41, ps<.01; based on Fromont et al.'s approach: rs >.32, ps<.05). However, the only signification correlation with PS was between the L1 PS and NP conditions using Tanner's approach (r=.48, p<.01). In conclusion, we found a consistent negative association between N400 and P600 responses in both the L1 and L2, although component overlap might have inflated the correlation coefficients using Tanner's approach. Second, our findings suggest that brain response dominance reveals stable IDs that generalize across different morphosyntactic agreement conditions in both the L1 and L2.

Topic Areas: Multilingualism, Methods

Repetition suppression and its release to phonological sequences within natural speech in native-speakers of English and Polish

Poster A33 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session A.

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Repetition of phonological sequences within natural speech, such as in the spoken message, "Stella-Stella", shows suppressed neural responses at early stages of cortical processing. A different phonological sequence (e.g., an added vowel) as within the phrase ".... not stella, setella" shows release from neural suppression that may reflect both release from stimulus-specific adaptation and prediction error. Elucidating cortical sensory processing in response to repeated and different phonological sequences within natural speech should contribute to the study of novel word-form learning in typical language-learners. The present auditory-evoked potential (AEP) study assessed the modulatory effects of native-language experience and attention on cortical sensory processing to repeated and different phonological sequences in native speakers of English and Polish. We compared AEP sensory responses and Global Field Power (GFP) to the first and second words within same and different nonword pairs, which were separated by 250 ms. Nonwords contained the phonological sequence onsets /st/, /sət/, /pt/ and /pət/ that occur in both the English and Polish languages, with the exception of /pt/, which never occurs in English without a preceding vowel. Phoneme sequences that followed the onsets varied (e.g., "ila"/ɪlə/, "eema"/imə/) and word types were matched for rhyme (/stimə/, /sətimə/, /ptimə/, /pətimə/).

High-density EEGs were recorded from 24 English and 24 Polish participants during two counterbalanced testing conditions. During one testing session, participants listened to word pairs and performed a behavioral task to the second word in the word pairs (Attend Condition) and, in the alternate session, participants were directed to simply listen to the stimuli (Passive Listening Condition). Global Field Power (GFP) and amplitude values (from central electrode sites) between 50 to 600 ms in response to the first and second words of the same (e.g., "petisa-petisa"/pətɪsə-pətɪsə/, "setisa-setisa"/sətɪsə-sətɪsə/) and different word pairs (e.g., "ptisa-petisa"/ptɪsə-pətɪsə/, "stisa-setisa"/stɪsə-sətɪsə/) were compared in the language groups, for both attend and passive listening conditions. Preliminary results revealed that response suppression to the repeated onsets within the same pairs was not modulated by native-language experience or attention. In contrast, for the attend condition, the response between 300-500 ms to the added vowel in the different pairs, which included the /pt-pət/ onset contrast that occurs only in the Polish language was modulated by native-language experience. The same comparisons for the passive condition revealed no effect of native-language. These results suggest that, when attention is directed to speech, sensory responses to sound changes are modulated by native-language experience. It will be important in future studies to examine whether individuals with language-learning disabilities, particularly those who demonstrate phonological processing deficits, show similar patterns of suppression to repeated phoneme sequences, as well as suppression release to sound changes that are modulated by language experience.

Topic Areas: Perception: Auditory, Phonology and Phonological Working Memory

Weighting of auditory dimensions in speech and music perception: individual differences and neural bases

Poster A34 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session A.

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Real-world auditory perception often involves integration of multiple auditory dimensions that contain overlapping and redundant information about the sound source or intended message. In speech, for example, pitch, duration, and amplitude redundantly convey prosodic features such as emphasis. Individuals tend to prioritize these dimensions differently (demonstrating stable, individualized perceptual strategies), but the drivers underlying these individual differences remain unclear. We explored this issue in groups of listeners with different perceptual abilities and linguistic backgrounds. In a speech cue weighting experiment (trial N = 990), we first demonstrate that 11 congenital amusics with a severe deficit in pitch perception categorize spoken stimuli similarly to controls (N = 11) when the main distinguishing cue is duration (which they perceive normally), and pitch cues play a secondary role. In contrast, when pitch cues are the main distinguishing feature, we show that amusics place less importance on pitch and instead rely more on duration cues—even when pitch differences in the stimuli are large enough for amusics to easily discern. This suggests that people with amusia may reweight their use of perceptual cues to linguistic features, such that perceptual cues like duration differences that are more perceptually reliable and less costly in processing terms are upweighted compared to the less reliable and more perceptually costly pitch changes. Next we investigated the neural basis for this perceptual reweighting. During fMRI, individuals with amusia and controls (N=30) matched auditory and visual sentences using pitch and duration cues. A data-driven analysis procedure detected prominent reductions in the amusic group's functional connectivity between left prefrontal language-related regions (inferior and middle frontal gyrus/DLPFC) and right hemisphere pitch-related regions (auditory and anterior insular cortex). Functional connectivity levels were also correlated with prosodic cue weights measured outside the scanner. Furthermore, group differences in functional connectivity between these regions were not present during a control task (passive listening to tones). The fact that such group connectivity differences were only observed during active sentence processing and not during passive tone listening suggests that individuals with amusia may alter functional connectivity between task-relevant frontal and perceptual regions in service of such perceptual reweighting. Finally, we investigated whether native language experience could also influence cue

weights in speech perception, as well as in music perception. In two experiments investigating second language speech and musical beat perception, native speakers of Mandarin (N=45) — where pitch is a crucial cue to word identity — placed more importance on pitch and less importance on other dimensions compared to native speakers of English (N=46) and Spanish (N=27), both non-tonal languages. We further show that Mandarin speakers are better able to attend to pitch and ignore irrelevant variation in other dimensions compared to English and Spanish speakers, but conversely struggle to ignore pitch when asked to attend to other dimensions. Thus, an individual's idiosyncratic auditory perceptual weights reflect a complex mixture of congenital predispositions, task-specific learning, and biases instilled by extensive experience in making use of important dimensions in their native language.

Topic Areas: Perception: Speech Perception and Audiovisual Integration, Prosody

Early-life signed language exposure does not impede the development of spoken language: A functional near infrared spectroscopy investigation of phonemic discrimination in cochlear implant (CI) users

Poster A35 [Poster PDF] Visit me at [Gather.Town] in the Wernicke room during Poster Session A.

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The impact of signed language exposure on the acquisition of spoken language through CIs remains controversial. Some research has claimed that signed language exposure is detrimental to spoken language development (Geers et al., 2017; Peterson et al., 2016) while others have suggested early (age<3) exposure to a signed language (early age-ASL) supports language development by offsetting the negative effects of language deprivation prior to implantation (Davidson et al., 2014; Jasinska & Petitto, 2013; Petitto et al., 2016). To address this controversy, we examined patterns of neural activation underlying phonemic discrimination (PD) in individuals who were both exposed to signed language and received CIs at different ages. We tested three hypotheses: (1) early age-ASL and access to spoken language through CI at different ages (age-CI) has a positive —or, (2) a negative impact—on spoken language PD, or (3) early age-ASL has no impact (neither behavioral nor neural) on spoken language PD. Eighteen individuals (M=19.9, SD=1.9; range=18-24 years) exposed to ASL between age 1-22 years and who received their CI between age 2-21 years completed an auditory PD task while undergoing fNIRS neuroimaging. PD ability was indexed by d' scores which indicated sensitivity to target phonemes. We used AnalyzIR toolbox to estimate effects of age-ASL, age-CI, and their interaction in frontal and bilateral temporal language regions as well as correlations between PD and neural activation patterns with a linear mixed-effects model. Individuals with early age-CI, but not with early age-ASL, showed marginally better PD ability (p=.094). Early-life language exposure (CI and/or ASL), as compared to later language exposure, was associated with better PD ability and greater activation of LH language areas that are critically involved in phonological processing (STG, IFG, MTG, Wernicke's). Moreover, activation in STG, IFG, MTG, and Wernicke's area was positively correlated with PD ability. Specifically, for participants with early ASL exposure and early CI, higher d' scores were positively correlated with activation in LSTG (p<.05), but negatively correlated with activation in LIFG (p<.001) and RMTG (p<.01). For participants with early ASL exposure, but later CI, higher d' scores were positively correlated with activation in LMTG (p<.05) and supramarginal gyrus of Wernicke's area (p<.05), but negatively correlated with activation in RIFG (p<.05). Our results show that (1) individuals with early age-CI had higher d' scores for PD, and (2) individuals with early age-ASL showed positive correlation between their d' scores and neural activation for PD in LH language areas that are involved in phonological processing. These findings suggest that early age-ASL has no impact on spoken language PD, supporting Hypothesis 3. In many cases, caregivers of deaf children are discouraged from using signed language in the fear that it impedes the development of spoken language via CI. Our findings suggest that exposure to ASL prior to CI implantation,

during a period which would otherwise be deprived of any language input, does not prevent subsequent spoken language development using CI.

Topic Areas: Perception: Speech Perception and Audiovisual Integration, Signed Language and Gesture

Intonation processing increases task-specific fronto-temporal connectivity in tonal language speakers

Poster A36 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session A.

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Language comprehension depends on tight functional interactions between distributed brain regions. While these interactions are established for semantic and syntactic processes, the functional network of speech intonation is not well-defined. Investigation with tonal language materials, such as Mandarin Chinese, will be a particularly interesting way to study the intonation network, given that linguistic pitch has dual functions of expressing both intonation (e.g. statement or question) and lexical tone (i.e. meaning). The present study used psychophysiological interaction (PPI) analyses of functional magnetic resonance imaging (fMRI) data to characterise the neural networks underlying intonation and tone processing in native Mandarin speakers. Based on the literature showing increased fronto-temporo-parietal activity in intonation and tone processing, we expected to find task-specific functional interactions between inferior frontal and temporo-parietal regions in both intonation and tone, potentially with lateralisation differences between the two domains. During fMRI, participants categorised either intonation or tone of mono-syllabic Mandarin words. Stimuli were generated via pair-wise audio-morphing between two intonation categories (statement, question) or two tone categories (high-rising tone, high-falling tone), thus ranging from clear to ambiguous stimuli for intonation or tone. We first identified brain regions involved in the processing of intonation or tone categories. To this end, we contrasted task-related activity during perception of clear > ambiguous stimuli, separately for the intonation and the tone task. This way, we assumed to identify brain regions associated with higher-level categorical sound representations in each domain without including potentially increased cognitive control in categorising ambiguous stimuli. Moreover, the stimulus-based contrast within each condition circumvents the use of a control task. Based on the group results of clear > ambiguous stimuli, we defined seed regions in bilateral inferior frontal gyrus (IFG) and conducted PPI analyses to identify task-related functional interactions during intonation and tone processing. Results for intonation showed that clear (compared with ambiguous) stimuli increased bilateral fronto-temporal activity and task-specific functional connectivity between left IFG and bilateral temporal regions. These results suggest the engagement of a phonological network for understanding intonation, which links between auditory perception of intonation categories in the temporal lobe and the explicit prosodic labelling in the frontal lobe. Increased functional interactions were also observed between bilateral IFG and the pre-supplementary motor area, which may reflect the automatic preparation of a possible verbal response. For tone, clear stimuli evoked activity in bilateral temporal regions only, likely associated with auditory representation of tonal (phonemic) categories. No task-related coupling between temporal and frontal regions was found for clear (compared with ambiguous) stimuli. Rather, we observed that the reverse contrast of ambiguous (compared with clear) tone stimuli showed stronger activity in bilateral IFG, suggesting stronger cognitive control due to increased task demands. Together, our data demonstrate that both intonation and tone processing in a tonal language show similar categorical sound representation in superior temporal regions, but only intonation includes additional contribution of higher-level phonological processes and verbal response preparation in bilateral fronto-temporal and lateral-medial frontal networks.

Topic Areas: Prosody, Speech Perception

Lesion Correlates of Emotional Prosody Recognition Impairments in Acute Right Hemisphere Stroke

Poster A37 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session A.

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Understanding emotional prosody (rate, rhythm, pitch, and intensity changes to speech to convey emotion) is often impaired following right hemisphere stroke. Previous work has indicated right hemisphere dorsolateral activation for emotional prosody comprehension and anterosuperior activation during emotional prosody production, mirroring propositional language ventral and dorsal streams in the left hemisphere. This study determined lesion correlates of emotional prosody recognition deficits in acute right hemisphere stroke. METHOD Twenty-nine participants (13 women, 16 men; age: M=61.79 years; education: M=13.68 years) with acute right hemisphere stroke were included. During acute hospitalization, participants completed routine clinical MRI with Diffusion-Weighted Imaging (DWI) and began behavioral testing within seven days of admission. Participants judged the emotional prosody (Happy, Sad, Angry, Afraid, Surprised, Bored) of sentences consisting of real words or pseudowords before and after training. Training tasks targeted acoustic-prosodic recognition and access to Abstract Representations of Acoustic Characteristics that Convey Emotion (ARACCE; e.g., sad prosody: low pitch, slow rate). Acoustic feature training comprised identifying the feature (e.g., pitch) by which pairs of tones differed. Prosodic feature training included identifying acoustic features (e.g., fast rate, high pitch) of sentences spoken with the tested emotional prosody. ARACCE training comprised specifying prosodic features of tested emotions (e.g., Sad: slow rate, low pitch, quiet). Regions of acute ischemia were manually traced on DWI in MRIcron. Normalization routines within SPM12 were used to warp DWIs and lesion tracings to MNI space. Lesion-symptom mapping (LSM) analyses (all right hemisphere regions within aalcat atlas, 5000 permutations, 2 (pseudoword sentences) or 3 (real-word sentences) patient minimum overlap) were conducted for prosody (Happy, Sad, Angry) and sentence type (pseudoword, real-word) separately in NiiStat. Participants were also divided into groups based on how they performed during training (acoustic-prosodic impairment (n=9), ARACCE impairment (n=3), acoustic-prosodic and ARACCE impairment (n=8), no impairment (n=9)). Impairment cutoff scores were derived from the fifth percentile of scores from a group of healthy adults matched in age and gender. Lesion overlay maps were created for each group in MRIcroGL and qualitatively analyzed. RESULTS After controlling for lesion volume, Sad prosody recognition was poorer in patients with infarcted right middle and inferior temporal lobes (real-word sentences) and right inferior fronto-occipital fasciculus (rIFOF) (pseudoword sentences) before training. Greater rIFOF integrity suggested greater benefit of acoustic-prosodic training for Sad prosody recognition with pseudowords ($ps<0.05$). No significant findings were observed for Happy or Angry sentences. Participants with acoustic-prosodic impairments demonstrated greatest lesion overlap in subcortical right insula, internal capsule, and basal ganglia. Participants with acoustic-prosodic and ARACCE deficits had greatest lesion overlap in subcortical posterior-inferior and middle temporal lobe. No lesions overlapped for ARACCE-only deficits. Participants with intact training performance had greatest overlap in subcortical right inferior frontal lobe, medial superior temporal gyrus, and basal ganglia. CONCLUSION/SUMMARY Lesions in brain regions supplied by the right middle cerebral artery inferior division were implicated in poorer Sad prosody recognition, aligning with accounts of ventral stream emotional prosody comprehension. Visual inspection of group lesion maps suggests possible hubs of acoustic-prosodic and ARACCE evaluation within the ventral stream.

Topic Areas: Prosody, Disorders: Acquired

Patterns of anatomical disconnection in chronic stroke reveal sublexical, lexical, and semantic contributions to reading

Poster A38 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session A.

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Reading is a cultural acquisition that requires learning the mappings between printed words, phonological forms, and word meanings. Interactive activation models of reading predict that the relative importance of sublexical decoding and lexical-semantic processing depends on lexicality, spelling-to-sound regularity, and imageability. Novel words (e.g., pseudowords) are thought to depend on sublexical decoding. In contrast, known words with irregular spelling-to-sound mappings depend more on whole-word knowledge. Within the division of labor between sublexical and lexical-semantic processing, imageability is hypothesized to modulate processing, such that rich semantic representations, as indexed by high imageability, improve reading accuracy. There is limited causal evidence outside of case studies of neurological patients for this division of labor in the brain. Additionally, it is debated whether lexical and semantic contributions to reading are dissociable. We tested the cognitive and neural separability of sublexical, lexical, and semantic contributions to reading by examining whether different patterns of disconnection in chronic stroke related to acquired effects of lexicality, regularity, and imageability. Thirty subjects with chronic left-hemisphere stroke read aloud 20 word-pseudoword pairs that constituted the lexicality contrast. Additionally, subjects read aloud 200 words varying orthogonally in frequency, regularity, and imageability, which enabled lexical (irregular versus regular) and semantic (high versus low imageability) contrasts. To capture the necessary contributions of both lesioned and spared, but disconnected, grey matter, we derived binarized structural connectomes via anatomically-constrained probabilistic tractography (Tournier et al., 2019). A connection between parcels (Lausanne atlas scale 125; Daducci et al., 2012) was classified as lesioned if the missing connection was present in 100% of 36 control subjects. To test the separability of sublexical, lexical, and semantic reading processes, support vector regression analyses identified regions that contributed connections necessary for accurate reading of 1) pseudowords, covarying real words (sublexical contrast), 2) irregular words, covarying regular words (lexical contrast), and 3) high imageability words, covarying low imageability words (semantic contrast). The reliability and specificity of lesion-behavior associations was increased by limiting analyses to left-hemisphere and interhemispheric connections lesioned in at least 10% of patients, and by covarying lesion volume, age, and education. Left frontal cortex was uniquely implicated in the accurate reading of pseudowords versus words, suggesting that sublexical decoding depends especially on connections supporting phonological output processing. Relative to regular word reading, accuracy reading irregular words was more affected by disconnections involving fusiform gyrus, ventral posterior superior temporal sulcus, supramarginal gyrus, angular gyrus, and anterior temporal cortex, but not temporal pole. This result suggests that lexical processing depends on connections to regions implicated in lexical orthographic and phonological processing. Left temporal pole, superior parietal cortex, and interhemispheric disconnections notably involving right hippocampus and right fusiform were uniquely implicated in the accurate reading of high imageability versus low imageability words. Semantic contributions to reading thus depend on both hemispheres. Left supramarginal gyrus was implicated in all analyses, suggesting that connections to the phonological processing system are generally important in reading aloud. Overall, our results provide evidence for at least partially separable neural architectures for sublexical, lexical, and semantic contributions to reading.

Topic Areas: Reading, Disorders: Acquired

Visual word recognition involves an abstract letter-based prediction error in posterior vOT

Poster A39 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session A.

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In previous work (Gagl et al., 2020), we proposed that our knowledge of the words of a language constrains the possible range of expected inputs into the visual word recognition system (thereby increasing the efficiency of reading). According to this predictive coding-based model, orthographic processing involves prediction error (PE) representations in the left ventral occipito-temporal cortex posterior to the word-sensitive 'visual word form area'. We demonstrated that responses of this brain region are better modeled by the difference between expected and actual orthographic input compared to a full representation of the physical input or traditional orthographic word metrics. In that model, the orthographic PE was implemented directly based on the physical word forms (approximated via their pixel-based representations). Here, we extend this work to include a more abstract letter-based prediction error additionally. We model the internally generated, abstract pre-lexical prediction of upcoming words, without a contextual constraint, as a matrix (stimulus length x number of letters) of lexicon-based probabilities that each letter occurs at a specific position of a word. To derive an abstract pre-lexical prediction error (abstract PE), we subtracted, for each position, the likelihood of the letter perceived at that position from 1, i.e., the cumulative likelihood of perceiving any letter at that position. The resulting PE is lower for letters that frequently occur at the respective position (e.g., an 'e' at the end of an English word) and higher for letters that rarely occur at that same position. This position-specific value is then either summed to calculate a word-level prediction error (WPE) or, in a separate analysis, integrated in a way that also takes into account the sequential position in the word (SPE). The resulting abstract PEs correlate positively with standard measures of orthographic processing (i.e., Orthographic Levenshtein distance; WPE: r = .76; SPE: r = .42) and with the pixel-based orthographic PE proposed in our original model (WPE: r = .60; SPE: r = .28). In two behavioral experiments (N=35; 24), lexical decision times were faster for more orthographically common words (i.e., low abstract PEs), while the inverse effect was found for non-words. Sequential PE accounted for more variance than the word-based PE, and including all three PE estimates in a combined statistical model increased the model fit significantly, indicating that they account for independent cognitive processes. fMRI results (N=39) show that the abstract letter-based PE is represented in the ventral occipitotemporal cortex, slightly anterior to the originally-proposed pixel-based PE. These results indicate top-down guided predictive processing based on abstract letter-based representations as essential in resolving the orthographic code before accessing word meaning.

Topic Areas: Reading, Computational Approaches

Applying neuro-cognitive models for efficient, individualized diagnosis and intervention: A case from reading research.

Poster A40 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session A.

Klara Gregorova[1], Benjamin Gagl[1]; [1]Department of Psychology, Goethe University Frankfurt, Frankfurt/Main, Germany

Efficient reading is essential for societal participation, like many other behaviors and skills too. Here we use the Lexical Categorization Model (LCM), a successfully evaluated computational model describing brain activation in the left ventral occipito-temporal cortex (lvOT) in response to words, as the basis for designing an individualized diagnostics/intervention program. The core assumption is that lvOT prevents semantic processing for non-words, i.e., filters out nonsense information by categorizing letter strings in words or non-words. In the LCM training, we implemented a lexical decision task, i.e., is the presented string a word or not, to explicitly train the categorization processes assumed by the LCM. We conducted a training study for adult German language learners suffering from slow reading (N=75). We found an overall reading speed increased after the LCM training (+23%). Besides, we used a cross-validated, self-developed, machine learning approach, including mixed modeling, to predict training outcomes for each reader based on the data from the initial training session. The predicted and the observed outcomes were strongly correlated (r = 0.69, t(73) = 8.16), and the LCM based parameter had high predictive strength. When we applied the diagnostic to the training data, the training effect increased to 36% (precision 81%). These findings have multiple implications. (i) We found causal evidence for an LCM based categorization process in reading. (ii) Computational models of brain functions are potent tools motivating new interventions and (iii) supporting individualized diagnostics. Thus, neuro-cognitive computational models open new possibilities for the implementation of highly effective intervention programs.

Topic Areas: Reading, Computational Approaches

Neurites orientation dispersion is associated with reading

Poster A41 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session A.

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Dyslexia is a common neurodevelopmental disorder characterized by difficulties with reading and spelling and affecting around 5-10% of the school aged children. Several studies have explored neuroanatomic (brain structure) correlates of the condition and have shown various white matter tissue properties to be correlated to phonological skills and reading skills. Most of these studies have used diffusion MRI and queried markers such as mean diffusivity (MD) and fractional anisotropy (FA). These are widely used surrogate measures with high sensitivity to tissue microstructural changes; however, they lack specificity for individual tissue microstructure features. Here, we investigated neurite orientation dispersion and density in order to exploring the underlying specific microstructural features more directly. Diffusion weighted images (DWI) and anatomical MPRAGE T1 images were obtained from 72 children (mean age 10.03 � 3.45 years) included in the Florida Learning Disabilities Research Center (FLDRC) mega analysis. A complete battery of behavioral and neuropsychological measures including Test of Word Reading Efficiency (TOWRE-2) and Comprehensive Test of Phonological Processing (CTOPP-2) was obtained for all subjects. The Imaging quality metrics of the obtained MRI data - Contrast to Noise Ratio (CNR), Average Absolute and Relative Motion (AM & RM) of each volume were computed for all subjects. Moreover, neurite orientation dispersion index (ODI, influenced by dispersion of axons and dendrites in the intracellular compartment ; 0 to 1; 0 = well-aligned neurites, 1 = highly dispersed neurites) and neurite density index (NDI, influenced by density of axons and dendrites based on intracellular diffusion 0 to 1; 0 = most extracellular diffusion, 1 = most intracellular diffusion) were obtained from 22 major tracts in human brain after preprocessing the data for artifact removal, motion correction and noise reduction. All of the above-mentioned parameters were obtained using FSL (ver. 6.1.0) and NODDI toolbox. Partial correlation was performed using age, sex, and image quality metrics (CNR, AM and RM) as covariates between Neurite indices (ODI and NDI) and measures of reading and phonological skills (TOWRE and CTOPP). We observed that ODI was negatively correlated with TOWRE and CTOPP scores in several tracts in the brain previously shown to have structural correlates with reading efficiency. Briefly, we found that: Sight word efficiency (TOWRE) was significantly ($p < 0.05$) correlated with ODI in left - arcuate fasciculus (AF), inferior longitudinal fasciculus (ILF), Inferior Fronto-Occipital Fasciculus (IFOF). Phonemic decoding efficiency (TOWRE) was significantly correlated with ODI in left – Superior longitudinal fasciculus (SLF), ILF, IFOF and bilateral uncinate fasciculus (UF). CTOPP - composite score of Blending words and Elision was significantly correlated with ODI in right AF, left – ILF, IFOF, SLF and bilateral UF. In sum, we found that better reading and phonological processing skills are associated with greater tract coherence (lower ODI index). We suggest that neurite complexity could be a useful tool for inferring specific white matter tissue microstructure and may promote better understanding of relations between brain structure and behavior.

Topic Areas: Reading, Disorders: Developmental

Differences in brain activation following reading intervention: A meta-analysis

Poster A42 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session A.

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Children with reading disability (RD) who receive remedial intervention show varying outcomes in their subsequent reading performance, and the neural mechanisms underlying response to intervention are not well understood. Some studies that employ functional neuroimaging (fMRI, MEG) techniques to investigate brain changes associated with intervention show "normalization" of reading-related brain activity following intervention with increased activation in left hemisphere temporo-parietal, occipito-temporal, and inferior frontal sites that compose the canonical "reading network" (Davis et al., 2011; Shaywitz et al., 2004; Simos et al., 2007a,b). Others have identified "compensatory" changes with activation increases in right hemisphere reading network homologues and/or regions that support domain-general cognitive processing (Odegard, et al., 2008; Partanen, et al., 2019), or a combination of normalized and compensatory changes (Eden et al., 2004; Gebauer et al., 2012; Meyler et al., 2008). A previous meta-analysis of 8 fMRI studies of reading intervention revealed significant post-intervention increases in RD groups in left thalamus, right insula/inferior frontal gyrus, left inferior frontal gyrus, right posterior cingulate, and left middle occipital gyrus (Barquero, Davis, & Cutting, 2014), regions associated with phonological processing as well as domain general functions which may serve a compensatory role for struggling readers. In the present study, we aimed to provide an updated meta-analysis of fMRI studies of reading intervention. We focused on changes in patterns of brain activation in children with RD from pre-to post-intervention. Based on empirical and theoretical work, we predicted that differences in brain activation following reading intervention in children with RD would be observed in regions of the canonical reading network such as temporo-parietal, occipito-temporal, and inferior frontal areas, and regions involved in general cognitive processing that may play a compensatory role in reading, such as cingulate gyrus, thalamus, and prefrontal cortex. Our literature search yielded 571 records after removal of duplicates. Primary research studies including reading intervention for participants with or at-risk for RD in which task-based fMRI was acquired before and after intervention were selected for inclusion in the meta-analysis: 9 studies met our criteria. Peak coordinates were identified for the contrast of interest for each study (in preferred order): post-intervention vs. pre-intervention in RD group, follow-up vs. pre-intervention in RD group, group x time interaction (e.g. RD post > pre vs. TD post > pre). The meta-analysis revealed significant clusters in right posterior cingulate gyrus, right superior temporal gyrus, left anterior thalamic projections, right superior longitudinal fasciculus/insula, and bilateral lingual gyrus ($p < .025$, uncorrected, min. 10 voxels). These findings are consistent with findings from the previous meta-analysis (Barquero et al., 2014) and support the engagement of putative compensatory brain networks following reading intervention. Specifically, increased engagement of right superior temporal, superior longitudinal fasciculus/insula, and bilateral lingual gyrus indicates development of a more bilateral distribution of reading-related activation. Furthermore, activation in right posterior cingulate gyrus, and left anterior thalamic projections may support improvement in reading via domain general cognitive functions such as attention monitoring, and learning. These findings may inform the understanding of cognitive mechanisms that support improvement in reading in RD.

Topic Areas: Reading, Disorders: Developmental

SVM decoding of predictive processing effects in EEG signals

Poster A43 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session A.

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Conventional univariate analysis methods for EEG and ERP data have provided invaluable insights into dynamic neural computations that underlie visual word recognition (Grainger & Holcomb, 2009). However, it is difficult to infer the linguistic content of these computations using traditional methods. Recently developed machine-learning classification methods are promising tools to gain further insight into the content of computations in

memory and attention paradigms (Bae & Luck, 2018; Hong et al., 2020), but there have been few applications of these methods to study word recognition. A recent study (Brothers et al, 2016) used ERP data to investigate the effects of pre-activation a visual ERP priming paradigm. In this paradigm, participants (n = 45) were shown a priming word and instructed to predict the target word. Word-pair trials were labeled according to the word relationship (related or unrelated) and self-reported prediction accuracy (predicted or unpredicted). The present study adapted a Support Vector Machine (SVM)-based classification analysis method (Bae & Luck 2018) with Brothers' and colleagues' EEG data to categorize the EEG signal according to prediction accuracy and semantic-relationship to further explore facilitation effects of pre-activation. First, we isolated three trial comparisons for decoding: 1) predicted-related and unpredicted-related trials, 2) unpredicted-related and unpredicted-unrelated trials, and 3) predicted-related and unpredicted-unrelated trials. The first comparison – predicted-related and unpredicted-related – isolates prediction accuracy effects. The second comparison – unpredicted-related and unpredicted-unrelated isolates effects of semantic relationship. The third comparison – predicted-related and unpredicted-unrelated – does not isolate the effects. It includes prediction accuracy effects, semantic relationship effects, and the interactions between semantic relationship and prediction accuracy. Differences between the conditions' time course and decoding accuracy reflect differences in the time course and facilitation of lexical processes. For each comparison, the SVM classified 500 time points across the -200ms to 1800ms stimulus-locked interval. Decoding accuracy was calculated for each participant and then averaged across participants for each time point. Cluster-based permutation testing was used for significance testing. We found grand-average decoding accuracy was significantly greater-than-chance (50%) in large clusters during the time interval for all three conditions. Predicted-related and unpredicted-related reliable decoding begins prior to 200ms (peak accuracy > 95%). Predicted-related and unpredicted-unrelated are decoded at stimulus onset and become more reliable around 200ms (peak accuracy > 95%). In contrast, unpredicted-related and unpredicted-unrelated reliably classify later (> 200ms) and with lower accuracy (peak accuracy > 80%). This is consistent with lexical processes beginning earlier and semantic processes begin later. The predicted-related and unpredicted-unrelated condition having greater decoding accuracy than the unpredicted-related and unpredicted-unrelated condition indicates facilitated processing of predicted words. Next, we performed using prime word locked data to classify prediction accuracy. Despite no differences between conditions in ERPs, we found multiple significant decoding accuracy clusters after 600ms. The most reliable classification occurs after 800ms (peak accuracy > 57%). This indicates consistent convergence on a representation of the target word when successfully predicted. Overall, these results provide further evidence of facilitation effects of pre-activation and a more precise time course of lexical and semantic processes.

Topic Areas: Reading, Methods

Localizing syntactic comprehension through syntactic acceptability judgments & lesion symptom mapping

Poster A44 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session A.

Danielle Fahey[1], Julius Fridriksson[1], Gregory Hickok[2], William Matchin[1]; [1]University of South Carolina, [2]University of California, Irvine

Introduction The neurobiological model of Matchin & Hickok (2020) posits hierarchical lexical-syntactic processing in the posterior middle temporal gyrus (pMTG) and linear morpho-syntactic processing in the inferior frontal gyrus pars triangularis (IFGtri). Evidence for the model includes lesion-symptom mapping studies that have associated damage to posterior networks with syntactic comprehension deficits (Pillay et al., 2017; Kristinsson et al., 2018; Rogalsky et al., 2018), as well as paragrammatic speech (Matchin et al., 2020). By contrast, lesion-symptom mapping studies have associated damage to frontal networks with agrammatic production deficits (Wilson et al., 2010; den Ouden et al., 2019; Matchin et al., 2020) but with little implication in syntactic comprehension deficits. However, most studies have assessed syntactic comprehension indirectly through the use of noncanonical sentence comprehension (cf. Wilson & Saygin, 2004). Syntactic acceptability judgments (SAJ), that is asking the subject to determine whether a structure is well formed or not, provide a much more direct assessment of syntactic comprehension. In this project, we propose a large-scale lesion-symptom mapping analysis of SAJ in people with chronic post-stroke aphasia following left hemisphere brain damage. Methods We will adapt Wulfeck & Bates (1991)'s SAJ task in two experiments. Rather than asking subjects to make artificial judgments regarding well-formedness, we will ask subjects to make a more ecologically valid judgment regarding whether the speaker is native or not. Task 1: materials constitute a 2x2x2 design: grammaticality (grammatical vs. ungrammatical), violation (agreement vs. word-order), and target (verb phrase (VP) vs. noun phrase (NP)): (i) VP, agreement: She is/*are baking a cake; (ii) NP, agreement: She is baking a cake/*a cakes; (iii) VP, word-order: They have listened/*listened have to some teachers; (iv) NP, word-order: They have listened to some teachers/*teachers some. Task 2: materials constitute a 2x2x2 design: grammaticality (grammatical vs. subcategorization violation), optionality (optional object argument vs. obligatory), and target: (v) VP, optional: They are hurrying/*have hurrying to a meeting; (vi) NP, optional: He is answering a phone call/*to a phone call; (vii) VP, obligatory: They have signaled/*have signaling to a boat; (iix) NP, obligatory: They are chasing a cat/*in a cat. Each task presents 64 sentences, eight of each type. Participants respond by pointing to "native" or "non-native" on the screen. We will analyze correspondence between participants' lesions and error detection. Results We expect variability in performance of people with aphasia on the SAJ task, with better performance on word-order conditions relative to agreement conditions (Wulfeck et al., 1991) or subcategorization violations, as word order violations give a much stronger subjective impression of ungrammaticality (see also Wilson & Saygin, 2004). In line with the model presented in Matchin & Hickok (2020), we expect that lesion-symptom mapping will show an association between deficits on all three tasks and damage to posterior temporal regions, but no association between task deficits and frontal damage. We will also expect tight spatial overlap between the lesions associated with subcategorization deficits, which are associated with specific lexical items, and word order and agreement deficits, which are associated with abstract sentence structure.

Topic Areas: Syntax, Disorders: Acquired

Building language: Investigating the neural processes involved in syntactic binding using MEG

Poster A45 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session A.

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Essential to the expressive power of human language is our ability to combine words in larger syntactic structures with more meaning, otherwise known as binding (Segaert et al. 2018), unification (Hagoort, 2003) or merge (Zaccarella & Friederici, 2015). Successful binding of a sentence requires both the semantic binding of the meaningful relationship between words, as well as the syntactic binding of the grammatical relationship between multiple words in the structure. However, it is often difficult to disentangle the neural networks separately involved in semantic and syntactic binding since the combinatorial processes occur at both levels for most sentence stimuli (Bemis & Pylkkänen, 2011, 2013). In order to isolate the neural networks specifically involved in syntactic binding, we employed a minimal sentence paradigm with pseudo-words (i.e., words that follow the syntactic rules of a language, but have no semantic meaning). The study was pre-registered on the Open Science Framework prior to data collection (https://osf.io/ntszu). We recorded the MEG activity of 24 right-handed healthy adults during the comprehension of two-word sentences that required binding (i.e., a pronoun combined with a peusdo-verb with the corresponding morphological inflection; "she grushes") to wordlists that did not require binding (i.e., two pseudo-verbs; "cugged grushes"). By comparing these conditions, we targeted syntactic binding while minimizing contributions from semantics and other cognitive processes, such as working memory. At the oscillatory level, we found that there was an increase in alpha power surrounding the onset of the target word ("grushes") in both conditions. Immediately preceding and following the target word (-0.05s to 0.1s), this increase in alpha power magnitude was less pronounced for syntactic binding compared to no binding ($p < .05$) – this condition difference was distinct from the evoked fields. Further source analyses revealed that the condition difference was localized to left-lateralized brain regions (p < .05), including the inferior frontal gyrus (BA44), the anterior frontal gyrus (BA46), the middle and inferior temporal cortex (BA21) and the angular gyrus (BA39). In conclusion, we suggest that the modulation in alpha power reflects an expectation of binding to occur, combined with the increased engagement of task-relevant brain regions involved in language comprehension and syntactic binding. Our findings are consistent with alpha oscillatory activity playing an important role in higher-order linguistic function (Meyer, 2018; Murphy, 2015; Segaert et al., 2018) and with neurobiological models of language (Hagoort, 2003; Tyler & Marslen-Wilson, 2008). Overall, our findings provide novel insight into the oscillatory brain activity and specific cortical regions involved in syntactic binding.

Topic Areas: Syntax, Meaning: Combinatorial Semantics

Syntax-sensitive regions of the posterior inferior frontal gyrus and the posterior temporal lobe are differentially recruited by production and perception

Poster A46 [Poster PDF] Visit me at [Gather.Town] in the Wernicke room during Poster Session A.

William Matchin[1], Emily Wood[1]; [1]University of South Carolina

Matchin & Hickok (2020) proposed that the left posterior inferior frontal gyrus (PIFG) and the left posterior temporal lobe (PTL) both play a role in syntactic processing, broadly construed, attributing distinct functions to these regions with respect to production and perception. Strong dissociations between damage to these regions have been observed with respect to syntactic deficits in aphasia, suggesting a role for the PIFG primarily in production and role for the PTL in both production and comprehension. In this light, it is surprising that neuroimaging studies of syntactic comprehension typically show similar activations in these regions (Fedorenko et al., 2012; Matchin et al., 2017; Goucha et al., 2015; Zaccarella et al., 2015), which might suggest that these regions play similar roles in syntactic processing (Blank et al., 2016; Fedorenko et al., 2020). However, few neuroimaging studies have compared syntactic production and comprehension to each other, which might reveal relevant functional differences. In order to identify whether these regions show distinct activation patterns with respect to syntactic perception and production, we performed an fMRI study contrasting the subvocal articulation and perception of structured jabberwocky phrases (syntactic), sequences of real words (lexical), and sequences of pseudowords (phonological). In the phonological condition, subjects were presented with sequences of pseudowords (e.g. bulbom foyrix); in the lexical condition, subjects were presented with sequences of real words (e.g. hermit dogma); in the syntactic condition, subjects were presented with sequences of jabberwocky phrases (e.g. this pand these clopes). By subtracting the perceive+rest condition (in which subjects perceived a single stimulus and then rested) from the perceive+rehearse condition (in which subjects perceived a single stimulus and then subvocally repeated that stimulus three times), we isolated brain activity associated with production. By examining the continuous perceive condition relative to rest (in which subjects perceived three stimuli) we isolated brain activity associated with comprehension. We defined two sets of language-selective regions of interest (ROIs) in individual subjects for the PIFG and the PTL using the contrasts [syntactic > lexical] and [syntactic > phonological] (see also Fedorenko et al., 2010; Rogalsky et al., 2015). We found a robust significant interaction of comprehension and production between these two regions at the syntactic level, for both sets of language-selective ROIs, p < 0.001. This suggests a core difference in the function of these regions with respect to production and perception, such that PTL is relatively more associated with syntactic perception and PIFG is more associated with syntactic production, consistent with the lesion literature.

Topic Areas: Syntax, Language Production

Another look at the constituent structure of sentences in the human brain

Poster A47 [Poster PDF] Visit me at [Gather.Town] in the Wernicke room during Poster Session A.

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In an influential paper, Pallier and colleagues (2011) used fMRI to examine the sensitivity of the language system to constituent structure. They presented participants with 12-word-long sequences that varied in their internal composition between 12-word-long sentences, sequences of two 6-word-long constituents, sequences of three 4-word-long constituents, sequences of four 3-word-long constituents, sequences of six 2-word-long constituents, and finally, sequences of unconnected words. Every brain region in the fronto-temporal language network was found to respond more strongly to larger constituents. Critically, the inferior frontal and posterior temporal language regions—but not the anterior temporal areas—additionally showed these effects for meaningless “Jabberwocky” materials that consist of a syntactic frame made up of function words and morphological endings but are not interpretable (e.g., “Twas brillig, and the slithy toves did gyre and gimble in the wabe”). The authors therefore argued that this subset of the language network operates “autonomously of other language areas and can extract abstract syntactic frames”. The goal of the current study was two-fold. First, in line with growing emphasis in the field on robust and replicable science, we sought to replicate the results reported in Pallier et al. (2011). Second, we tested whether constituency is special by looking for similar effects of chunk length in naturally-occurring contiguous word sequences that do not form constituents (an example string of three 4-word-long non-constituents: “to facilitate production of reach accurate conclusions about shining like bits of”; cf. a string of three 4-word-long constituents: “gave up most unwillingly shone from every window about visiting the well”). Across two fMRI experiments (n=15, and n=25), we replicated the basic result—stronger responses to longer constituents in materials with real words—but we challenge the critical claim that a subset of the language network is sensitive to abstract syntactic structure and not to word meanings. In particular, we find that every language region, including anterior temporal regions, i) is sensitive to constituent structure in both real and Jabberwocky materials, and ii) exhibits a strong main effect of lexicality, with stronger responses to real-word than Jabberwocky materials. Furthermore, we find similarly robust sensitivity to the size of non-constituent strings, calling into question the privileged role of constituent structure in these effects. Overall, our results support the view of human language where syntactic structure is strongly integrated with word meanings (e.g., Dick et al., 2001; Fedorenko et al., 2020).

Topic Areas: Syntax, Meaning: Combinatorial Semantics

Enhancing unconscious language learning by cognitive depletion

Poster A48 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session A.

Eleonore Smalle[1], Tatsuya Daikoku[2], Arnaud Szmalec[3], Wouter Duyck[4], Riikka Möttönen[5]; [1]postdoc, Ghent University

Explicit and implicit memory systems related to human learning can interact in cooperative but also competitive ways to optimize performance. We tested a hypothesis that higher cognitive mechanisms related to the explicit system compete with implicit learning mechanisms that are important for acquiring basic human skills, such as language. Specifically, we tested the prediction that depleting higher cognitive resources in adults enhances unconscious auditory statistical word-learning abilities. A total of 100 young adults were exposed to continuous streams of syllables that repeated into hidden words while watching a silent movie. Learning was measured after exposure in a force-choice test, which measured recognition accuracy of the hidden words and whether participants remembered or guessed them to dissociate explicit and implicit knowledge. We additionally measured EEG during exposure in order to measure neural entrainment processes to the hidden repeating words. Higher cognitive resources were depleted prior to exposure by using two methods. In Experiment 1, inhibitory continuous theta-burst stimulation was applied to the left Dorsolateral Prefrontal Cortex. In Experiment 2, participants performed a dual-working memory task that induced high or low levels of cognitive fatigue. Cognitive depletion enhanced recognition of the hidden words in both experiments, and especially

when participants claimed to guess. TMS additionally modulated online neural entrainment to the syllables and hidden words. These findings suggest that cognitive depletion can improve the acquisition of implicit linguistic knowledge. Overall, our findings support the hypothesis that higher cognitive mechanisms compete with unconscious mechanisms that contribute to language learning. This can offer novel insights into developmental changes in language acquisition.

Topic Areas: Perception: Auditory, Development

Audiovisual Comprehension in Aphasia under Clear and Distorted Listening Conditions

Poster A49 [Poster PDF] [Poster Tour] Visit me at [Gather.Town] in the Wernicke room during Poster Session A.

Anna Krason[1], Gabriella Vigliocco[1], Marja-Liisa Mailend[2], Harrison Stoll[2], Laurel J. Buxbaum[2]; [1]University College London, [2]Moss Rehabilitation Research Institute

Human face-to-face communication involves multisensory processes of perceiving and integrating auditory as well as visual information. It is well-established that mouth movements facilitate speech processing in neurotypical individuals, especially in noisy environments. Mouth movements are also often a key component of speech and language therapies for persons with post-stroke aphasia (PWA). Yet, beyond the level of phonemes and meaningless syllables, very few studies have assessed audiovisual speech comprehension and its neuroanatomical basis in PWA. It is therefore unclear whether and under what circumstances PWA benefit from mouth movements. The current study is the first to investigate whether and how the presence of mouth movements influences word recognition in clear and degraded speech conditions in PWA. Thirty-six PWA and 13 neurotypical participants carried out a computer-based picture-word verification task. Participants had to indicate whether a spoken stimulus matched a previously seen picture. Fifty percent of the trials required a "yes" response (i.e., matching trials) and the other 50 percent required a "no" response (i.e., mismatching trials). In the mismatching trials, the target word could be paired with a phonologically or semantically related picture, or an unrelated one. Words were either presented as audiovisual (audio accompanied by a video of the speaker's face), or auditory-only (audio accompanied by a picture of a female silhouette). In addition, we manipulated the clarity of speech (clear vs. noise-vocoded). We carried out mixed-level regressions separately for the matching and mismatching trials. We also performed a support-vector regression (SVR) lesion-mapping analysis on the matching trials to investigate lesioned brain areas associated with reduced benefit of audiovisual relative to auditory-only input, when the speech was degraded. Our behavioral results indicated that performance was more accurate when the speech was accompanied by mouth movements ($B=0.395$, $SE=0.200$, $z=1.977$, $p=0.048$ for "yes" trials; $B=0.457$, $SE=0.083$, $z=5.479$, $p<0.001$ for "no" trials). Although PWA performed overall poorer relative to the control group ($B=0.507$, $SE=0.196$, $z=2.586$, $p=0.009$ for "yes" trials), they did not benefit from the audiovisual speech to a larger extent. For the "yes" trials, participants, and in particular PWA, were also less accurate ($B=-0.280$, $SE=0.151$, $z=-1.848$, $p=0.065$) and slower ($B=0.07$, $SE=0.03$, $z=2.309$, $p=0.025$) when the speech was noise-vocoded (compared to clear speech). On the "no" trials specifically, participants performed significantly worse when the pictures were semantically or phonologically related to the target words relative to the unrelated pictures ($B=1.509$, $SE=0.187$, $z=8.088$, $p<0.001$). Preliminary lesion-mapping analysis suggested that lesioned voxels in peri-sylvian regions, including insula and inferior frontal gyrus (IFG), as well as lesioned voxels in the middle frontal gyrus (MFG) and sensory association cortex were associated with reduced benefit from audiovisual speech relative to auditory-only speech during noise-vocoded word recognition. To conclude, these data suggest that both PWA and neurotypical controls benefitted to the same extent from the audiovisual speech. Both groups, and in particular PWA, were also negatively affected by the degraded listening conditions. Lesion-mapping results indicate that parts of IFG, insula, MFG, and sensory association cortex are associated with the processing of mouth movements under distorted listening conditions.

Topic Areas: Perception: Speech Perception and Audiovisual Integration, Disorders: Acquired

The Role of Attention in Statistical Learning

Poster A50 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session A.

Presenter Note: For comments/suggestions on my MSc proposal, please contact me at sreyes4@uwo.ca

Stacey Reyes[1], Stephen Van Hedger[1], Laura Batterink[1]; [1]Western University

The process of extracting regularities in the environment, known as statistical learning (SL), has been well-documented to play a key role in speech segmentation and language acquisition. In a linguistic context, Batterink & Paller (2017) have proposed SL as being comprised of two separable steps: 1) perceptual binding of adjacent individual units (syllables) into their integrated composites (words), and subsequently, 2) memory storage and retrieval of these integrated composites. Whether SL is automatic or requires voluntary top-down attention is a key, unresolved question. The current proposal aims to examine whether these dissociable components of statistical learning are differentially impacted by attention, using a sensitive neural index of SL in addition to classic post-learning behavioural tests. Building on previous findings (e.g. Batterink & Paller, 2017; 2019, Batterink, 2020), we will use a direct, EEG-based neural entrainment measure of SL to quantify the online perceptual binding component, during exposure to a nonsense speech stream. Following exposure, SL will be assessed with offline tests, including a post-exposure familiarity rating task, and an indirect reaction-time based memory task. Participants will either focus towards, or divert their attention away from an auditory speech stream made of repeating nonsense trisyllabic words. Attention will be diverted by taxing either visual or auditory processing during exposure to the speech stream. As used by Ding, Pan, Luo, Su, Zhang, & Zhang (2018), auditory attention will be taxed through a tone detection task in which participants are to detect deviants in a tone series. Visual attention will be taxed through the classic Multiple Object Tracking paradigm (Pylyshyn & Storm, 1988), requiring tracking of multiple randomly moving objects. To account for bottom-up effects of distractor stimuli, a separate group of participants will focus their attention to the speech stream while also being presented with concurrent auditory or visual distractor stimuli. Similar to recent work examining the role of focused attention on learning (Batterink & Paller, 2019), we expect the theoretically distinct components of SL to be differentially impacted by diverted attention. Neural entrainment to the component words is expected to occur without the focus of attention, as found by Batterink & Paller, (2019). The largest attentional effect is expected for the explicit rating task, given the well-established finding of impaired explicit memory when attention is diverted at encoding. A smaller attentional effect may be found for performance on the reaction-time based memory task, as implicit learning may be more likely to occur automatically without focused, top-down resources. As well, the greatest reduction in SL should occur when within-domain (auditory) resources are taxed, as compared to when across-domain (visual) resources are taxed. How and whether SL is governed by an attentional bottleneck will offer insights into the nature and underlying mechanisms of SL. At a more applied level, these results will also further our understanding of both the necessary and optimal conditions for adult second language learning.

Topic Areas: Phonology and Phonological Working Memory, Speech Perception

Gesture production during spontaneous speech in left and right hemisphere stroke

Poster A51 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session A.

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Introduction: Co-speech gesture, which naturally occurs alongside spontaneous speech, has received comparatively little attention in post-stroke aphasia. The limited research in post-stroke aphasia has focused on differences in gesture production between persons with and without aphasia. Further, gestures used by persons with aphasia have been exclusively evaluated using semi-structured discourse tasks, such as story retelling or picture description, tasks which do not parallel the co-speech gesturing occuring during an organic narrative (e.g., free speech). Finally, there has been limited research comparing gesture between persons with left hemisphere stroke (and aphasia), and persons with right hemisphere stroke. Methods: In this study, gestures were characterized during spontaneous speech samples from AphasiaBank and RHDBank [Right Hemisphere Damage]. We rated iconic, deictic, and emblematic gestures. Iconic gestures relate to the semantic content of speech and are made up of referential, observer viewpoint, and character viewpoint subtypes. Deictic gestures reference a concrete object in the room. Emblematics are well known, culturally-specific gestures (e.g., nod for "yes"). For each gesture, we characterized informational relationship (how meaning of gesture related to speech: add, disambiguate, redundant, unintelligible) and temporal relationship (how timing of gesture related to speech: gesture first, gesture second, simultaneous, no vocalization). While we rated gestures across three tasks (free speech, a personal narrative about their stroke, and a story retell of Cinderella), here we report preliminary data for only the personal narrative task. Planned Analyses: Our overall goal is to examine the extent to which gesture (by which we mean: frequency, type, informational relationship, and temporal ordering) differs by group and task, and the interaction of group and task. We will simultaneously examine the explanatory power of demographic factors (e.g., physical status [like hemiparesis], language impairment severity, time post-stroke) on these relationships. Results: Preliminary results suggest a difference in gesture frequency and type between our two groups (aphasia, RHD). During the personal narrative task, the AphasiaBank sample (N=265 speakers in total) produced all gestures: iconic gestures (referential, M=2.07±3.64; observer viewpoint, M=0.34±0.89; character viewpoint, M=1.50±2.81), deictic gestures (M=1.47±2.14), and emblem gestures (M=3.11±3.74). The RHDBank (N=16 speakers in total) sample likewise produced all types of gestures, but to a lesser degree: iconic gestures (referential, M=1.35±1.54; observer viewpoint, M=0.35±1.09; character viewpoint, M=2.12±3.21), deictic gestures (M=1.06±2.22); and emblem gestures (M=0.71±1.06). Anecdotally, we found that gestures for both groups tended to be redundant in informational relationship and simultaneous in temporal ordering. We have yet to analyze informational relationships, temporal ordering, or the impact of task; these data will be provided at the conference. Conclusions: This is the largest gesture study, to our knowledge, evaluating these questions. This work has translational implications for assessment and treatment in acquired brain injury.

Topic Areas: Signed Language and Gesture, Disorders: Acquired

Monitoring self-produced speech variability in native and learned languages

Poster A52 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session A.

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Learning to produce new phonetic contrasts in a second language (L2) is challenging because learners are less experienced with new speech targets and may be less sensitive to production errors. When native speakers detect errors in their own speech, they will change their articulation so that their productions better match their targets (e.g. Houde & Jordan 1998). In addition, native speakers correct subphonemic variability in their speech, where less canonical productions undergo greater correction (Niziolek et al. 2013). Here, we present two ongoing experiments that compare the role of auditory feedback while producing L1 (English) and L2 (French). In Experiment 1, we used masking noise to assess the role of auditory feedback in sensitivity to variability in the two languages. Speakers (n=11) produced words in English and French in separate experiment runs. In each 30-trial block, one of three noise levels was presented over headphones to modulate access to auditory feedback while speaking: no noise, soft noise (~60dB), or loud masking noise (~80dB). The stimuli were Eve [iv], eff [ɛf], and add [æd] in English, and Yves [iv], hais [ɛ], and oeuf [œf] in French. The first two formants (F1/F2) were measured in two time windows: vowel onset and vowel midpoint. Speech targets were defined as the median F1 and F2 values in each time window. The Euclidean distance between F1 and F2 measurements in a time window and the target for that window quantified variability on a trial; the third of trials with greatest initial variability were analyzed further. Reduction in variability between first and second time windows defined self-correction. We hypothesized that poorly-defined L2 speech targets would display both greater variability and possibly less self-correction compared with the native language. Preliminary analyses show greater self-correction but also greater variability in both time windows in French than in English, suggesting that self-correction was less successful in L2. Further, variability differences by language varied by noise level: the difference between English and French was largest in quiet and smallest in masking noise. A differential use of auditory feedback in L1 vs. L2 may explain differences in midpoint but not initial variability. The presence of noise may differentially trigger production changes in L1 and L2. In French, there was greatest variability in [œ], a vowel absent from English phonology, supporting the hypothesized relationship between phoneme familiarity and precision. In Experiment 2, we altered auditory feedback in near-real time to investigate feedback-based error correction. Speakers (n=8) produced words in English and French, but unlike Experiment 1, they simultaneously heard their productions over headphones. On 1/3 of trials, F2 was shifted either up or down by 100 mels, creating the perception of an error. Preliminary analyses show an earlier onset of shift-opposing changes in production in L2 than in L1, suggesting a possible stronger reliance on auditory feedback in L2 production than in L1. Results from both experiments suggest that the speech production system may differentially treat auditory feedback in L1 and L2.

Topic Areas: Speech Motor Control, Multilingualism

Examining predictors of stuttered versus fluent speech prior to vocalization with magnetoencephalography

Poster A53 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session A.

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Stuttering is a neurodevelopmental communication disorder that manifests itself, most saliently, as intermittent interruptions in speech production. Despite significant progress towards discovering structural and functional abnormalities in the brains of speakers who stutter, little is known about the neural bases of these interruptions. Neuroimaging studies have typically compared the brain activity of people who stutter with that of fluent speakers during fluent speech, primarily due to the difficulty of reliably eliciting stuttered speech during laboratory testing. These studies reveal general processing differences associated with stuttering but do little to elucidate differences associated with actual stuttering events. Recent functional near-infrared spectroscopy (fNIRS) work (Jackson et al., submitted) has suggested a preparation mechanism – activation in well-known speech and inhibitory regions prior to speech initiation - that may differentiate stuttered from fluent speech. However, fNIRS relies on the “slow” hemodynamic response, leaving the precise timing and dynamics underspecified. Here, we report the preliminary design and pilot data of a magnetoencephalography (MEG) investigation aiming to characterize these dynamics and their relation to stuttering events. Methods: Twenty-five participants will be recruited for participation. Inclusionary criteria will include a diagnosis of stuttering by a certified speech-language pathologist. The experimental protocol will require two sessions. First, participants will complete a stuttering assessment and clinical interview following Jackson et al., (2019) to construct individual “feared” word lists likely to elicit stuttered speech. Second, participants will complete a MEG procedure during which they will produce 300 words from the list constructed in session 1 to best ensure a reasonable number of stuttering events (approximately 40% of the trials) are elicited. Words will be presented on a screen one at a time followed by a preparation cue and a cue to speak. Brain responses will be continuously recorded with MEG and lip muscle activity signalling the initiation of vocalization with electromyography (EMG). Data Analysis: A cross-validation decoding approach will be applied to data from the preparation window to classify an utterance as stuttered or fluent. This approach quantifies the extent to which stuttering can be predicted from responses prior to vocalization, implying atypical planning. Moreover, it can reveal the time point(s), before vocalization onset, at which brain activity differs between subsequently stuttered versus fluent productions. Multivariate logistic regression models will be fit to MEG data at each time point. At time points where robust decoding is found, MEG responses will be projected onto the cortical surface to estimate the generators of abnormal activity. Pilot Results: In pilot testing focused on the MEG and EMG procedures, we used the same recording and analysis paradigm to differentiate one- versus three-syllable words in a control speaker. Recorded EMG activity consistently preceded speech onset, suggesting a reliable marker for speech initiation. The decoding procedure showed promise (65-75% accuracy) in differentiating upcoming one- versus three-syllable productions using a conservative distribution (30% one syllable, 70% three syllables) to match our anticipated proportion of stutter versus non-stutter events. Once possible (due to COVID-19 restrictions), pilot data collection will continue to assess robustness of decoding performance.

Topic Areas: Speech Motor Control, Disorders: Developmental

Effects of choral speech on speech production and sensorimotor adaptation

Poster A54 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session A.

Presenter Note: If you would like to discuss this work further with the lead author (Dr Abbie Bradshaw), please contact: a.bradshaw@ucl.ac.uk.

Abigail Bradshaw[1], Carolyn McGettigan[1], Daniel Lametti[2]; [1]University College London, [2]Acadia University

Self-generated speech auditory feedback is well known to affect speech motor control; however, there is increasing evidence that perception of external speech inputs may also have effects on a speaker's production of speech sounds. We aimed to investigate this idea in the context of choral speech - the act of speaking in synchrony with another speaker. We propose that participating in choral speech with another speaker may engage a mode of speech motor control in which guidance of articulatory speech gestures is less dependent on one's own auditory speech feedback, and more dependent on speech input from the partner's voice. This would be expected to result in phonetic convergence type effects, in which the acoustic-phonetic characteristics of the speaker's voice start to 'shadow' or imitate those of the partner's voice. We plan to test this in two ways. First, using an online choral speech task, participants will be asked to read sentences alone and then in synchrony with a pre-recorded voice. We will manipulate the fundamental frequency (F0) of the pre-recorded voice to gradually increase through the test session. To test for convergence, we will measure in-session changes in the F0 of the participant's productions, and compare these with baseline (solo reading). We predict that the participant's F0 will increase during choral speech to shadow that of the pre-recorded voice, reflecting the use of external speech cues in the updating of speech motor plans. Second, we are planning an in-lab study to investigate the effects of choral speech on speech motor adaptation during an altered feedback experiment. This will use the sentence-level adaptation paradigm developed by Lametti, Smith, Watkins and Shiller (2018), which involves introducing a formant perturbation in self-generated auditory feedback during production of sentences. In this paradigm, participants are found to compensate by changing their production of speech sounds to oppose the perturbation. We predict that speaking these sentences in unison with another speaker will reduce the magnitude of compensation to such perturbations of self-generated feedback. We would interpret this as evidence that choral speech serves to bias speech motor control away from error detection based on internally stored sensorimotor targets, towards an externally cued mode of motor control that relies on auditory targets from the partner's speech input. To rule out an explanation based on general changes related to the task of speaking in chorus (e.g. slowing of speech rate), we would also include a control condition in which participants experienced the feedback perturbation while speaking in time with a metronome. We predict that speaking to a metronome will have no effect on the participant's adaptation response. It is anticipated that the results from this research will have important implications for models of speech motor control, which currently do not explicitly incorporate influences from external speech inputs on speech production. They will also have implications for interpretation of the efficacy of choral speech in inducing fluency in people who stutter.

Topic Areas: Speech Motor Control, Multisensory or Sensorimotor Integration

Functional Connectivity Changes in ECOG during Language Perception and Production

Poster A55 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session A.

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It is well established that resting state network dynamics emerge during cognitive tasks as well as rest. However, it is unclear how these connectivity patterns emerge and change over time during language related tasks and speech production. Here we use Electocorticography (ECoG), with a combined high signal to noise ratio, temporal and spatial resolution to investigate the functional connectivity (FC) during rest compared to language tasks. Seven adult epilepsy patients undergoing intracranial, pre-surgical evaluation completed a prompted rest task and 5 speech production tasks involving auditory (repetition, sentence completion, naming to definition) and visual (picture naming, reading aloud) modalities with matched stimuli across tasks. We used Pearson's r of the high-gamma (70-150 Hz) signal to generate FC correlations between all electrode pairs within subjects, for each task (epoched into stimulus perception and item production) as well as rest. Permutation testing (1000 iteration, $p<0.01$ threshold) was used to test for significant electrode pair FC (r values) change from rest. Speech perception correlated with increased FC between left SFG and left IFG as well as within left IFG, MTG and STG (range of .79 to .82 increase in r compared to rest). Speech perception and production generated strong changes between the left IFG and STG, as well as left IFG and left inferior parietal cortex (average increase in r >1 compared to rest). Speech production related FC increased from rest between the precentral gyrus with STG, and precentral and inferior/superior-parietal areas (r increase ranging between .78 and 1.2). These findings implicate the dependence of sensory-motor interactions on high frequency network coordination increasing from rest. The pattern of connectivity appears to move from networks including STG and IFG for perception, independent of task, and then continues on to STG and parietal areas for speech production.

Topic Areas: Speech Perception, Language Production

Tracking the impact of fMRI acoustic noise on spoken word recognition

Poster A56 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session A.

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Background. Functional magnetic resonance imaging (fMRI) generates loud acoustic noise that affects brain activation patterns, decreases task performance, and increases listening effort and discomfort (Healy et al., 2007; Peelle, 2014). In spite of this, continuous scanning paradigms are common in fMRI studies of auditory language comprehension (Adank, 2012) due to other advantages (e.g., efficiency of data collection). Understanding the effects of scanner background noise (SBN) on auditory language comprehension may help researchers weigh these factors. In this study, we used in-scanner eye-tracking to investigate the effects of SBN on spoken word recognition. We hypothesized that SBN would slow word recognition and alter the time course of phonological competition effects. Methods. Five young adults participated. In each trial, they saw four object pictures, heard a word, and clicked on the matching (target) picture. The pictures remained on-screen until trial end (2.24 seconds after word onset). There were four blocks, each with 32 onset-competitor trials (containing the target picture (e.g., letter), a competitor with the same onset (e.g., lemon), and two unrelated pictures), 32 rhyme-competitor trials (e.g., carrot, parrot), and 32 no-competitor trials. Two of the blocks were presented with SBN (due to concurrent fMRI data collection) and two in Silence. The right eye was tracked at 1000 Hz. Eye-tracking data were analyzed using generalized additive mixed models (GAMMs; Porretta et al., 2018; Wood, 2017). Binomial GAMMs were estimated for each condition for the time period starting at word onset and ending at trial end. The response variable was target advantage, i.e., whether the target picture or another picture was fixated. The predictor variables were smooth curves for SBN and Silence and crossed random effects. Significant effects of SBN were identified when the 95% confidence intervals of the modeled difference curve (SBN-Silence) excluded zero (e.g., Porretta et al., 2018). For purposes of interpretation only, we characterize significant effects as occurring during the word window (from word onset to mean word offset: 0.715 seconds), post-word window (from 0.715 seconds to the grand mean RT, 0.98 seconds) or post-response window (from 0.98 seconds to trial end). Results. For the onset-competitor and no-competitor conditions, target advantage was significantly greater in Silence vs. SBN during portions of the post-response window only (Onset-competitor: 1.34-2.24 seconds; no-competitor: 1.3-2.24 seconds). For the rhyme competitor condition, target advantage was significantly greater in SBN at word onset (0-0.36 seconds); this effect starts too early to reflect word processing and instead most likely reflects noise in the data. Target advantage was greater in Silence during portions of the post-word and post-response regions (0.72-2.04 seconds). Conclusion. In our small sample, SBN did not significantly slow the early stages of word recognition. However, SBN was associated with increased rhyme competition after word offset (cf. Ben-David et al., 2011; Brouwer & Bradlow, 2011; McMurray, Farris-Trimble, & Riegler, 2017). Robust post-response effects suggested that SBN may increase participants' uncertainty about their responses. If confirmed in a larger sample, these findings may inform decisions about when to use continuous scanning for studies of auditory language processing.

Topic Areas: Speech Perception, Methods

Semantic integration of audiovisual-words and pictures in in hearing and deaf children using cochlear implants: an N400 experiment

Poster A57 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session A.

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The development of lexical representations depends on the ability to associate word forms to conceptual semantic knowledge. Semantic integration, however, might be affected by a lack of auditory input early in life, as in the case of children with hearing-loss who later receive cochlear implants (CIs). In this study we measured event-related potentials (ERPs) during a word-picture priming task in normal-hearing (n = 18, mean age = 77 mos) and CI-using deaf children (n = 25, mean age = 82 mos). Children saw pairs of audiovisual-word primes and picture targets that were either semantically related or unrelated, while EEG activity was recorded. In hearing children, semantic relatedness modulated ERP amplitude in a window of 300-500ms after picture onset. More negative responses were elicited to unrelated word-picture pairs than related pairs (p = .0175). This effect was mirrored in deaf children with CIs (p < .001). In both groups, negativity was greatest in anterior channels, consistent with previous findings reporting N400-like responses to pictorial stimuli. Importantly, the deaf children's responses to unrelated pairs were significantly more negative than hearing children's responses (p = .008). We evaluate these findings in relation to individual characteristics of the participants including chronological age and time-in-sound and group differences in electrophysiological responses to the audiovisual-word primes. Preliminary results indicate greater processing costs for the integration of verbal and nonverbal semantic information in deaf children using Cis. This study informs our understanding of the development of cognitive and linguistic abilities in deaf children.

Topic Areas: Development, Disorders: Developmental

Microstructural integrity of crucial white-matter tracts for category fluency in elderly with cerebral small vessel disease

Poster A58 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session A.

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Recent studies have suggested that language production abilities decline in patients with small vessel disease (SVD) a pathology that is one of the main contributors of cognitive impairment in older adults. The loss of microstructural integrity in multiple white-matter fiber pathways has been previously associated with cognitive problems in people with SVD. Our previous work has shown that the presence of white matter lesions (WML), the most common neuroimaging marker of SVD, at the intersection between the anterior thalamic radiations (ATR) and forceps minor (FM) was associated with lower performance in Category Fluency in patients with SVD. Notably, the presence of WML is just a small part of a bigger problem as damage to white matter fibers can occur in areas remote from the location of WML. Importantly, evidence is lacking on whether performance in the Category Fluency test is associated with lower microstructural integrity in the ATR and FM. In addition, the uncinate fasciculus (UF), a ventral white-matter tract relevant for language, overlaps anteriorly with the ATR and FM and is therefore of interest for the present investigation. Our aim was to assess the association between Category Fluency scores and measures of microstructural integrity in ATR, FM and UF in patients with SVD. Diffusion tensor imaging is a suitable technique to investigate changes in the integrity of white matter fibers. We obtained a measure of microstructural integrity by quantifying fractional anisotropy (FA) and mean diffusivity (MD) by using TRActs Constrained by UnderLying Anatomy (TRACULA). The total mean FA and MD were calculated for FM, left and right ATR and UF in 221 patients with SVD (101 women, mean age 70.1). Mean diffusivity in FM ($p = 0.000$), in left ($p = 0.019$) and right ATR ($p = 0.004$), and in left ($p = 0.034$) and right UF ($p = 0.013$) were associated with worse Category Fluency scores. FA in FM, ATR and UF was not statistically associated with Category Fluency scores ($ps > 0.05$). In line with previous studies, we find that MD is a more promising biomarker of microstructural integrity in SVD relative to FA. The present findings extend our previous results, confirming an important role for FM and ATR for Category Fluency abilities in patients with SVD, and provide evidence for a link between microstructural integrity in FM, ATR and UF and the language decline in SVD. Our results have potential clinical implications in revealing an overlooked deficit in SVD and in suggesting a critical role of the integrity of FM, ATR and UF in this population.

Topic Areas: Disorders: Acquired, Language Production

Evaluating laterality of spoken word recognition and basic composition in adults and children with MEG

Poster A59 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session A.

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[INTRODUCTION] Current models of the neural organization of language provide little insight into the developmental trajectory by which our brains reach this organization. While it is possible that the cortical organization found in adulthood exists from birth or early childhood (Skeide & Friederici, 2016), a recent meta-analysis of fMRI studies on 3-15 year olds (M age= 8 years, 10 months) suggests a more bilateral neural basis without left hemispheric specialization for speech comprehension in children than in adults (Enge et al., 2020). We report an evaluation of this hypothesis using MEG, allowing us to characterize the timing of possible laterality differences. We focus on the superior temporal gyri (STG), which have been linked to discerning speech sounds in the adult brain (Binder et al., 2000; Mesgarani et al., 2014). However, our sample is small and the results are preliminary. This is an ongoing study; data collection is paused because of COVID-19. [METHODS] 12 adults (M age= 34 years, 2 months) and 7 children (M age= 9 years, 2 months) participated in several tasks within a larger protocol measuring the spatiotemporal profile of lexical access and basic composition between groups. The present results are from a task that mimics real-life dialogue: participants “converse” with the computer by taking turns to name objects on the screen. Trials start with a picture of two colored objects. The participant hears a description of one object, and then names the other object aloud. This “naming game” is played either with adjective-noun descriptions (green glass) or noun-only descriptions with the speech sound “mmm” replacing the adjective (mmm glass). Thus, our results reflect comprehension within this interactive context as compared to our baseline condition, where the computer remains silent after showing the picture.

Left and right STG (BA 22) time courses were analyzed with temporal cluster permutation tests during the first (0-875 ms) and second word (875-1750 ms) time windows, determining whether activity was (i) increased for speech sounds, (ii) increased for words and (iii) increased in the presence of composition. [RESULTS] LEFT: In adults, early auditory responses in both word time windows were increased for sound over silence, but most robustly for adjectives over non-lexical “mmm” in the first. Children showed no left STG effects of the stimulus manipulation. RIGHT: In adults, early auditory responses in both positions were again increased for sound over silence, but with less sensitivity to the presence of lexical or combinatory content. Children showed this same pattern at the first stimulus, though slightly later in time. On the second stimulus, children showed a clear three-way contrast, with more activity for words than silence and for words in the combinatory context than when preceded by “mmm”. [CONCLUSION] Our design was developed to elicit a three-way contrast between silence, words, and phrases. So far, we observe this pattern in adults in the left hemisphere and in children in the right hemisphere. While there appears to be a contrast in laterality between adults and children; here, children appear surprisingly right-lateral as opposed to bilateral.

Topic Areas: Perception: Speech Perception and Audiovisual Integration, Development

Poster Session B

Neuromodulation of verb-transitivity judgments

Poster B1 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session B.

Presenter Note: Contact information Dirk den Ouden (University of South Carolina): denouden@sc.edu; 803-777-9241 Biweekly lecture series on the neurobiology of language and recovery from aphasia, organized by the Center for the Study of Aphasia Recovery (C-STAR): https://cstar.sc.edu/lecture-series/

Dirk Den Ouden[1], Michael Zhu[1]; [1]University of South Carolina

Introduction: Left inferior frontal brain areas are important for sentence production as well as action naming, but neuroimaging research also links left posterior temporal cortex to knowledge of verb argument structure (VAS) and syntactic processing in general. VAS reflects the number of people or objects a verb is associated with. For example, "to cough" only requires one argument (‘John coughs’), whereas a verb like "to paint" requires two arguments (‘John paints the wall’). Verbs with a greater number of arguments have been shown to impose a greater processing cost in single-word-level as well as sentence-processing tasks. By contrast, other studies show behavioral facilitatory or null effects of increased argument numbers. Such studies often employ shallow processing tasks, like lexical decision, which may not require access to all VAS components. The current study used a task that taps into participants’ conscious knowledge of VAS, and trained this under conditions of High-Definition transcranial Direct Current Stimulation (HD-tDCS) of left inferior frontal gyrus (IFG) versus posterior superior temporal gyrus (pSTG). We hypothesized that specific involvement of a brain region in conscious access to VAS information would be reflected in qualitative effects on task performance after neuromodulation. Methods: In a between-subjects design, forty-five students (32 females, 13 males; mean age 20.3yrs; range 18-27) were split into three groups, for Sham, IFG, and pSTG stimulation. Participants responded to orthographically presented verbs on a screen, by pressing one of three buttons, labeled “1”, “2”, or “3”, to indicate whether the action of the verb required one, two, or more participants or objects. Participants were first trained on the task, with examples that did not return in the experiment. The task drew from 40 intransitive, 40 transitive, and 20 ditransitive verbs. Half of the stimuli were presented prior to stimulation, and the other half were presented after stimulation. No performance feedback was provided during these blocks. During the 15-minute stimulation session, all items were repeatedly presented in random order, followed by performance feedback (correct/incorrect). Cathodal HD-tDCS was administered with 1x4 electrode configurations targeting left-hemisphere IFG and pSTG, with a maximum intensity of -1mA. In the Sham condition, current was only applied for 1 minute. Response times were entered into a linear mixed-effects regression analysis, in a fully interactive model with the variables Block (pre vs post stimulation), Target (Sham vs IFG and pSTG stimulation), and VerbType (intransitive vs transitive and ditransitive). Accuracy data were entered in a mixed-effects logistic regression analysis, using the same model. Results: Stimulation of left-hemisphere IFG resulted in significant behavioral interactions, with responses to intransitive verbs speeding up to a greater extent than responses to transitive verbs, and responses to transitive verbs gaining in accuracy more than responses to intransitive verbs. Stimulation to pSTG, like sham stimulation, only resulted in a general speeding up of responses, coupled with reduced accuracy, without differential effects between verb types. Conclusion: These results suggest that left-hemisphere IFG supports access to VAS information, either directly from lexical representations, or indirectly through conscious interpretation and sentence projections.

Topic Areas: Syntax, Control, Selection, and Executive Processes

Neuroanatomical and functional characterization of human laryngeal motor cortex

Poster B2 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session B.

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INTRODUCTION: Several lines of evidence suggested that vocalization evokes activity in both a dorsal and a ventral region of the central somatomotor region in the human brain (1). Whether one or both of these representations specifically controls laryngeal activity and their precise functional roles remain debated. We set out to characterize the cortical representations of the larynx in the human brain using anatomical and functional studies. We determined the location of larynx-related neural activity and quantified the cortical structure underlying both larynx representations (2). Next, we examined whether variability in sulcal morphology explains variability in the locations of these representations (3). Using non-invasive brain stimulation, we started exploring the functional contribution of the dorsal larynx representation to pitch control. METHODS: In a group of healthy adults (n=20), we acquired structural data (T1w, T2w), quantitative multi-parameter maps (4) and functional MRI data. Sulcal morphology was examined in additional data provided by the Human Connectome Project (5) (n=30). To functionally localize larynx activity during vocalization, we used a factorial design with orthogonal main contrasts for vocalization and articulation during syllable production (6). The breathing patterns were matched across all conditions. We also obtained basic localizers for the hand, lips, and tongue. Using surface-based labelling, we identified segments of the central sulcus and the subcentral sulci in individuals (7). To characterize morphological variability, we generated spatial probability maps. Next, we examined the spatial relationships between task activation peaks and the sulcal segments. To study the functional contributions of the dorsal larynx representation, we piloted the use of online repetitive transcranial magnetic stimulation (TMS) in a pitch production task. RESULTS: We found that two distinct brain regions activated during vocalization: a dorsal and a ventral larynx representation. The dorsal-to-ventral somatotopic pattern in motor cortex ('hand-dorsal larynx–lip-tongue-ventral larynx') was consistent across individuals. Quantifications of cortical microstructure showed that the dorsal larynx activation is located in highly myelinated and thick cortex, similar to the other primary motor representations. In contrast, the ventral larynx representation has lower myelin and thinner cortex, indicating that it is not located in primary motor cortex. We observed a tight link between sulcal morphology and the location of fMRI peaks. The anatomy of the subcentral region, where the ventral larynx area is located, was highly variable across subjects explaining, in part, the functional variability. Only preliminary TMS data were obtained thus far. CONCLUSION: We demonstrated that the human brain contains a dorsal and a ventral larynx representation. We suggest that the dorsal larynx representation is the primary locus of laryngeal motor control, while the ventral larynx area relates to secondary activations in non-primary motor cortex. High inter-individual variability of underlying anatomy might explain previous inconsistent findings regarding the larynx areas, in particular the ventral one. The different functional contributions of both areas remain unclear. REFERENCES: 1---Belyk. & Brown (2017) NeurosciBiobehavRev 2---Eichert et al. (2020, accepted) CerebCortex 3---Eichert et al. (2020). bioRxiv 4---Weiskopf et al. (2013). FrontNeurosci 5---Van Essen et al. (2013). NeuroImage 6---Murphy et al. (1997) JApplPhysiol 7---Germann et al. (2019). CerebCortex

Topic Areas: Speech Motor Control, Language Production

Print Exposure, not ASL comprehension, predicts silent contextualized reading fluency in Deaf college students

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Many Deaf individuals who use a sign language—soundless, natural languages that do not directly map to written languages—are nonetheless able to learn to read written text (Petitto et al., 2016). The performance of Deaf readers, however, is variable, and there is interest in identifying factors that contribute to a Deaf individual's ability to read fluently. Previous studies have shown that factors such as age of American Sign Language (ASL) exposure, ASL fluency, and fingerspelling skill significantly predict Deaf individuals' reading fluency (Stone et al., 2015). What other possible factors beyond those variables could contribute to their reading fluency? The Author Recognition Test (ART) is a list of author and non-author names given to participants with instructions to scan the list and pick out names recognized as authors (Moore & Gordon, 2015). Past studies have shown the ART to be a reliable predictor of reading-related variables (e.g. word recognition, reading volume, and cultural literacy) in hearing adults [Moore & Gordon, 2015) and children (Mol & Bus, 2011). Here, we ask whether ART performance predicts reading fluency above and beyond age, non-verbal IQ (NVIQ), age of ASL exposure, and ASL comprehension ability in a sample of 44 Deaf college students. Participants completed the K-BIT 2 matrices subtest (NVIQ), the latest version of the ART (Moore & Gordon, 2015), the Test of Silent Contextual Reading Fluency (TOSCRF-2), and the ASL Comprehension Test (ASL-CT) (Hauser, et al., 2015). Data were analyzed using a three-stage hierarchical multiple regression to determine whether the addition of age of ASL exposure and then ART score improved prediction of reading fluency over and above age and NVIQ score alone. Our baseline model entered age and NVIQ as predictors of reading fluency. This model was statistically significant ($F(2,43)=3.36$, $p<.05$, $R2=0.14$) with NVIQ a significant predictor of reading fluency (beta=0.30). At the next stage, we entered age of ASL exposure and raw ASL-CT scores as additional predictors. This did not significantly improve the model ($R2$ change=0.06, $p<.05$). Neither age of exposure nor ASL-CT scores predicted reading fluency. Finally, the addition of ART scores resulted in a significantly improved model ($R2$ change=0.20; $F(5,43)=5.18$, $p=.001$, $R2=0.41$) with ART scores being a significant predictor of reading fluency (beta=0.47). After controlling for age and NVIQ, age of exposure to ASL and ASL comprehension scores did not predict reading fluency in a sample of 44 Deaf college students. However, after controlling for age, NVIQ and ASL exposure/comprehension, we found that an index of print exposure (i.e. ART) did significantly predict reading fluency as measured by the TOSCRF-2. We suggest that early exposure to ASL and healthy linguistic development in the sign modality may scaffold English print comprehension, as suggested by previous work, but that it is the act of reading itself that allows Deaf individuals to develop better silent contextualized reading fluency. Our work emphasizes both the importance of early natural language exposure for Deaf children, and the importance of fostering consistent reading habits. Funded by NIH.

Topic Areas: Signed Language and Gesture, Reading

Time in language: past and future are differently processed and both verbs and adverbs matter

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Existing accounts suggest that past is more complex than non-past (i.e. future, present) processing, because past interpretation needs a link to a time specified in the discourse context (Bastiaanse et al. 2013; Zagona, 2003). Evidence for the past-present dissociation has been provided, but it is yet unclear whether past and future differ. Both past and future imply the displacement of an event outside the "now". Yet, interpretively, past refers to real/inalterable events, while future to abstract/alterable events and possible worlds (Comrie, 1985; Bochnack, 2019). In this study, in Spanish, past and future processing was tested in isolated tensed verbs, using a tense decision task (TDT), and within a sentence with past/future temporal adverbs followed by mis/matching verbs, using eye tracking (ET). Longer reaction times and earlier mismatch effects were expected for past compared to future. The role of adverbs in temporal processing is also unclear. Adverbs, albeit syntactically optional, convey relevant information: deictic adverbs (e.g. "last/next year") provide defined past/future time frames, as opposed to the undefined frame of non-deictic adverbs (e.g. throughout the year). We thus contrasted the effect of deictic/non-deictic adverbs on the reading of past/future-tensed verbs in sentences. Deictic adverbs were expected to facilitate past and future verb's (first-pass) reading compared to non-deictic adverbs. In the ET experiment (N=60), verb tense was manipulated (96 experimental sentences, 122 fillers) to match/mismatch the time reference set by a deictic adverb ("Gracias a la beca, EL AÑO PASADO(deic-adv.past)/EL PRÓXIMO AÑO(deic-adv.fut) los investigadores PROGRESARON(past)/PROGRESARÁN(fut) en sus estudios", Thanks to the scholarship, last year/next year the researchers progressed/will progress on their studies). To assess the role of adverbs, the correct deictic past/future sentences were compared to a set of non-deictic past/future sentences ("[…]DURANTE EL AÑO(nondeic-adv) los investigadores PROGRESARON(past)/PROGRESARÁN(fut)[…]", […]throughout the year the researchers progressed/will progress[…]). Afterwards, the same participants performed the TDT, by categorizing past and future verbs (96 experimental, 96 fillers) presented in isolation. Separate linear mixed-effect model analyses were performed to assess the effect of past/future reference violations and of deictic/non-deictic verbs, as well as differences in the categorization of past/future verbs. In the TDT past took longer than future categorization; in the ET experiment, past-reference violations yielded effects on the verb from the first pass on, while a reliable effect of future-reference violations emerged only in total time, as predicted. Unexpectedly, future verbs triggered longer go-past and total reading times compared to past verbs, in (non-/deictic) grammatical sentences. Deictic adverbs did not facilitate verbs' reading. Rather, higher regression probabilities to the adverb were found in the presence of non-deictic adverbs and mismatching verbs. These findings show that past and future are differently processed, but this difference cannot be limited to the presence/absence of discourse-linking. We claim that future's longer reading times in sentences (compared to isolated verbs) and delayed mismatch effects (compared to past) are related to a more abstract and alterable temporal representation of future events. The greater probability of regressions to the adverb region suggests that temporal adverbs influence reanalysis routines rather than facilitating initial verb reading.

Topic Areas: Reading, Morphology

From letter strings to complex concepts: A magnetoencephalography study of reading

Poster B5 [Poster PDF] [Poster Tour] Visit me at [Gather.Town] in the Broca room during Poster Session B.

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Language comprehension relies on the recognition of words and the combination of their meanings to yield complex interpretations (i.e., a phrase or sentence). This process often requires inferences regarding the semantic relations between words (e.g., apartment dog is a dog that lives in an apartment), with different relations relying on distinct types of knowledge (e.g., taxonomic vs. thematic; Wisniewski, 1997). Although recent evidence suggests a neural dissociation between these relations, with feature relations relying on the left anterior temporal lobe (ATL) and thematic relations on temporoparietal cortex (TPC; Boylan et al., 2017), the

details remain underspecified, particularly with regard to timing and connection to earlier sensory processing. Here, we used magnetoencephalography (MEG) to carefully study neural responses to word combinations that varied the type of relation between composing words in visual reading. Participants read two-word phrases consisting of container-denoting head nouns modified by a preceding word to specify their color (green cabinet), material (steel cabinet), or contents/function (trophy cabinet). This facilitated the comparison of combinations specifying a visual feature (color/material) vs. a spatial/functional relation (contents). Motivated by accounts of semantic representation positing a ventral ATL hub that integrates color and shape information (Coutanche & Thompson-Schill, 2015), we also included a letter-string response localizer to isolate ventral stream responses in word recognition and assessed where along this stream feature/relation information modulated responses. Methods: Twenty-eight native English speakers completed three MEG procedures to probe the processing of (i) letter strings; (ii) adjective-noun phrases; (iii) noun-noun combinations that varied semantic relations. On each trial, participants passively viewed stimuli or responded to a subsequent picture to indicate whether it matched the word(s) on that trial. MEG data were converted to estimates of activity on each participant's cortical surface using minimum norm estimates. Region of interest analyses focused on the responses of the left ATL and TPC, and functional regions along the ventral visual stream. Results & Conclusion: Replicating previous work, we observed a series of letter-sensitive responses spanning left occipital cortex to the ventral ATL, 100 to 250 ms after stimulus onset. The most anterior of these also showed a sensitivity to simple combinations of color adjectives and nouns, displaying greater responses to their combination than lists of two non-combining words ($p < 0.001$). Similar responses to adjective-noun combinations were observed in the lateral ATL (150-300 ms, $p < 0.0021$) as were individual word frequency effects (250-300 ms, $p < 0.0127$). Finally, only temporoparietal cortex differentially responded to the type of semantic relation between words, with increased responses to the modification of a noun's function or contents (150-300 ms, $p < 0.0004$). Together, these results suggest a detailed characterization of how the brain's reading system supports the construction of multi-word concepts: Ventral stream responses underpin a forward pass of signal to the ATL where feature-based information can be used to construct meaning as early as 150 ms after word onset, while neural activity in left temporoparietal cortex is recruited, at approximately the same time, when word combinations require thematic (i.e., spatial/functional) linking relations.

Topic Areas: Reading, Meaning: Combinatorial Semantics

What's in a Game: Visual-spatial changes in video games are associated with endogenous attentional cuing and phonetic decoding

Poster B6 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session B.

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Introduction: Research by Franceschini et al. (2015) has suggested action video game experience can improve reading ability, but the reason for this relationship has not been fully explained. Some studies have demonstrated behavioural links between action video game experience and visual-spatial attention (e.g., Green & Bavelier, 2003) and our lab has identified neurobiological links between visual-spatial attention and reading processes whereby endogenous attention and phonetic decoding share dorsal stream regions whereas exogenous attention and lexical reading share ventral stream regions (Ekstrand et al. 2019). The current study investigates whether visual-spatial changes in video games played by our participants are related to behavioural endogenous cuing effects in a hybrid spatial attention/reading task. Given our previous neuroimaging research, one would expect that central endogenous attentional cuing effects during phonetic decoding (both dorsal stream processes) should show stronger associations to game-specific centrally located visual-spatial changes than peripherally located visual-spatial changes. Methods: Twenty-two participants completed an 8-location hybridized endogenous attention/reading task where a location cue (e.g., NW, 75% cue validity) was followed by a target that required either lexical reading (exception word; EXC; e.g. 'yacht') or phonetic decoding (pseudohomophone; PH; e.g. 'yawt'). At the end of the experiment, participants reported their most frequently played games and time spent playing these games. Brief gameplay videos from each game reported were analysed for the frequency of four types of visual-spatial changes. Central graphical changes (CG) were defined as the average number of graphical changes per minute within a 3.5cm radius from the centre of the screen (corresponding to the foveal area), peripheral graphical changes (PG) were defined as the graphical changes per minute that occurred outside this radius, central textual changes (CT) were text based changes within the 3.5 cm radius, and peripheral textual changes (PT) were text based changes outside this radius. Results: 58 games were reported by participants and 39 games have had visual-spatial change analysis completed at this time. Each participants' "Sum Score" for each visual-spatial change was calculated as Σ(monthly hours for each reported game * visual change score for each reported game). CT Sum Score was correlated with PH cuing effect ($r = 0.453$, $p = 0.034$). CG Sum Score was correlated with PH cuing effect ($r = 0.487$, $p = 0.022$). PT Sum Score was correlated with PH cuing effect ($r = 0.477$, $p = 0.025$). In summary, the magnitude of the PH cuing effect increases as a function of increases in CT, CG, or PT Sum Scores. Conclusion: These results suggest that video game experience may be related to reading performance through the attentionally demanding visual changes of video games. The correlation between visual-spatial changes in games played and PH cuing effect is consistent with our previous neuroimaging research which demonstrated overlap between PH reading and endogenous attention regions of the brain (Ekstrand et al., 2019), and extends it to the behavioural level. Future studies will examine the role of visual-spatial changes in video games in exogenous attentional cuing and lexical reading (both ventral stream processes).

Topic Areas: Reading, Control, Selection, and Executive Processes

Effect of excitatory and inhibitory theta burst stimulation (TBS) on resting state connectivity

Poster B7 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session B.

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Introduction. Repetitive transcranial magnetic stimulation (rTMS) is a focal, noninvasive brain stimulation method that can induce cortical plasticity. High frequency rTMS protocols, such as intermittent theta burst stimulation (iTBS), are delivered in short intervals to facilitate neuronal responsiveness in the stimulated area of the cortex. In contrast, low frequency rTMS protocols, such as continuous theta burst stimulation (cTBS), are delivered in continuous trains to inhibit neuronal responsiveness. The purpose of this study was to understand the modulatory effects of excitatory and inhibitory TBS applied to the left anterior supramarginal gyrus (LaSMG), on the behavioral performance and functional connectivity within and between the left hemisphere and right hemisphere homologous brain regions. LaSMG is part of the brain network involved in processing of phonology and intact phonological processes are essential for skills such as writing and reading. Resting-state functional connectivity (rsFC) provides direct robust measures of interregional interaction, and it can be used to understand the modulatory effects of iTBS on neuronal communication across regions. Methods: Ten, right handed healthy adults (Age: M=25 years, SE=3.14; Education: M=16.68 years, SE=0.79) underwent iTBS, cTBS, or sham to the LaSMG. The sessions were separated by at least seven days to avoid interference from different stimulation types. Immediately before and after each TBS session, participants performed an auditory minimal-pairs same/different judgement task and underwent a 6-minute resting-state fMRI scan. Accurate discrimination on the judgement task required participants to detect small phonological contrasts at the word offsets (e.g., an-and vs. an-ant). The processing of minimal phonological contrasts was supposed to engage phonological processing. Results: iTBS to the LaSMG decreased reaction times on the auditory version of the same/different task for words with consistent phonology (both words: and-an and nonwords: feep-fipt), $t(8) = -2.392$, $p = 0.04$. The accuracy was not modulated by iTBS because healthy controls were already at ceiling. In contrast, cTBS increased reaction times and decreased accuracy on the more difficult phonological contrasts in the same individuals ($t(8)= 2.40$ $p=0.02$) but did not modulate performance on the easier inconsistent phonological contrasts (e.g., ant-an). Analyses of resting-state functional connectivity revealed that iTBS decreased connectivity between the left and right aSMG. In contrast, cTBS increased connectivity between these left and right hemisphere regions. These results indicate that TBS to the localized brain region induces transient reorganization in functional connectivity. Conclusions: The results indicate that TBS to the localized brain region modulates behavioral performance and induces transient changes in the interhemispheric connectivity. The exact pattern of functional connectivity differed for stimulation with excitatory and inhibitory pulses.

Topic Areas: Phonology and Phonological Working Memory, Perception: Speech Perception and Audiovisual Integration

Cortical thickness of the left ventral stream is predictive of long-term retention of phonologically related pseudowords in children

Poster B8 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session B.

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Introduction: The ability to learn new words is critically related to the development of reading and language comprehension skills, and is compromised in children with reading and language deficits. In a recent study (Malins et al., 2020), we observed that the ability to learn and remember a spoken artificial lexicon (SAL; Magnuson et al., 2011) of pseudowords differed between typically developing children (TD), children with reading disability (RD-only), and children with reading disability and developmental language disorder (RD+DLD). Differences between learner groups were especially prominent when the words shared onset or rhyme with other items in the learned set (e.g, pibu in relation to pibo or dibu). In addition to these results, we previously observed that reading skills and vocabulary were associated with the magnitude of SAL consolidation effects, measured with fMRI, in several brain regions (Landi et al., 2018). Methods: In the current study, we evaluated the association between brain structure (measured using structural and diffusion MRI) and word learning and retention measures in 113 children who participated in Malins et al. (2020). In this paradigm, participants are presented with pairs of pictures of unusual animals, and learn to associate these with spoken labels, receiving feedback on each trial. Extending upon our previous analyses, we assessed whether subcortical volume, cortical thickness, and fractional anisotropy were associated with learning and retention over a short interval (overnight) as well as a longer interval (after five months). For this analysis, we selected the set of brain regions identified in Landi et al. (2018) as well as several regions and tracts implicated in meta-analyses of reading and language development. Results: We observed that long-term retention of item pairs sharing onset (e.g., pibu-pibo) was significantly associated with cortical thickness of the left inferior temporal gyrus and the left fusiform gyrus, both of which are located in the ventral stream and have been previously associated with reading development. This relationship held when including the following predictors in the model: age, learner group (TD, RD-only, RD+DLD), time elapsed between testing sessions, and total gray matter volume. Conclusion: These findings suggest that the thickness of regions involved in word recognition is predictive of long-term retention of newly learned words over time, especially when these words are phonologically similar. This motivates future work concerning how developing brain networks support the organization of new word knowledge in children. References Landi, N., et al. (2018). Neural representations for newly learned words are modulated by overnight consolidation, reading skill, and age. Neuropsychologia, 111, 133–144. Magnuson, J. S., et al. (2011). Phonological instability in young adult poor readers: Time course measures and computational modeling. In P. McCardle, B. Miller, J. Lee, & O. Tseng (Eds.), Dyslexia Across Languages: Orthography and the Brain-Gene-Behavior Link (pp. 184–201). Baltimore, MD: Paul Brookes Publishing. Malins, J.G., et al. (2020). Is that a pibu or a pibo? Children with reading and language deficits show difficulties learning and remembering phonologically similar pseudowords. Developmental Science.

Topic Areas: Phonology and Phonological Working Memory, Disorders: Developmental

More than words: The online orchestration of prosody, mouth movements, and gesture during real-world language comprehension

Poster B9 [Poster PDF] [Poster Tour] Visit me at Gather.Town in the Broca room during Poster Session B.

Presenter Note: A preprint can be found at https://www.biorxiv.org/content/10.1101/2020.01.08.896712v2. Please contact Ye (y.zhang.16@ucl.ac.uk) if you want to know more about our research!

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Introduction The human brain supports communication in face-to-face environments where spoken words are embedded in linguistic discourse and accompanied by multimodal cues. Research has shown that prior discourse but also prosody, mouth movements, and gestures individually contribute to comprehension. In electroencephalography (EEG) studies, more predictable words show reduced N400 activity, indicating easier processing. Meaningful gestures and prosody also reduce N400, while effects of rhythmic gestures and mouth movements remain unclear. However, while previous studies have used a reductionist approach therefore focusing on individual cues, in real-world communication cues co-occur. In two separate EEG experiments, we investigated and then replicated whether and how naturally occurring multimodal cues modulate language comprehension. Methods In both experiments we measures the EEG responses while participants watched videos of a speaker producing short naturalistic passages. For each word, we quantified: information carried by linguistic discourse (surprisal), prosody (mean pitch), mouth informativeness (behavior task), and presence of meaningful and/or rhythmic gestures (expert coders). We first located the EEG time-window sensitive to the change of discourse using hierarchical-LInear-MOdeling (LIMO). We then extracted the averaged ERP in this time-window (300-600ms, N400) per word. To investigate whether and how multimodal cues modulate the processing of linguistic discourse, we used linear-mixed-effect regression (LMER) analysis with the N400 amplitude as dependent variable, and the above cues and their up to three-way interactions as independent variables. Forty-one participants were recruited in Experiment 1 and 24 in Experiment 2 (replication). Different materials were used in each study. Results In both experiments, we found that discourse affected processing in a 300-600ms time-window in LIMO analysis, replicating past N400 studies. LMER in this time-window, addressed three questions: (1) are multimodal cues central to language processing? We found that higher pitch and meaningful gestures reduced N400 (beyond the effect of discourse) suggesting less predictable words are easier when these cues are present. In contrast, rhythmic gestures increased N400 amplitude. (2) Does the brain dynamically weight each cue depending on the other cues? We found that cues interacted: higher pitch increased the effect of cues on N400, while co-occurrence of highly informative mouth movements and meaningful gestures brought less N400 change. (3) Is there a hierarchy among the cues? Prosody showed the most extensive effect, modulating the processing of other cues. Whereas, effects of hand gestures and mouth movement are less extensive. Conclusion Our study investigated language processing in its naturalistic multimodal environment for the first time, and provided novel and robust evidence that, first, multimodal cues have a central role in processing as they always modulate processing of linguistic discourse; second, they dynamically interact among one another and with linguistic cues to shape language comprehension; and finally, cues are not equal but are organised in a hierarchical manner. More generally, our study provides a new, more ecologically valid, way to understand the neurobiology of language, in which multimodal cues are dynamically orchestrated.

Topic Areas: Multisensory or Sensorimotor Integration, Meaning: Discourse and Pragmatics

ERP signatures of suppression of a task-irrelevant language in bilingual word recognition

Poster B10 [Poster PDF] [Poster Tour] Visit me at Gather.Town in the Broca room during Poster Session B.

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Previous studies suggest that bilinguals can quickly identify the language to which a word belongs and use this information to suppress a task-irrelevant language at the global level. Research also suggests that language activations depend on the language mode of the current setting, such as the amount of each language present in the input. The current study aimed to establish the locus of language suppression at lexical and/or semantic levels of abstraction. Additionally, we aimed to assess whether increasing the proportion of the task-relevant (target) language enhances suppression of the task-irrelevant (nontarget) language. 32 Spanish-Basque bilinguals made simultaneous language membership and semantic classification decisions on Spanish and Basque words during electrophysiological (EEG) recording. Frequency and concreteness were orthogonally manipulated within each category of words (Spanish/Basque, Living/Non-living), and the proportion of words belonging to each language was manipulated across blocks. Results show that task demands and language proportion differentially influenced frequency and concreteness effects in the event-related potential (ERP) signal for words belonging to the target and nontarget languages. These results provide evidence that the nontarget language was suppressed relative to the target language to different degrees at lexical and semantic levels of representation. In addition, the language membership of prior bottom-up input in different contexts influenced the degree of suppression of the nontarget language. The findings enhance our understanding of the neurocognitive mechanisms of bilingual language control during comprehension and call for revisions to current models of bilingual visual word recognition.

Topic Areas: Multilingualism, Meaning: Lexical Semantics

In defense of individual-level functional neural markers

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Most cognitive neuroscience investigations attempt to characterize the human brain in general, with emphasis on patterns shared across individuals. However, for many questions, it is no less important to understand the neural variability that exists between individual participants, and to relate these neural differences to differences in behavior and cognition, as well as to genetic variation (e.g., Dubois & Adolphs, 2016; Mahowald & Fedorenko, 2016; Seghier & Price, 2018). At the core of this program's success is the premise that neural markers are stable within individuals over time, and some recent papers have raised concerns about the reliability of individual-level markers (e.g., Elliott et al., 2020). Indeed, most fMRI studies—which tend to focus on traditional group-averaged responses—typically collect small amounts of data from each individual; but there is one approach in cognitive neuroscience that relies on robustly identifying functional areas within individuals using well-validated 'localizer' paradigms (Brett et al., 2002; Saxe et al., 2006; Nieto-Castanon & Fedorenko, 2012). By design, these localizers tend to be highly stable within individuals within and across scanning sessions, and thus are promising for yielding robust individual-level measures. Here, focusing on the fronto-temporal language network, we establish the stability of several key markers of linguistic activity. We use fMRI data from 1,024 scanning sessions in the lab's database (811 unique individuals) each containing a language localizer task which targets high-level (lexico-semantic and combinatorial) linguistic processes by contrasting the reading of sentences versus nonword sequences (Fedorenko et al. 2010). This contrast has been shown to generalize across materials, tasks, languages, and modality of presentation, and is recoverable from task-free resting-state data (e.g., Blank et al., 2014; Braga et al., 2019). First, in the full set of n=811, we show that the fine-grained activation patterns for the Sentences>Nonwords contrast are highly stable within individuals across runs (Fisher-transformed spatial correlations within the mask encompassing the left-hemisphere fronto-temporal language network are, on average, r=0.935 ; see Mahowald & Fedorenko, 2016, for similar estimates from smaller sets of participants). Similarly, the Sentences>Nonwords effect sizes, volumes, and lateralization based on effect sizes or volumes are strongly correlated across runs (r=0.684, 0.545, 0.834, and 0.681 , respectively). And second, for the 148 participants with two or more scanning sessions, we show that the fine-grained activation patterns are also stable within individuals across scanning sessions (r=0.755). Similarly, the other four functional measures are highly reliable across sessions: effect sizes (r=0.558), volumes (r=0.563), effect-size-based lateralization (r=0.724), and volume-based lateralization (r=0.581). Strong and highly significant correlations persist even when choosing pairs of sessions (from participants with >2 sessions) that have a) the longest temporal interval between them, or b) the lowest within-session across-runs spatial correlation values. These results suggest that robust well-validated tasks designed to pick out 'natural kinds' in the mind and brain yield highly stable individual-level markers that can be leveraged to meaningfully probe the relationship among neural, behavioral, and genetic variability.

Topic Areas: Methods, Meaning: Combinatorial Semantics

Quality Control of Manual Lesion Tracing with Automatic Segmentation Approaches

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Manual tracing is the gold standard for lesion segmentation, and it is widely used to develop and evaluate supervised automated segmentation algorithms (Ito, Kim, & Liew, 2019; Despotović, Goossens, & Philips, 2015). This is despite the fact that manual segmentation is itself an imperfect technique, with human tracers exhibiting substantial inter-tracer variability (Fiez et al., 2000). Here, we examine whether agreement between two supervised automated segmentation algorithms can be used to screen the quality of manual tracings and identify cases that may be challenging or incorrectly segmented. We used a publicly available dataset of T1-weighted MRIs of chronic stroke (n = 181) which were segmented manually and with two automatic approaches: Gaussian Naïve Bayes lesion detection (GNB) (Griffis et al., 2016) and Lesion Identification with Neighborhood Data Analysis (LINDA) (Putsina et al., 2016; Liew et al., 2018; Ito et al., 2019). We compared the predicted masks from the automated algorithms to each other and to the "ground truth" manual trace. We used Dice Score (DC), which measures the degree of overlap between segmentations, as our performance metric. For each volume in the dataset, we computed the difference between the DC of the two automated segmentations minus the average DC of the automated segmentations as compared to the manual segmentation. An independent tracer manually traced a new segmentation for outlier cases in which the difference was more than 2 standard deviations greater than the mean value. Seven such cases were identified, and for each, the DC was computed to compare the new trace to the original manual segmentation as well as the automatic segmentations. Results for these seven cases revealed a range of inter-tracer DCs from 0 to 0.42. For reference, an inter-tracer DC of 0.73±0.20 was reported across 11 tracers during the creation of the original dataset (Liew et al., 2018). This result suggests that these particular seven lesions have challenging boundaries, and closer inspection of the new segmentations revealed that three of them aligned more with the automatic segmentations than with the original manual segmentation, two were more similar to the original manual segmentation, and the last two cases overlapped with neither. Overall, the identified lesions were small to medium in size, found in both hemispheres, and all except one were subcortical or cerebellar. Our results show that the segmentation overlap of two supervised automated algorithms can help identify lesions that may be particularly challenging to trace manually. Supervised algorithms can thus be used to identify manually segmented cases that may be incorrect or challenging.

Topic Areas: Methods, Disorders: Acquired

Reliability and stability in shortened versions of an auditory functional language localizer

Poster B13 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session B.

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Functional localizers are effective tools for independently defining neural selectivity. Previous studies have shown that a language localizer can reliably identify language-selective regions in individual brains (Fedorenko et al., 2010). An auditory version of the language localizer was developed to be more suitable for use with children and other special populations (Scott et al., 2017). However, children and other special populations often will not tolerate long scanning sessions, so in-scanner tasks need to be as short as possible without sacrificing localizer accuracy. In this project, we examined how much data is needed to provide robust functional localization of language regions. Participants (N=24, native English-speaking adults) underwent the functional language localizer described in Scott et al. (2017). Participants listened passively to audio recordings of speech and unintelligible degraded speech. All participants completed two runs of the localizer (TR=750 ms, 45 axial slices, 5 simultaneous slices, 3 mm isotropic voxels, 484 TRs). In each run, participants heard 16, 18-s blocks each of the intact and degraded speech conditions (interleaved with resting baseline) for a scan time of 6:03 per run. Language selectivity was assessed by the intact > degraded speech contrast. We compared activation maps obtained from the full dataset to smaller amounts of data. Each run was subdivided into four spans of increasing duration to see when language-selective activation patterns stabilized: spans of 4, 8, and 12 blocks (1:44, 3:09, and 4:35) per run were compared to the full-length dataset. All spans maintained the ratio of intact to degraded speech and stimulation to rest. We analyzed the data using the group-constrained subject-specific (GCSS) approach (Fedorenko et al., 2010; Nieto-Castanon & Fedorenko, 2012): The group-level activation probability map was used to create parcels, within which individually-specified functional regions-of-interest (fROIs) were obtained from participants' peak activations. We used the Jaccard index as a measure of spatial similarity to compare the patterns of activation for smaller amounts of localizer data vs. the full dataset, and between the two runs of each span length. We applied these analyses to (i) individual subjects' activation maps at multiple voxelwise thresholds; (ii) the parcellation obtained from the group probability map, and (iii) subject-specific fROIs obtained from the GCSS parcellation. The group-level parcellation, individual-subject activation maps, and individual-subject fROIs based on 24 blocks were most convergent with the full, 32-block dataset. For each of these metrics, similarity to the full dataset diminished as the amount of data was reduced to 16 and again to 8 blocks. Between-run measures of reliability for activation, parcellation, and fROI location were also most similar between the full dataset and the 24-block span, with diminishing between-run reliability for less data. These results suggest that reliable activation maps of language-selective cortex can be obtained from two, 4:35-runs of the auditory localizer, and they demonstrate how much accuracy and precision is lost with further reductions in scan time. These data can guide decisions for using a functional language localizer when scan time is a limiting factor in experimental design.

Topic Areas: Methods, Language Production

Simultaneously recorded subthalamic and cortical LFPs reveal different lexicality effects during reading aloud

Poster B14 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session B.

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Although language function is classically considered to be supported by cortical regions, recent theoretical accounts and empirical evidence increasingly implicate nuclei of the basal ganglia, including the subthalamic nucleus (STN), in various aspects of language processing. Clinically, basal ganglia contributions to language function are evidenced by linguistic deficits in patients with degenerative disorders affecting the basal ganglia, e.g. Parkinson's disease (PD), and by impairment of phonemic and semantic verbal fluency as a frequent sequela of PD treatment involving STN Deep Brain Stimulation (DBS). However, due to the low resolution of neuroimaging and EEG methods for measuring activity of small-volume subcortical structures, the STN's specific role in language processing remains unknown. We employed a novel experimental paradigm, during which local field potentials (LFPs) are simultaneously recorded from the STN and the cortex (M1, S1, STG) while patients (n =13) read aloud words and pseudowords as part of DBS implantation surgery for treatment of PD symptoms. Real words have fully specified representations stored in the long-term memory, while pseudowords do not. Accordingly, processing of words and pseudowords may recruit different mechanisms. If sampled STN and cortical sites play a role in these mechanisms, we expected to observe differences in the underlying neural activity for these two types of stimuli. A total of 240 consonant-vowel-consonant stimuli (120 words and 120 pseudowords) were constructed, e.g., “fame” vs. “fape”. The stimuli were divided into 4 60-trial lists with alternating presentation of words and pseudowords. We found that, when averaged across both types of trials, both STN and cortical activity are significantly modulated during spoken response, but not during stimulus presentation, with significant decreases in spectral power in the theta (4-8 Hz), alpha (8-12 Hz) and beta (12-30 Hz) bands and power increases in the gamma (30-70 Hz) and high gamma (70-150 Hz) bands. When we compared word and pseudoword trials, we found that the lexicality effect was instantiated differently in the two brain structures. In the cortex, 11 sites in the M1, S1 and STG showed differentiated activity for words vs. pseudowords in the alpha, beta, and gamma frequency bands either before or during spoken response, but not during written stimulus presentation. In the STN, increases in gamma power were observed in pseudoword compared to word trials. These appeared with a temporal jitter across almost the entire trial epoch from stimulus presentation to speech response offset. According to the ‘match-and-utilization’ hypothesis and the ‘representational’ hypothesis, such gamma bursts may reflect processes related to memory and attention. Thus, greater STN gamma activity in the pseudoword condition may not relate to lexical processing per se, but rather reflect the utilization aspect of matching the stimulus-related information to memory contents (inhibition of competition from real words, suppression of habitual responses, switching from automatic to more controlled processing in pseudoword trials). These findings represent a step forward to understanding the role of the STN (and the basal ganglia) in language processing and add a new level of specificity to our knowledge about lexical processing in the brain.

Topic Areas: Meaning: Lexical Semantics, Disorders: Acquired

Positivity bias in low-arousing language in healthy older adults

Poster B15 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session B.

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Positivity bias is the phenomenon where older adults attend to positive information more than negative information and memorize it better (Mather & Carstensen, 2005). Many have examined positivity bias in faces and scenes, but seldom in language. A seminal study using fMRI found that older adults elaborated positive words more than younger adults (Leclerc & Kensinger, 2011). The current study used EEG to examine positivity bias in language. Specifically, we asked whether positivity bias is modulated by emotion intensity (i.e., arousal). Our hypothesis is based on the strength and vulnerability integration (SAVI) model (Charles, 2010): older adults display greater and more sustained emotional distress when experiencing high-arousing events due to reduced physiological flexibility. In contrast, low-arousing events may allow for better emotional outcomes in older adults because of their tendency in approaching positive information. Thus we predict enhanced positivity bias in low-arousing words, not necessarily in high-arousing words. We focused on theta oscillations often associated with lexical-semantic retrieval (Bastiaansen et al., 2008) and emotion (Jessen & Kotz, 2011). Participants included 35 younger (21 females, Mage = 18.64) and 35 older (18 females, Mage = 67.36) adults given a lexical decision task. All were non-depressed (Beck Depression Index-II) with older and younger subjects matched on cognitive function within the normal range (Mini-Mental State Examination, Digit Symbol Substitution task). The stimuli consisted of 36 high-arousing positive (winner), 36 low-arousing positive (grandpa), 36 high-arousing negative (pain), 36 low-arousing negative (trash), and 36 neutral words (teeth), and 180 pseudowords (thack). We decomposed the EEG data in time-frequency space from 2-30 Hz in steps of 10 ms. Statistical tests were conducted in theta (4-6.5Hz) power between word types and age groups, by nonparametric permutation-based t-tests within pre-selected time of interests (maxT-corrected). Our main finding is an enhanced theta for low-arousing positive words (versus neutral words) in older compared to younger adults, from 700-900 ms, at mid-frontal sites. We suggest that this reflects a top-down, controlled process for up-regulating mildly positive emotions in healthy older adults. While this interpretation is consistent with Leclerc and Kensinger (2011), our novel contribution is that arousal modulates age-related positivity bias effects during word processing. A second finding is that, irrespective of age, low-arousing negative words showed a significant increase of power in the theta band compared to high-arousing negative words, from 300 to 700 ms, at left frontal sites. One explanation is that the salient emotional features in high-arousing negative words facilitated word retrieval, reflected in a theta decrease. Alternatively, the not-so-salient emotional features in low-arousing negative words allow for activations of multiple meanings, reflected in a theta increase. Behaviorally, younger adults recognized the negative words and high-arousing words more accurately than neutral words, whereas older adults recognized all words equally accurately (>99%). Thus negative/high-arousing information interferes with word recognition in younger adults, not in older adults. Overall, we found that older adults indeed prefer positive content in language, and specifically in language with low-arousing emotion. These are partially consistent with the SAVI model where arousal modulates positivity bias.

Topic Areas: Meaning: Lexical Semantics, Development

Self-reported word-finding difficulties are associated with the presence of Alzheimer's disease biomarkers in cognitively normal older adults

Poster B16 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session B.

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INTRODUCTION: Since amnesia is the most common and early symptom in patients with Alzheimer's disease (AD), self-reported memory complaints among cognitively normal older adults (CN) have received considerable attention in recent years as a possible early marker of the disease. Nonetheless, several studies have shown that self-reported language complaints, and more specifically word-finding difficulties, are among the most frequent cognitive complaints in CN. The clinical significance of elevated self-reported word-finding difficulties in CN is still a matter of debate: conflicting results have been reported regarding the association between self-reported word-finding complaints and biomarkers of AD pathology. The present study aims at: 1) characterizing the frequency and severity of word-finding difficulties in CN compared to other language and cognitive domains; 2) identifying sociodemographic and psychological characteristics associated with word-finding complaints in CN and; 3) determining if word-finding complaints can predict pathological levels of cerebrospinal fluid Aβ levels, a biological marker of AD. METHODS: 239 cognitively unimpaired older adults (52.7 % female, mean age = 73.1 ± 6.1 years old) from the Alzheimer's Disease Neuroimaging Initiative (ADNI) database were selected. All participants completed the self-rated version of the Everyday Cognition (ECog) questionnaire, as well as a lumbar puncture for Aβ. The ECog is a validated 39 items-scale probing an individual's subjective complaints through 6 cognitive dimensions (memory, language, visuospatial, planning, organization, divided attention) on a scale of 1 to 4 (1= no change or actually performs better than 10 years ago; 4 = performs the task much worse than 10 years ago). Within the language dimension, 2 items are related to word-finding difficulties, namely "Forgetting the names of objects" (Lang1) and "Finding the right words to use in a conversation" (Lang3). RESULTS: Both word-finding complaints were rated as more severe compared to all the other items, except for three other memory items which were rated as equally severe. Lang1 was not related to any demographic (age, gender, years of education) or psychological variable (depression-related symptoms, anxiety-related symptoms), while Lang3 was significantly negatively associated with years of education and positively associated with depression-related symptoms. Lang1 severity significantly predicted CSF Aβ levels in CN, and this result remain significant even when controlling for all demographic and psychological variables as well as general level of cognitive complaint. Lang3 was not significantly associated with CSF Aβ. DISCUSSION: Overall, our results support the fact that word-finding difficulties are amongst the most frequent and severe cognitive complaints in CN. Forgetting the names of object is also a significant predictor of CSF Aβ levels. Contrarily to previous studies suggesting that word-finding complaints are not worrying in older adults, our study actually suggests that these complaints should be taken seriously. This study highlights the importance of investigating word-finding subjective complaints in CN for the screening of AD. More specifically, this investigation should be at least specific to forgetting the names of objects and conducted using a continuous scale.

Topic Areas: Meaning: Lexical Semantics, Disorders: Acquired

ERP effects of affective valence in sincere and sarcastic utterances: When 'awful' means 'happy'

Poster B17 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session B.

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The comprehension of sarcastic utterances provides an excellent arena in which to study how and when contextual factors impact affective processing of literal and nonliteral dimensions of meaning. Here we address when the brain response differentiates sincere and sarcastic utterances, and whether/when affective valence effects reverse in sarcastic utterances. Scalp-recorded EEG was collected as 32 healthy adults listened to short vignettes, each of which ended with an utterance intended either sincerely or sarcastically. This final utterance was presented with rapid serial visual presentation and ERPs were time-locked to the final, critical, word. Vignettes were constructed in pairs such that the same critical word was intended sincerely in one (e.g., winning this vacation makes me feel so happy) and sarcastically in another (e.g., in a story about a bratty child who harasses an elderly neighbor, your child always makes me feel so happy); likewise, the sarcastic ending for one vignette (winning this vacation makes me feel so awful) served as the sincere utterance in the other (your child always makes me feel so awful). The use of counterpart vignettes thus enabled us to fully cross the affective valence (positive versus negative) of critical words with the sincerity (sincere versus sarcastic) of the utterance. Mean amplitude ERPs were measured 150-250ms (P2), 300-500ms (N400), and 600-900ms (P600) after the onset of the critical word. Analysis with repeated measures ANOVA suggests that valence and sincerity have independent effects in the initial stages of processing 150-250ms onset, as positively valenced words ("happy") elicited larger P2 than negative ("awful") and sarcastically intended words elicited larger P2 than sincere. Analysis of ERPs 300-500ms indicated a discrepancy between effects over anterior and posterior electrode sites. Over posterior sites where N400 is typically focused, negatively valenced words ("awful") elicited less positive (more negative) ERPs than positively valenced words ("happy"), and this effect was similar in sarcastic and sincere utterances. Over anterior sites, no valence effects were evident 300-500ms post-onset for words in sarcastic utterances. By contrast, positively valenced words ("happy") in sincere utterances elicited relatively more positive (less negative) ERPs over anterior sites than negatively valenced words ("awful"). Analysis of ERPs 600-900ms post-onset suggests a cross-over interaction such that positively valenced words ("happy") elicit a larger frontally focused positivity (P600a) than negative words ("awful") in sincere utterances, while negative words ("awful") in sarcastic utterances elicit larger P600a than positive ones ("happy"). The P600a is thus larger for words intended in a complimentary manner. Neural measures differentiate the brain response to sincere and sarcastic utterances beginning 150-250ms, and sarcasm modulates affective valence effects evident over frontal electrodes beginning 300-500ms. However, these data suggest sensitivity to the intended meaning in a sarcastic utterance does not emerge until 600ms when valence effects in sarcastic utterances were the reverse of those in sincere ones.

Topic Areas: Meaning: Discourse and Pragmatics, Meaning: Lexical Semantics

An ERP Investigation of the Effects of Emoji Valence on Text Processing

Poster B18 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session B.

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People often use face-emojis in their text-messages. Does a recipient take emojis into consideration when interpreting a text message? A seemingly obvious answer is yes, as psycholinguists have shown that comprehenders rapidly integrate social information, such as speaker identity, during language comprehension (Van den Brink et al., 2010). However, research in computer-mediated communication found that emojis can be used to maintain a conversational connection, where the recipient simply acknowledges that they got the message (Kelley & Watts, 2015). Synthesizing these two lines of research, we hypothesize that the emotional valence of emojis matters for whether and how they are integrated with the text by the recipient. Specifically, negative emojis signify emotional needs and are integrated as content in text interpretation. Positive emojis are socially relevant in that they primarily serve to maintain the conversational flow. To test this, we used ERPs to investigate the comprehension of emotionally ambiguous text messages preceded by happy and sad emojis. Participants included 37 undergraduates. We created 102 emotionally ambiguous text-messages (e.g., please call me) and normed them for valence (M=3.07, SD=0.74 on a 6-point scale). We started with 20 most frequently used face-emojis and selected 5 happy (valence M=4.81, SD=0.46) and 5 sad (valence M=1.40, SD=0.63) after norming. A third condition with a comma at the emoji position acted as a baseline. Items are rotated and randomized such that each participant only saw each text-message once. During EEG recording, participants read text-messages (Example: Hey [😁/ 😔/ ,] please call me) presented word-by-word. Each word/emoji was on for 300ms, followed by a blank screen for 500ms. Their task was to describe the sender's mood using a keyboard. Verifying manipulation, ERPs for experimental conditions were more alike and very different from baseline. At the first word, both texts preceded by sad and happy emojis elicited a more negative N400 than text preceded by a comma. Importantly, texts preceded by sad emojis elicited a larger frontal negativity from 450-550ms (p=.066) than texts preceded by happy emojis. This timing suggests that sad emojis encourage a longer search for meaning and the frontalness suggests imagery processing, where sad emojis were processed as content to be integrated with text. At the second word, texts preceded by sad emojis showed a reduced frontal negativity at ~100ms (N1) (p=.033) and a reduced positivity at ~600ms (LPC) in parietal channels (p=.04) compared to texts preceded by a happy emoji. This suggests that in the sad emoji condition, much of the meaning processing is prioritized and completed at the first word, whereas in the happy emoji condition, meaning construction continues. To summarize, while happy emojis maintain processing capabilities, sad emojis elicit more in-depth processing at the first word, leading to reduced attentional resources for subsequent words. Our work contributes to understanding the social and emotional factors in text processing by showing that emoji valence determines their relevance for text interpretation. While happy emojis simply act to maintain the social relationship between sender and recipient, sad emojis are of emotional significance.

Topic Areas: Meaning: Discourse and Pragmatics, Meaning: Combinatorial Semantics

Processing speech in- and out-of-context

Poster B19 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session B.

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Understanding the top-down cues that affect language comprehension informs the broader ways that the parser integrates with other cognitive processes. Previous studies have focused on predictability effects and relied on sentential context or statistical knowledge as the top-down cue. In our approach, we introduce a novel interactive task that mimics naturalistic dialogue in a controlled, minimal paradigm and compare it to a contextless phrase/word comprehension task, keeping the auditory stimulus constant. This allows us to separate the effects of lexical predictability from processes related to production planning and working memory. Our minimalistic paradigm was specifically designed to be feasible for both child and adult participants, as well as clinical populations. [METHODS] We recorded brain activity from 24 adults using magnetoencephalography in a 2x3 within-subjects design of task (IN-CONTEXT, OUT-OF-CONTEXT) by phrase-type (PHRASE, NOUN,. COLOR). In both tasks, stimuli consisted of either a two-word phrase (e.g., 'red house' -- PHRASE condition) or a single word that followed backwards speech (e.g., 'backwards-speech house' -- NOUN condition). The OUT-OF-CONTEXT task resembled standard comprehension tasks: participants heard a stimulus, then selected the matching image. During the IN-CONTEXT task, participants saw two images side-by-side, then heard the computer name one image and responded with the unmentioned image, mirroring the normal back-and-forth of naturalistic conversation. The pictorial context here made the lexical material of the auditory stimulus more predictable than in the OUT-OF-CONTEXT task. [RESULTS AND DISCUSSION] We conducted cluster-based permutation tests over time windows within the presentation of the first and second word in four ROIs (left and right) implicated in auditory language processing: inferior frontal gyrus (IFG), primary auditory cortex (Aud), superior temporal gyrus (STG), and anterior temporal lobe (ATL). **Lexical predictability** NOUN and COLOR conditions showed a left-lateralized effect of greater activation compared to PHRASE on Word2 in both STG and Aud in the IN-CONTEXT task, and only the left STG in the OUT-OF-CONTEXT task. There was no interaction of task by condition in these two ROIs. Lexical access over a more constrained set of possibilities resulted in decreased activation, but contextual cues that further reduce the space of possible lexical items to 1 did not further reduce activation. **Production planning** In the IN-CONTEXT task, both COLOR and NOUN showed greater activation than PHRASE on Word2 during a time window consistent with production planning in the left but not right ATL, possibly reflecting that participants could have already fully planned their response in the PHRASE condition after Word1. **Working memory load** We found an interaction of task by condition on Word1, characterized by increased activation for NOUN and COLOR compared to PHRASE only for the IN-CONTEXT task in the right, but not left IFG. The fully predictable stimulus showed the greatest activation, which may reflect working memory maintenance of both objects through the presentation of the backwards speech. [CONCLUSION] We have demonstrated through a novel conversational task suitable to children and adults from clinical and non-clinical populations that greater lexical predictability corresponds to a sustained decrease in neural activity during production planning.

Topic Areas: Meaning: Combinatorial Semantics, Control, Selection, and Executive Processes

The neural mechanisms underlying tDCS effects in PPA: Evidence from resting-state functional network analysis

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Presenter Note: Drop me an email if you have any questions or would like to get a copy of the poster! yuan.tao@jhu.edu

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Anodal transcranial direct current stimulation (tDCS) over the left inferior frontal gyrus (LIFG), a key region for language processing, has been shown to have augmentative benefits in post-stroke aphasia rehabilitation (e.g., Fridriksson et al., 2018) and primary progressive aphasia (PPA) (e.g., Cotelli et al., 2018; Roncero et al., 2017; Gervits et al., 2016; Tsapkini et al., 2018). However, the underlying neural mechanism is not understood. Recently, in a clinical trial of the effects of tDCS in PPA, we found that tDCS-based behavioral benefits were modulated by decreased resting-state functional connectivity (RSFC) strength between the stimulation site (LIFG) and several temporal and parietal regions, suggesting tDCS may serve to strengthen functional segregation (Ficek et al., 2018). In this study, we evaluated the functional segregation hypothesis by examining brain-wide RSFC network property of the simulation site LIFG with graph-theoretic methods. Specifically, we examined differences in the global, inter-network connectivity for the LIFG under tDCS compared to the sham condition. Methods: Thirty-two PPA participants underwent language training (oral and written naming/spelling) in a clinical trial with a double-blind, sham-controlled, crossover design (NCT02606422). Here we present the results of the first period, during which half (N=16) received anodal tDCS over the LIFG and half received sham, both coupled with language therapy. Resting-state fMRI data were collected before and after treatment. First, for each participant, whole-brain pairwise FC was computed for 78 anatomical ROIs. Second, using a separate healthy control dataset, the ROIs were grouped into 7 resting-state functional networks (RSNs). These served as the basis for computing the LIFG's pre- and post-treatment participation coefficient (PC) values, a graph-theoretic measure indexing the inter-network connectivity diversity of a given region (Guimera & Amaral, 2005). PC changes for tDCS and sham groups were compared with one-sample (within-subject) and independent (between-subject) t-tests. Finally, the PC changes were correlated with behavioral changes for each group. Results: All tDCS and sham participants showed behavioral improvement but it was marginally larger in tDCS vs. sham ($p=0.08$). Regarding the PC changes of the LIFG, the tDCS group showed a significant decrease ($t(15)=-2.3$, $p=0.04$), indicating that the LIFG became less widely connected across the functional networks, whereas the sham group showed a non-significant increase ($t(15)=1.21$, $p=0.24$); there was a significant interaction between time-point (pre and post treatment) and treatment group ($p=0.03$). Regarding the relationship with behavior, the PC increase of the sham group was positively correlated with behavioral improvement ($r=0.40$, $p=0.07$), whereas for the tDCS group the correlation was negative ($r=-0.17$, $p=0.28$) and there was a marginal interaction ($p=0.08$). The finding of relationships in opposing directions suggests that tDCS produced distinct and more beneficial neural changes compared to those experienced by the sham group. Conclusions: We examined the tDCS-related functional connectivity changes of the LIFG and the relationship of these neural changes with treatment outcomes. Our results suggest that one mechanism underlying the effects of tDCS delivered to the LIFG is a decrease in the LIFG's connectivity with other functional networks and hence enhanced system segregation.

Topic Areas: Language Therapy, Disorders: Acquired

Neural representation of syntactic prediction: A simultaneous eye-tracking and EEG study

Poster B21 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session B.

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Introduction: To process sentences efficiently, human brain rapidly integrates linguistic information and makes online prediction about upcoming words as sentences unfold in time. Behavioral and ERP studies have provided ample evidence that linguistic cues, such as verb bias, guide people's predictions of the upcoming words (e.g. Kamide, Altmann, & Haywood, 2003; Wlotko et al., 2008; Snedeker & Trueswell, 2004; Ryskin et al., 2017). However, most evidence of prediction is inferred from processing cost when unexpected words are encountered. It is still unclear when the prediction is formed and what neural features of prediction are activated in the brain when people start making prediction. We ask how verb bias guides syntactic prediction during real-time sentence processing with a simultaneous eye-tracking and EEG technique. Methods: The computerized visual world paradigm and stimuli are identical to Ryskin, Qi, Duff, & Brown-Schmidt (2017). Participants (N=25) heard globally ambiguous sentences (e.g., "Pet the duck with the hat.") containing a prepositional phrase ("with the hat") that could be interpreted as modifying the first noun ("duck") or referring to an instrument with which to enact the verb ("pet"). Participants were asked to use the mouse to act out the instruction. Critically, 1/3 of the verbs were modifier-biased, 1/3 were equi-biased, and 1/3 were instrument-biased (based on prior norming). Participants' mouse click location, eye-gaze, and EEG were recorded throughout the experiment. The eye-gaze and EEG data were analyzed after the onsets of verb (e.g. "pet"), first noun (e.g. "duck"), and the prepositional phrase noun (e.g. "hat"). Preliminary results & conclusion: Our mouse clicks and eye movement results replicated the verb bias effects at the end of the sentence, as reported in Ryskin et al. (2017). Critically, we found a reliable verb bias effect emerged immediately after the verb, measured by listeners' first eye-fixation after the offset of the verbs. Listeners fixated less at either animal and more at either instrument immediately after hearing instrument-biased verbs, compared to both the modifier- and the equi-biased verbs, providing evidence for anticipatory looking. ERPs in response to the instrument-biased verbs showed a significant negativity effect 100 ms before the first eye-fixation. In order to further confirm the nature of this prediction component, the future analyses will implement an EEG decoding approach to investigate the time-course of syntactic prediction. We plan to first decode the verb biases using leave-one-out cross-validation within each individual participant and identify the time windows of above-chance classification. We will also evaluate the representational similarity between the EEG topographic patterns during the prediction window and those during the disambiguation window as a measure of prediction precision. If listeners use verb bias as a strong prediction cue, we expect to find a greater representational similarity in the strongly-biased conditions (instrument- and modifier-biased) than the weakly-biased condition (equi-biased).

Topic Areas: Syntax, Perception: Speech Perception and Audiovisual Integration

Electrophysiological (EEG/ERP) measures of cognitive spare capacity during speech perception in a dual-task experiment: effects of signal-to-noise ratio and memory load

Poster B22 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session B.

Cynthia Hunter[1]; [1]University of Kansas

Speech perception is one of many everyday activities that draws on a limited capacity of working memory resources as task difficulty increases. Listening effort refers to the allocation of working memory resources to speech comprehension and varies inversely with cognitive spare capacity (CSC). That is, effortful listening reduces one's available cognitive resources. For people with hearing loss, this constant drain on CSC during spoken communication is an important but as yet difficult to quantify dimension of hearing handicap (for reviews see McGarrigle et al. 2014; Ohlenforst et al. 2017; Pichora-Fuller et al. 2016). In dual-task experiments, behavioral performance on a secondary task performed concurrently with speech perception has been shown to decline as the speech signal becomes more degraded, providing a measure of CSC and LE (Gagne et al., 2017). Electrophysiological measures such as alpha oscillatory activity and event-related potentials (ERPs) may be able to serve as more direct measures of CSC (Obleser et al., 2012; Hunter, 2020). Yet a mechanistic (or even descriptive) understanding of how changes in CSC are reflected in EEG/ERP measures has yet to be delineated for the basic scenario in which electrophysiological responses are measured during speech perception and both memory demands and background noise vary, as in a dual-task experiment. The goal of the current, ongoing study in young adults with normal hearing (n=8) is to compare the effects of signal-to-noise ratio (SNR) and memory load in a dual-task experiment on EEG/ERP measures hypothesized to reflect changes in CSC, particularly alpha (8–13 Hz) oscillations and the P300 or late positive complex (LPC) ERP. On each trial, a memory load of one (low load), three (medium load), or five (high load) visually-presented digits was followed by a spoken word that was presented in background noise at an easy, medium, or difficult SNR. All measures reported are time-locked to speech onset. As expected, an alpha event-related desynchronization (ERD) marked the onset of the speech stimulus. The alpha ERD showed a linear relation with memory load, being greater with higher load. The P300/LPC amplitude was quadratic as a function of SNR, being smaller at the medium-difficulty SNR than either the hard or easy SNR. In line with prior behavioral work, digit recall was less accurate at more difficult SNRs, indicating decreased CSC. Although the behavioral results are consistent with the expected increase in effort for listening at less favorable SNRs, the electrophysiological data reveal a more complex response. The linear relation of alpha ERD to memory load likely reflects decreased allocation of cognitive resources to speech perception under high cognitive (memory) load. The quadratic relation of P300/LPC amplitude to SNR indicates reduced CSC (increased LE) when SNR decreased from easy to medium coupled with an increase in CSC (reduced LE) when SNR decreased further from medium to difficult. This may reflect disengagement from the speech perception task when intelligibility was very low. The current data contribute to a growing knowledge base on electrophysiological markers of CSC during speech perception.

Topic Areas: Speech Perception, Control, Selection, and Executive Processes

Voices of social manipulation: Real-time MRI videography of vocal tract lengthening

Poster B23 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session B.

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Speech shares the voice with a host of social information. Listeners readily make inferences about speakers from their voices, for example in judging their age, gender, attractiveness, or trustworthiness. However, speakers can manipulate some voice qualities that contribute to these judgements by lengthening or shortening their vocal tracts. We had 55 participants (half trained singers) imitate spoken words that were manipulated with elongated or shortened apparent vocal tract lengths as well as raised or lowered fundamental frequency (f0). Half of the stimuli ranged along a biologically plausible axis in which apparent vocal tract length and f0 covaried from masculinised (elongated vocal tract, low f0) to feminised (shortened vocal tract, high f0). The remaining stimuli ranged along a biologically less plausible axis in which apparent vocal tract length and f0 were uncoupled. Real-time Magnetic Resonance Imaging (MRI) videography was used to monitor the shapes of participants' vocal tracts. We developed a bespoke software tool to semi-automatically track vocal tract shapes from these images. We plan to use functional data analysis to quantify variation in vocal tract shapes. We predict that speakers can manipulate vocal tract shapes to a degree that it is likely to skew listeners' judgements. We further predict that trained singers are more effective at manipulating vocal tract length, particularly for biologically less plausible configurations. This study provides a paradigm for studying the degree to which speakers are able to manipulate vocal cues that listeners generally interpret as though they were stable over time, as well as the generalisability of vocal training to the social aspects of speech motor control.

Topic Areas: Speech Motor Control, Morphology

Language-specific phonological contrast and neutralization: an intracranial EEG study

Poster B24 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session B.

Presenter Note: Please view the video walk-through of this poster here: https://youtu.be/999clb6eaIM

Anna Mai[1]; [1]UC San Diego

Using intracranial EEG recorded during a passive listening task, this study provides preliminary evidence that the brain abstracts phonemic category identity in a language-specific way from contextually conditioned acoustic variants of phonemes (allophones). Participants listened to excerpts of American English conversational speech that contained allophones of the phonemes /d/ and /t/. These two phonemes have many distinct allophones, but when either /d/ or /t/ occurs following a stressed syllable and between two vowels, their acoustic contrast is neutralized (e.g. writing, riding), and the sound they make is called a tap. Here it is hypothesized that phonemic identity is computed during language processing, even when the acoustic contrast between two phonemes is neutralized, predicting the existence of sites where the neural response to phonemically /t/ taps (dx_t; i.e., writing) is more similar to other allophones of /t/ (t; i.e., voiceless alveolar stops) than to phonemically /d/ taps (dx_d; i.e., riding). Neural epochs were defined for all t, dx_t, and dx_d phones as the 500ms following phone onset with a 100ms baseline prior to phone onset. From 798 electrodes (486 right hemisphere) recorded across six patients, 15 electrodes selective to t over noise were isolated using a sliding-window one-way ANOVA. Of those, a sliding-window one-way ANOVA comparing the high gamma power (70-150Hz) of t, dx_t, and dx_d trials was significant for three electrodes. Two sites in left posterior superior temporal gyrus (STG) exhibited a significant difference between alveolar stop /t/ and phonemically /t/ taps 150-250ms after phoneme onset and a lack of difference between taps. This result suggests that these two sites track acoustic rather than phonemic identity, consistent with results reported in Mesgarani et al. (2014), Hullett et al. (2016), and elsewhere concerning STG sensitivity to complex acoustic features during natural speech processing. One site in left prefrontal cortex exhibited a significant difference between phonemically /d/ taps and both phonemically /t/ sounds 250-350ms following phone onset. This activity may suggest that a phonemic representation is computed during passive listening to natural speech in frontal areas. Although lesion studies suggest that frontal areas are not the main substrate for speech perception (see Hickok & Poeppel 2007), this result may be consistent with work showing engagement of frontal areas during phonological tasks involving segmentation (Burton 2001) and phonetic competition (Xie & Myers 2018). However, this result will require replication with MEG or intracranial patients with broader frontal coverage in order to fully substantiate. From these results, we tentatively conclude that both acoustic and phonological contrasts are computed during passive listening to natural speech. Future work with this dataset will assess the role of acoustic variability in the trial-by-trial neural response and will estimate spectrotemporal receptive fields for these speech-selective sites.

Topic Areas: Phonology and Phonological Working Memory, Speech Perception

A visuomotor route for speech

Poster B25 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session B.

Presenter Note: A visuomotor route for speech is a post-doctoral RESEARCH PROJECT. Since it is a work in progress, you may notice that there are methodological differences between abstract and poster. Any opinions, suggestions, or recommendations to improve the quality of our experimental design are welcome. Also, we are interested in new collaborations, so please don't hesitate to contact us: mmichon@uc.cl www.neuro.cl

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The traditional model for the neurobiology of language, based on Broca's and Wernicke's areas for language production and perception respectively, is outdated (Tremblay & Dick, 2013). On the other hand, the dual route model proposed more recently by Hickok & Poeppel (2007) is failing to account for increasingly numerous evidences of a functional role of visual and motor systems for speech perception. The current project emerges into the frame of a recently hypothesized trimodal repertoire for speech perception and production, in which the auditory (phoneme), the visual (viseme) and motoric (articuleme) elementary units of speech are bounded (Michon, López & Aboitiz, 2019). Time-frequency and event-related potentials analyses of electrophysiological data have provided preliminary evidence for the existence of a visuomotor route for speech perception. The general objective of this postdoctoral project is to further investigate the neuroanatomical dynamics underlying the processing of silent orofacial speech movements. More specifically, we aim to determine the nature of the interaction between occipital-visual and frontal-motor regions underlying viseme-articuleme binding and evaluate the possible contribution of a ventral neural pathway called the inferior fronto-occipital fasciculus (IFOF). In order to address these goals, the brain activity of 30 right handed participants will be registered using functional magnetic resonance imaging (fMRI) while they complete three different tasks. The first task consists in an auditory task in which the participants will be asked to attentively listen to monosyllabic speech sounds. The second task corresponds to a visual task where the participants will be asked to watch short videos silently displaying orofacial speech movements. The third task will be designed and introduced in order to assess whether visuomotor integration for lexical versus semantic associative learning involve similar or different neural pathways. In this task, the participants will undergo a learning phase in which they will be trained to associate a viseme (i.e., visual lip/tongue/mouth movements required to produce a syllable) to an articuleme (i.e., production of the vocal-motor sequence required to articulate a syllable). Some of those viseme-articuleme association will result either in a bi-syllabic word (semantic task) or in a bi-syllabic pseudoword (lexical task). Based on the literature reviewed and concordantly with the trimodal framework, we formulate the following hypotheses. Relative to the first task, we expect to replicate the findings of previous works showing that auditory and motor regions interactively process speech sounds through the dorsal stream. Respect to the second task, we hypothesize that the visuomotor integration of orofacial movements will be carried by the interaction of visual occipital and frontal motor regions via the ventral stream. More specifically, we expect this

integration to involve the IFOF, arguably the only neural pathway described in the human brain as having direct projections running ventrally from the frontal to the occipital cortex. Since previous studies using fMRI have consistently reported a functional role of the left IFOF in semantic processing and of the right IFOF in socioemotional processing of faces, we expect to observe a lateralization effect in the third task.

Topic Areas: Perception: Speech Perception and Audiovisual Integration, Multisensory or Sensorimotor Integration

Co-activation of Haitian Creole when reading in Brazilian Portuguese

Poster B26 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session B.

Presenter Note: Thank you so much for your interest in this planned study. If you have any comments or questions, we would appreciate your feedback. You can contact us via e-mail: pietra.rigatti@posgrad.ufsc.br

Pietra Rigatti[1], Mailce Mota[1], Kenneth Pugh[2,3,4,5]; [1]Universidade Federal de Santa Catarina, Brazil, [2]University of Connecticut, [3]Yale University, [4]Yale University School of Medicine, [5]Haskins Laboratories

Being able to read well in a second language (L2) can be a challenging task, especially for immigrant children and adults living in another country. The first language (L1) is always active to some extent, influencing the development of reading skills in the L2. Moreover, learning to read depends on both decoding and oral language skills. Since 2010, due to the earthquake which hit Haiti, Haitian children and adults migrate to Brazil. They are native speakers of Haitian Creole (HC) learning to read in Brazilian Portuguese (BP), who are mostly illiterate in their L1. In this planned study, we are interested in investigating how their L1, Haitian Creole, influences the learning of reading in the new language, Brazilian Portuguese. In order to answer that, language co-activation will be tested using cognate words, which are words that share form and meaning across languages, in word recognition and sentence reading tasks. In Experiment 1, a group of school-age children, native speakers of HC, and a group of school-age children, native speakers of BP, will complete four tasks in BP: a phonological awareness task, a naming task, a visual lexical decision task and an auditory lexical decision task. The last three tasks will include cognate and non-cognate words across HC and BP. The rationale is that the minority children are acquiring BP and learning to read in this language at the same time. Thus, they are developing L2 phonological awareness while being orally influenced by their L1 and L2. We expect to observe a cognate effect leading to faster reaction times and higher accuracy for cognate words in comparison with non-cognate ones, and a positive correlation between task performance and phonological awareness. In Experiment 2, a group of adults, native speakers of HC, and a group of adults, native speakers of BP, will complete three tasks in BP: a visual lexical decision task, a visual sentence comprehension task and an auditory sentence comprehension task, all with cognate and non-cognate words. They will also fill a questionnaire about their reading habits in BP. During the reading tasks, eye-movements will be recorded. Our motivation for this experiment is that the cognate effect seen in isolated word context is also present in sentence context, but constrained. Moreover, reading habits and listening comprehension are associated with reading skills. According to previous studies, we expect to identify a cognate effect producing shorter first fixation durations, total reading times and go past times on cognate words in comparison with non-cognate ones, and a negative correlation between eye-tracking measures and L2 reading habits and listening comprehension. These outcomes will be interpreted according to bilingual reading and reading development models and will be linked to Brazilian public policies concerning how a minority language may contribute to the insertion of immigrants in school and society and improve their learning of the majority language.

Topic Areas: Multilingualism, Reading

Taxonomic and thematic semantic relationships in picture naming

Poster B31 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session B.

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Language production is complex and comprised of distinct and overlapping processes difficult to delineate. In picture naming, semantically-related pictures may cause interference or facilitation depending on the nature of the semantic relationships (Costa et al. 2005). Taxonomically-related words (e.g., wolf and dog) have been shown to cause semantic interference on behavioral measures (i.e., longer reaction times and more errors in semantically-related versus unrelated contexts), while thematically-related words (e.g., bone and dog) have been associated with semantic facilitation (i.e., shorter reaction times and fewer errors in semantically-related versus unrelated contexts). It is unclear where these interference and facilitation effects stem from in terms of the different stages leading to word production. Here, we used Event-Related Potentials (ERPs) to study the time-course of the brain activity leading to word production. Thirty monolinguals participated in a picture-word interference experiment to examine stages of word retrieval impacted by different semantic relationships. Naming latencies were longer for related than unrelated taxonomic pairs and shorter for related than unrelated thematic pairs, replicating the taxonomic interference and thematic facilitation effects previously reported (Taxonomic: $F(1, 25) = 5.96$, $p<.05$; $\bar{x}$RTs = 791.4ms, 776.9ms; SD = 94.2ms, 84.64ms; Thematic: $F(1, 25) = 7.99$, $p<.01$; $\bar{x}$RTs = 766.4ms, 776.1ms; SD = 90ms, 83.1ms). We used traditional Monopolar analysis and Laplacian analysis. Laplacian analysis was utilized to enhance the topographical localization of ERPs in comparison to the traditional monopolar analysis (Babiloni et al. 2001). Monopolar and Laplacian analyses revealed a greater negativity (150-250ms after stimulus presentation) for unrelated than related taxonomic pairs; this effect was more restricted in space for thematic pairs. In the 300-500ms epoch, Monopolar analysis revealed a greater negativity for unrelated pairs in both taxonomic and thematic conditions. Laplacian analysis revealed a larger left frontal negativity in taxonomically-related pairs compared to unrelated pairs during the 300-500ms epoch, which was not the case for thematically-related pairs. This pattern of results is interpreted as indicating more effortful processing in later stages of lexical retrieval when placed in the context of taxonomically-related words, leading to the engagement of left frontal control not seen in the thematic context. In the exploration of differences between taxonomic and thematic relationships at the start of the current study, our norming survey found that respondents judged thematically related words to be significantly more related than taxonomically related words ($t=5.37$, $p<.01$). After controlling for this disparity, we found persisting differences with Resnik scores, which quantify relatedness based on a hierarchical network of superordinate relations. As in previous literature, taxonomic pairs were more highly related than thematic pairs, corroborating our choice in stimuli ($F(1,436)=61.43$, $p<.01$) (McDonagh et al. 2020). The differences observed during neural processing may be due to influential factors such as the density of the semantic network activated during spreading activation in lexical access (proposed to be denser for taxonomic versus thematic relationships) and/or inherent differences between word relationships. These results illustrate the importance of considering the nature of semantic relationships on the dynamics of word retrieval in future language production studies.

Topic Areas: Language Production, Meaning: Lexical Semantics

Semantic blocking creates interference in naming by increasing neural pattern dissimilarity

Poster B32 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session B.

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It has been shown consistently that increasing semantic relatedness among objects slows the speed with which those objects are named, though the source of this semantic interference is under debate. The current study addresses this issue by investigating how increasing semantic relatedness changes the neural representations that underlie our ability to speak. We analyzed EEG data from a blocked cyclic naming task using Representational Similarity Analysis (RSA) to explore neural activity associated with semantic interference. In the blocked cyclic naming task, participants name a small set of pictures in the semantic context (“homogeneous”) or from different categories ("heterogeneous"). Replicating previous studies, we found that objects were named slower in the homogenous blocks than the heterogeneous blocks. We then quantified the similarity between patterns of brain activity for each object after the onset of object presentation in the homogenous and the heterogeneous conditions. We found greater dissimilarity in neural activation in the homogeneous blocks than the heterogeneous blocks, at 180-360 ms post picture onset. This window was nearly identical to the window in which we found greater similarity between same-category items than different-category items (160-380 ms post-picture onset). Taken together, these results suggest that semantic relatedness among objects interferes naming by increasing neural pattern dissimilarity across trials, specifically during a time window that reflects semantic processing. This semantic blocking effect may reflect the fact that speakers pay more attention to distinctive semantic features of objects (i.e., features unique to each item) when they name objects in the context of same semantic category, thus increasing the semantic dissimilarity between words and slowing naming times. These findings provide important insights into the neural representations of semantics and the cognitive processes involved in word retrieval.

Topic Areas: Language Production, Meaning: Lexical Semantics

White Matter Independently Mediates Age-Related Production Deficits

Poster B33 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session B.

Sara B.W. Troutman[1], Mary Henderson[1], Michele T. Diaz[1]; [1]Pennsylvania State University

Picture naming ability, which relies on many other cognitive abilities, declines with age. According to the Transmission Deficit Hypothesis, deficits in phonological processing, specifically, lead to age-related language production deficits (McKay & Burke, 1990). Neurobiologically, there is substantial evidence to suggest age-related deficits in cognition may be due to age-related deficits in white matter structure. However, it is an open question if age-related white matter deficits mediate the relationship between phonological deficits and language production deficits in aging. To test for such a mediating relationship, we used diffusion tensor imaging in a large, across-the-lifespan sample of 91 participants (M = 46.76 years). We used probabilistic tractography at the participant level to define the Superior Longitudinal Fasciculus (SLF)—a region of white matter implicated in phonological processing (Stamatakis, Shafto, Williams, Tam, & Tyler, 2011; Troutman & Diaz, 2019). We then queried each participant's average Fractional Anisotropy (FA) and Radial Diffusivity (RD) along their SLF as indices of white matter structure. We conducted two separate path analyses predicting RT and accuracy from FA, age, and Phonological Neighborhood Density (PND). For both models, chi-square tests indicated good model fits a large, across-the-lifespan sample of 91 participants ($p > .05$). Results showed that higher FA was associated with better naming performance (faster RTs, $\beta = -1.98$, $p < 0.001$; better accuracies, $\beta = 0.01$, $p < 0.001$). Target pictures with denser phonological neighborhoods (i.e., higher PND) were associated with faster ($\beta = -0.81$, $p < 0.001$) and more accurate naming ($\beta = 0.02$, $p < 0.001$). There was also a main effect of age in which older age was associated with slower ($\beta = 0.61$, $p < 0.001$) and less accurate naming ($\beta = -0.02$, $p < 0.001$). FA along the SLF significantly mediated the relationship between PND and naming for both RT ($\beta = 1.60$, $p < 0.001$) and accuracy ($\beta < 0.01$, $p = 0.001$). Lastly, FA along the SLF also mediated the relationship between age and naming performance for both RT ($\beta = 0.001$, $p < 0.001$) and accuracy ($\beta = - 0.003$, $p < 0.001$). PND did not significantly mediate the effect of age on naming ($p > 0.05$) in either model. We also ran the same analyses using RD. That is, we predicted accuracy and RT from RD, age, and PND. For both RT and accuracy models, chi-square statistics indicated good model fits ($p > .05$). No main effect of RD was observed ($p > 0.05$) and RD did not mediate either the PND - naming or age - naming relationships. PND did not significantly mediate the effect of age on naming ($p > 0.05$) in either RD model. Taken together, these results confirm that age-related deficits in FA along the SLF explain age-related deficits in picture naming and the relationship between age-invariant PND effects and picture naming. Importantly, these results show that both picture - naming and phonological processing are independently affected by deficits in dorsal white matter.

Topic Areas: Language Production, Phonology and Phonological Working Memory

Controllability of structural brain networks predicts treated aphasia recovery after stroke

Poster B34 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session B.

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Introduction: Network control mechanisms underlying recovery from aphasia after stroke are poorly understood, but are nevertheless pivotal for elucidating language processing mechanisms and translational approaches. Neural network control theory provides a unique approach to understand how structural brain networks can modulate brain activation states. We evaluated 1) whether neural networks with chronic post-stroke brain lesions are controllable, and 2) whether baseline controllability features of regions in the residual language network predict treated language recovery after stroke. Methods: We studied data from 70 participants who were part of a randomized controlled clinical trial assessing the futility of anodal transcranial direct current stimulation (A-tDCS) as an adjunct to aphasia treatment. All participants had a chronic ischemic stroke in the left hemisphere and were diagnosed with aphasia according to the cut-off for aphasia of the Western Aphasia Battery (Revised) (WAB-AQ). As part of the clinical trial, participants completed 3 weeks of language training focusing on lexical-semantic processing. Half of the participants were randomized to receive A-tDCS concomitant to the language training, while the other half of participants were randomized to receive sham tDCS (S-tDCS) concomitant to the language training. Using probabilistic tractography and imaging approaches to accommodate for structural lesions, we reconstructed diffusion tensor structural connectomes from all participants. We calculated 1) the controllability Gramian of each connectome network to determine if the network is controllable, and 2) the average controllability (ability to steer the brain to easy to reach states) and modal controllability (ability to steer the brain to difficult to reach states) of 20 language-related left hemisphere brain regions. Using elastic net models with ten-fold cross-validation we identified the best predictors for treated aphasia recovery. The set of candidate predictors included 106 variables: average controllability, modal controllability, node degree, node betweenness centrality, lesion volume for each of the 20 nodes, age, education, baseline WAB-AQ, treatment type (A-tDCS versus S-tDCS), total lesion volume, and number of edges. Results: Sixty-eight of 70 participants had controllable structural brain connectomes after excluding zero-degree nodes (nodes that are not connected to the remaining network). With elastic net modeling, 6 out of 106 candidate variables were selected as the optimal model to predict a change in naming accuracy: 1) modal controllability of the IFGorb, 2) modal controllability of the middle temporal gyrus, 3) node degree of the pSTG, 4) node degree of the middle occipital gyrus, 5) betweenness centrality of the IFGorb, and 6) baseline WAB-AQ. The model significantly predicted change in naming accuracy, $F(6,57)=63.02$, $p<0.001$, with a model fit of $R2=0.613$ (expected prediction error estimate=0.55, SD=0.10). Conclusions: This is the first study on network controllability and aphasia. Our results provide a foundation for clinical applications of network control theory in structural brain connectomes from individuals post-stroke. We demonstrate an added value of modal controllability of preserved regions in the language network to predict treated aphasia recovery that goes beyond traditional demographic, lesion, and graph theory measures. These findings are instrumental for developing treatment approaches that target desired brain states and are explained through structural neural network mechanisms.

Topic Areas: Language Production, Methods

Phonological Retrieval Mediates the Relation of Phonological Working Memory and Narrative Production

Poster B35 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session B.

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Recently, Martin and Schnur (2019) examined the role of semantic (s-WM) and phonological working memory (p-WM) in narrative production for a large sample of acute stroke patients. They found that s-WM but not p-WM capacity predicted sentence elaboration measures, consistent with prior findings (Martin & Freedman, 2001; Martin, Miller & Vu, 2004). However, p-WM but not s-WM capacity had a significant independent role in predicting speech rate (measured as words per minute). Follow-up analyses showed that p-WM, but not s-WM, was negatively related to the ratio of pronouns to nouns (i.e., higher p-WM capacity, fewer pronouns relative to nouns). The p-WM results were unexpected, given the preserved language production seen in case studies of p-WM deficits. Based on prior evidence for the role of p-WM, we hypothesized that the relations of p-WM to narrative production derived from patients' phonological retrieval abilities at the single word level, rather than their p-WM capacity. That is, greater ease in phonological retrieval would increase speech rate and support rehearsal during p-WM tasks (Baddeley et al. 1975). A higher pronoun ratio might arise because the retrieval of longer, less frequent words, with low phonological neighborhood density (PND) would be most affected, leading to an over-reliance on pronouns, which are short, highly frequent and have dense neighborhoods. If these hypotheses are correct, we predicted that: 1) phonological errors in picture naming and word repetition, reflecting phonological retrieval impairment, should be related to slower speech rate, lower p-WM, and a higher pronoun ratio, 2) pronoun ratio should be positively related to frequency and PND, and negatively related to the length of content words that individuals produced in their narratives, 3) p-WM capacity and speech rate should show these same relationships with frequency, PND, and length of content words in narrative production. Sixty-four patients (including 37 from Martin & Schnur, 2019) were tested within one week of left-hemisphere stroke. Digit matching span was used to assess p-WM. Cinderella narratives were scored according to the Quantitative Production Analysis (Rochon et al., 2000). The frequency, length, and PND of content words from individuals' narratives were calculated. The proportions of phonological and semantic errors in single word production were assessed from a 45-item object naming task and 17-item word repetition task. Consistent with the phonological retrieval hypothesis, digit matching span, words per minute, and pronoun ratio were all significantly correlated with the proportion of phonological errors in picture naming and word repetition. When pronoun ratio was regressed on content word length, frequency, and PND simultaneously, frequency and length effects were significant ($ps < .01$), whereas the PND effect was non-significant ($p = .79$), due to its correlation with the other measures. However, when digit matching and speech rate were regressed on frequency, length, and PND no significant effects were found. Most results supported the hypotheses that phonological retrieval abilities underlie the relationship between p-WM and narrative production measures. Potential sources of the discrepant results will be considered, including a possible separation between input and output p-WM (Martin, Lesch, & Bartha, 1999).

Topic Areas: Language Production, Phonology and Phonological Working Memory

Impact of auditory intervention on neural synchronization to sounds in pre-readers at cognitive risk for dyslexia

Poster B36 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session B.

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Previous research has indicated that deficits in auditory temporal processing and synchronization of neural oscillations to auditory input signals, specifically related to rise time processing, underlie phonological processing problems in dyslexia. At the same time, speech envelope enhancement, which emphasizes onset cues or rise times and reinforces the temporal structure of the speech envelope, has been shown to reduce speech perception deficits in both children and adults with dyslexia. While recent studies have elaborated on precursors of dyslexia, it is usually only diagnosed after several years of reading instruction. However, the most effective period for intervention is during kindergarten and first grade. To overcome this dyslexia paradox, it is imperative to develop an intervention that targets precursors of dyslexia, such as the deficient neural synchronization. In this study, we aim to investigate changes in neural synchronization to auditory input signals following a preventive intervention in pre-readers at cognitive risk for dyslexia. More specifically, we investigate changes in Auditory Steady State Responses (ASSRs) in children who listened to enhanced speech during a preventive intervention, compared to children in non-enhanced listening conditions. Stimuli were sinusoidal amplitude modulated speech-weighted noises (AM stimulus) and speech-weighted noises with the same rate of amplitude modulation but with reduced rise times (PULS stimulus). Amplitude modulation frequencies were 4 and 20 Hz, corresponding to syllable and phoneme rates in speech. A sample of 90 children was selected based on tests administered during a screening, showing that they are at cognitive risk for dyslexia. The children were divided in three groups of 30 children each. Two groups received a tablet-based intervention and served as intervention groups while the other group served as control group. The tablet-based intervention consisted of a for Flemish kindergarteners adapted version of GraphoGame, shown to have a positive impact on beginning readers. This was combined either with or without enhanced envelope training, known to aid speech perception in hampered listening conditions. The children played both games six times a week, for a total period of 12 weeks. Children in the control group played commercial entertainment games six times a week for 12 weeks. EEG measures were administered before and directly after the intervention. The results showed no intervention effects. However, all children showed a relative decrease in the response to the PULS stimulus compared to the AM stimulus at 20 Hz. Adults with dyslexia have already been shown to exhibit this atypical relative decrease, whereas this was not the case in adults without dyslexia. Since all children in our study are at cognitive risk for dyslexia, this measure could be a marker for future reading problems. Follow-up after the start of reading instruction will further clarify this link by enabling to correlate this measure with later phonology and reading skills. To summarize, no effects of the envelope enhancement intervention were found. Interestingly, all children displayed neural responses that were previously found to distinguish adults with dyslexia from adults without dyslexia. Follow-up will enable us to possibly confirm this as a marker for dyslexia.

Topic Areas: Disorders: Developmental, Perception: Auditory

White matter pathways in adult Hebrew readers with developmental dyslexia: a compensatory role of the right hemisphere in phonological and morphological processing

Poster B37 [Poster PDF] Visit me at [Gather.Town] in the Wernicke room during Poster Session B.

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Developmental dyslexia is a prevalent reading disorder which persists into adulthood. Numerous studies address the neural correlates of reading impairment in children, but for many individuals with dyslexia reading remains a lifelong struggle. The aim of the current study was to characterize the structural reading pathways in adults with dyslexia, and examine their relations to specific language skills. Based on previous findings (e.g., Vandermosten et al., 2012, Yeatman et al., 2012a) we targeted three reading-related tracts bilaterally, both ventral (inferior fronto-occipital fasciculus, IFOF; inferior longitudinal fasciculus, ILF) and dorsal (the fronto-temporal segment of the arcuate fasciculus, AF). Twenty-one university students diagnosed with developmental dyslexia (11 females, 22-34y) and 22 university students with no history of reading difficulty (12 females, 20-33y) completed a diffusion MRI scan (3T GE scanner, 19 diffusion directions at b=1000 s/mm2, 1 volume at b=0; voxel size: 0.9*0.9*2mm; resampled to 2*2*2mm). We used deterministic tractography and automatic tract segmentation (Yeatman et al., 2012b) to identify the tracts of interest in each participant's native space. We then calculated fractional anisotropy (FA) and mean diffusivity (MD) profiles along each tract, and compared these profiles between the two groups. To shed light on the bases of specific language skills in the dyslexia group, we next calculated Pearson correlations between the diffusion profiles and behavioral measures of phonological and morphological awareness, evaluated in a separate session. Our results show lower MD in dyslexics compared with controls in clusters within the right IFOF, left ILF and right AF ($p < 0.05$, corrected for multiple comparisons). Within the dyslexia group, phonological awareness was negatively correlated with MD in the left

AF (r = -0.55, p<0.05, FDR corrected), replicating previous findings. Additionally, correlations with phonological awareness were found in several ventral tracts: the left IFOF, right IFOF and left ILF (r = -0.62, r = -0.61, r = -0.59, respectively, all p<0.05, FDR corrected), tracts which are not classically associated with phonological processing. In contrast, morphological awareness was positively correlated with FA in the right ILF (r = 0.53, p<0.05, FDR corrected). In sum, we found lower MD in ventral and dorsal tracts of adults with dyslexia, predominantly in the right hemisphere. Importantly, while dyslexics showed lower MD than controls as a group, within the dyslexia group lower MD was associated with better, not worse, phonological awareness. This paradoxical finding may be interpreted in terms of successful compensation via the right hemisphere tracts. In other words, recruitment of right hemisphere tracts in dyslexia may facilitate performance, hence participants who differ more from controls also perform better. Lastly, we found a functional dissociation between tracts that contribute to phonological awareness and those involved in morphological awareness in dyslexia. Together, our findings expand our understanding of the structural foundations of language skills in adults with developmental dyslexia.

Topic Areas: Disorders: Developmental, Reading

Dynamics of right-hemisphere language reorganization in agrammatic aphasia: evidence from fMRI.

Poster B38 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session B.

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Introduction. Recent studies suggest that recruitment of right hemisphere (RH) homologs of language regions in the face of left hemisphere (LH) lesions in aphasia may be limited to frontal (and not temporal) regions, and may be a consequence of lesions to frontal areas in the LH [1-2]. Furthermore, recruitment of RH frontal regions may be beneficial during the subacute, but detrimental in the chronic, phase of recovery [1]. However, research on the effect of language interventions on network reorganization in chronic aphasia has reported increased activation in RH frontal and temporo-parietal regions associated with positive treatment outcomes [3]. The present study used fMRI to (1) investigate activation overlaps in healthy and chronic aphasic individuals (N=19 per group) during sentence production and comprehension tasks, and (2) the relation between sentence production/comprehension ability, aphasia severity, lesion site and RH activation patterns in aphasic participants. Method. Two fMRI tasks, each including the same set of active and passive sentences (N=48/each), were employed. In an event-related sentence completion task (SC), a written sentence lacking the main verb and a picture were simultaneously presented, as participants were required to select the verb form (active or passive) that completed the sentence and matched the picture. In a block-design picture verification task (PV), participants listened to a sentence while viewing a picture and were asked to determine if picture and sentence matched. A control condition, in which randomly-generated letter strings (for SC) or reversed speech (for PV) were presented in conjunction with scrambled pictures, was included in both tasks. Results. In healthy individuals, region-of-interest (ROI) analyses revealed, for both tasks, activation for passive>control in a large LH network, as well as in RH posterior middle temporal regions. An inferior/middle frontal cluster was also found for the SC (but not the PV) task. In individuals with aphasia, RH activation was found for both tasks in an inferior/middle frontal cluster (same as healthy controls' in SC), and was negatively related to comprehension of syntactically complex sentences. However, the PV task, which also yielded RH activation in a posterior middle temporal cluster (same as healthy controls' in PV), was predicted by aphasia severity (the less severe, the more activation). RH activation in both tasks was greater in individuals who were further along in their recovery, and not predicted by lesion location. Discussion. These findings indicate that RH frontal and temporal regions that are active in healthy participants are recruited during the chronic phase of recovery. The frontal activation may indicate reliance on domain-general mechanisms, which does not reflect sentence processing ability [2] and may be detrimental to recovery in the absence of treatment. However, posterior activation is related to language ability and has been shown to increase as a function of treatment [3]. Future research tracking RH treatment-induced changes in both frontal and temporal regions will clarify their role in language recovery.

References 1. Stockert, A., et al. (2020). Brain, 143(3), 844-861. 2. Turkeltaub, P., et al. (2012). Cortex, 48(9), 1179-1186. 3. Barbieri, E., et al. (2019). Cortex, 120, 394-418.

Topic Areas: Disorders: Acquired, Syntax

Auditory verb generation performance dissociates variants of Primary Progressive Aphasia.

Poster B39 [Poster PDF] [Poster Tour] Visit me at [Gather.Town] in the Wernicke room during Poster Session B.

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Primary Progressive Aphasia (PPA) is a clinical syndrome in which patients progressively lose speech and language abilities. Three variants are recognized, associated respectively with semantic deficits and anterior temporal lobe (ATL) atrophy (svPPA), grammar and/or speech-motor deficits and inferior frontal gyrus (IFG) atrophy (nfvPPA), phonology and/or short-term verbal memory deficits and left temporo-parietal atrophy (lvPPA). These patients might all fail to perform a language task (e.g., produce a verb in response to a noun), yet for unique syndrome-specific reasons, i.e. due to the failure of different cognitive mechanisms. Thus, an analysis of their pattern of responses can provide insights on the neural correlates of different components of language. Wee set out to investigate how the processes involved in the semantic analysis of verbal stimuli and spoken response production may be differentially impacted by atrophy to different parts of the brain in different PPA variants. Participants (27 HC, 28 svPPA, 24 nfvPPA, 21 lvPPA) performed an auditory verb generation task: prompted with a noun (50 words, presented twice each in randomized order, ISI=4s), they were asked to respond with an associated verb. Three raters coded each response as a related verb (e.g., "ball" = "bounce"), not a verb (e.g., "ball" = "bat"), or an unrelated verb (e.g., "ball" = "eat"). Using healthy controls data, we computed an index of verb generation agreement for each noun (H-value). The three clinical cohorts statistically differ in terms of overall accuracy ($F(3)=33.46$, $p<0.001$) as well as in the kind of errors produced ($F(2)=28.28$, $p<0.001$). Critically, a machine learning algorithm trained to classify the participants in the correct diagnostic group based on the distribution of errors performed well above chance level (cross-validated score = 0.64 ± 0.11, $p<0.001$). Moreover, performance correlated with critical psycholinguistic variables of the stimuli: H-value in all cohorts (svPPA: $r=-0.25$, $p=0.0136$; lvPPA: $r=-0.4$, $p<0.001$; nfvPPA: $r=-0.37$, $p=0.002$), frequency (svPPA: $r=0.34$, $p=0.0006$; lvPPA: $r=0.09$, $p=0.39$; nfvPPA: $r=0.23$, $p=0.023$) and familiarity (svPPA: $r=0.45$, $p<0.001$; lvPPA: $r=0.16$, $p=0.12$; nfvPPA: $r=0.25$, $p=0.016$) only in svPPA and nfvPPA, number of phonemes only in lvPPA (svPPA: $r=-0.04$, , $p=0.72$; lvPPA: $r=-0.21$, $p=0.03$; nfvPPA: $r=-0.05$, $p=0.62$). No correlations were found with the number of letters, concreteness or imaginability. Finally, performance correlated with key neuropsychological features of the patients: MMSE in all cohorts but svPPA (svPPA: $r=0.2$, $p=0.32$; lvPPA: $r=0.5$, $p=0.02$; nfvPPA: $r=0.55$, $p=0.005$), naming only in nfvPPA (svPPA: $r=0.29$, $p=0.13$; lvPPA: $r=-0.035$, $p=0.9$; nfvPPA: $r=0.4$, $p=0.04$), semantic fluency only in svPPA (svPPA: $r=0.4$, $p=0.034$; lvPPA: $r=-0.16$, $p=0.49$; nfvPPA: $r=0.54$, $p=0.006$). Taken together, our findings indicate that error patterns in an auditory verb generation task depend on the breakdown to different neurocognitive mechanisms across PPA variants. Specifically, they corroborate the link between ATL with semantic processes, temporo-parietal regions with phonology, and IFG with speech production, thus improving our understanding of the neural basis of language.

Topic Areas: Disorders: Acquired, Language Production

Musical and linguistic syntactic processing in agrammatic aphasia

Poster B40   Poster PDF   Visit me at Gather.Town in the Wernicke room during Poster Session B.

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Introduction Understanding the relationship between linguistic and musical syntactic processing could have clinical implications for people with language disorders such as aphasia. According to the Shared Syntactic Integration Resource Hypothesis (SSIRH)1, syntactic processing relies on shared resources for the integration of words/chords into sentences/musical phrases. One prediction of the SSIRH is that aphasic people with agrammatic comprehension should present with musical syntactic deficits. The present study is the first to examine neurophysiological responses to musical and morphosyntactic violations in people with aphasia. A secondary aim of this study was to determine the relationship between musical training and neurophysiological responses. Methods Participants included 7 people with aphasia (3 female; mean age = 56.0 years) and 14 healthy controls (6 female, mean age = 62.4 years). The groups did not differ in age, education, or musical training. All participants were right-handed, monolingual, native English speakers. The participants with aphasia suffered a single left hemisphere stroke at least one year prior to the study and presented with language impairments consistent with agrammatism. Participants completed an acceptability judgment task while EEG was recorded from 32 scalp electrodes. The stimuli included 100 sentences2 and 72 musical phrases3. Half of the sentences and musical phrases were grammatical, and half contained a syntactic violation (subject-verb disagreement or an out-of-key chord). ERPs were time locked to the onset of the critical word/chord, with a 200ms pre-stimulus baseline and 1200ms epoch for each. Results Both groups showed a significant P600 in response to violations of morphosyntax. However, the aphasic group presented with a reduced-amplitude P600 in posterior regions, but a larger positivity in anterior regions. As expected, the aphasic group was impaired in their ability to discriminate grammatical from violated sentences. In response to musical syntactic violations, both groups showed a significant P600. The amplitude of the P600 was larger for the aphasic group in all regions. The groups did not differ in their ability to discriminate in-key from out-of-key musical phrases. For both groups, musical training was associated with larger posterior P600 responses to syntactic violations across both domains. Conclusions These findings are not in line with the predictions of the SSIRH, and instead suggests that linguistic, but not musical, syntactic processing may be selectively impaired in agrammatic aphasia. Given the relationship between musical training and P600 amplitude in both language and music, these findings motivate more research on the relationship between language abilities and musical training. References 1. Patel, A. D. (2003). Language, music, syntax and the brain. Nature Neuroscience, 6(7), 674–681. 2. Barbieri, E., Litcofsky, K. A., Walenski, M., Chiappetta, B., Mesulam, M.-M., & Thompson, C. K. (in prep). On-line sentence processing impairments in agrammatic and logopenic PPA: Evidence from ERP. 3. Patel, A. D., Gibson, E., Ratner, J., Besson, M., & Holcomb, P. J. (1998). Processing Syntactic Relations in Language and Music: An Event-Related Potential Study. Journal of Cognitive Neuroscience, 10(6), 717–733.

Topic Areas: Disorders: Acquired, Syntax

Temporal dissociation of white matter fasciculi in post-stroke aphasia outcomes

Poster B41   Poster PDF   Poster Tour   Visit me at Gather.Town in the Wernicke room during Poster Session B.

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Context: post-stroke aphasia (PSA) is one of the most devastating consequences of stroke, causing permanent impairments in approximately two thirds of affected individuals. PSA recovery can be divided into two main periods: early recovery (between 0 to 4 weeks post onset) during which a steep recovery curve is generally observed, and chronic recovery (between 4 weeks to 6 months post onset), when rehabilitation takes place, with a plateaued recovery curve towards the end. Behavioral (e.g., initial aphasia severity) and neuroimaging measures, (e.g. measures extracted from the arcuate fasciculus (AF)), have been proven to be good predictors of long-term recovery (from 3 to 6 months). However, this relation has been less explored in earlier phases, and recent studies suggest that the inferior frontal-occipital fasciculus (IFOF) may also play a role in PSA recovery (Zavanone et al., 2018). This study aims to identify the best predictors of early and late recovery in PSA. Methods: sixteen individuals with PSA (69 ± 12 y.o., 6 females) with an ischemic stroke in the left middle cerebral artery territory were recruited. Magnetic Resonance Imaging (MRI) and a language assessment were conducted in the acute (2±1 days), subacute (10±2 days) and chronic phases (> 6 months). Aphasia severity was measured using a Composite Score (CS) assessing naming, comprehension and repetition (Osa García et al., 2020) at each time point (CSacute, CSsubacute, CSchronic,). The MRI was acquired on a 3T-Siemens scanner, including a T1-weighted (T1w) and a diffusion weighted imaging (DWI) sequence. Tractographies from both left and right AF and IFOF were reconstructed using HARDI diffusion data processing (Boukadi et al., 2019), and fractional anisotropy (FA) and axial diffusivity (AD) were extracted. Univariate and multivariate regression analyses were performed for each recovery period, using the CSsubacute and CSchronic as dependent variables respectively, with age, CSacute, lesion size and white matter (WM) measures as predictors. Results: significant improvement of the CS was found between the acute and subacute assessment; however, the change was not significant between the subacute and the chronic assessment. In the early recovery multivariate model ($R2$ = 0.83), CSacute was the best predictor of CSsubacute (β= 0.897, p= 0.004), and FA from left IFOF was the WM measure with the highest predictive power (β= 0.756, p= 0.019). However, in the chronic recovery multivariate model ($R2$ = 0.39), no variable was a significant predictor of the CSchronic. Among the univariate models, only FA from left AF predicted CSchronic (β= 0.524, p= 0.037). Conclusion: FA of the IFOF in the acute phase appears to be a good predictor of aphasia severity in the subacute phase, whereas FA of the AF seems to be a good predictor in the chronic phase. Consistent with previous evidence, this suggests that there is a temporal dissociation or shift in involvement of the functional language pathways after a stroke. Future studies will include other biomarkers to provide a more comprehensive understanding of aphasia outcomes at different time points, which will better help to characterize the factors in recovery of PSA.

Topic Areas: Disorders: Acquired, Methods

Unexpected absence of aphasia following left temporal hemorrhage: A case study

Poster B42 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session B.

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When damage to left hemisphere perisylvian regions unexpectedly does not result in aphasia, it is often assumed that the individual must be right lateralized for language. However, this supposition is rarely confirmed, and there are two other explanations that should also be considered. First, many individuals demonstrate some degree of bilateral representation for language, with imaging studies suggesting that bilateral representation may actually be more common than right lateralization [1, 2], raising the possibility that the contribution of the undamaged right hemisphere could be sufficient to sustain normal language function. Second, there is individual variability in the precise localization of critical language regions [3], raising the possibility that a focal lesion could entirely avoid a left-lateralized language network, leaving language function intact. In this case study, we used fMRI to determine the reason for a lack of aphasia in a gentleman who sustained a left temporal lobe hemorrhage. Mr. B (not his real initial) was a 26-year old, left-handed man who reported to the hospital after sustaining a seizure. Structural imaging revealed a substantial acute left temporal hemorrhage. He did not present with any symptoms of aphasia, per the Quick Aphasia Battery [4]. Mr. B was scanned with fMRI 55 days after his stroke. Two validated language mapping paradigms were used: an adaptive semantic matching paradigm [5] and an adaptive rhyme judgment paradigm [6]. We found unequivocal evidence that right hemisphere lateralization of language function was the reason why Mr. B experienced no aphasia after his left temporal hemorrhage. Both paradigms activated exclusively right hemisphere cortical regions. Specifically, both paradigms identified core frontal and temporal language regions, but lateralized to the right hemisphere, and closely mirroring differential patterns more commonly observed in the left hemisphere [5, 6], each paradigm additionally revealed regions specific to the linguistic domains targeted: the semantic paradigm activated the right anterior temporal lobe and right angular gyrus, while the rhyme judgment paradigm activated the right supramarginal gyrus and right ventral precentral gyrus. Although the possible alternative explanations were not borne out in this case, we argue that they should still be considered when evaluating other cases. Our presentation will highlight questions that remain about the various ways that language can be distributed in the brain, and the implications of damage to different regions in different scenarios. References: [1] Springer et al. Brain 1999; 122: 2033-46. [2] Szaflarski et al. Neurology 2002; 59: 238-44. [3] Ojemann et al. J Neurosurg 1989; 71: 316-26. [4] Wilson et al. PLoS One 2018; 13: e0192773. [5] Wilson et al. Hum Brain Mapp 2018; 39: 3285-307. [6] Yen et al. NeuroImage 2019; 189: 368-79.

Topic Areas: Disorders: Acquired, Meaning: Lexical Semantics

Simulating multiple sources of surface alexia in a computational model of reading

Poster B43 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session B.

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The canonical symptoms of surface alexia (an enhanced frequency by regularity interaction and the production of regularization errors; pronouncing “pint” to rhyme with “mint”) have traditionally been considered to arise from damage to semantic representations (Coslett, 2000). Recent evidence, however, has demonstrated that surface errors can arise in the absence of impairment on semantic tasks (Binder et al., 2016). We use an artificial neural network (ANN) implementation of the triangle model of reading to examine the effects of lesions at multiple locations along the semantic pathway. We hypothesize that surface alexia with and without accompanying semantic impairment can be simulated in a single system. The model was a simple recurrent ANN with an input layer of 105 orthographic units. This layer was fully connected to two hidden layers. A 100-unit hidden layer connected the orthographic layer directly to the 61-unit phonological output layer. A 250-unit hidden layer connected the orthographic layer to a 300-unit semantic layer. This semantic layer projected onto a 300-unit context layer, which served to create an attractor basin, and onto a 100-unit hidden layer, which itself projected onto the phonological output layer. Five re-initializations of the model were trained using standard back-propagation of error. Training consisted of three tasks: a “reading” task, where targets were applied to both the semantic and phonological layers (60% of epochs), a “phonic reading” task, where targets were applied to only the phonological layer (30% of epochs), and a “silent reading” task, where targets were applied to only the semantic layer (10% of epochs). The trained model read 99.6% of the 2998-word training set correctly and averaged 78.5% accuracy on novel pseudowords. Each model initialization was then lesioned 3 times at each of 4 locations (the hidden layer between orthography and phonology, the hidden layer between orthography and semantics, the hidden layer between semantics and phonology, and the semantic layer) by removing 50% of the links into and out of the location of damage. The model was allowed to re-train for 125 epochs and tested using crossed sets of high or low frequency and regular or irregular words. Magnitudes of the frequency by regularity interactions for each lesioned model were estimated with logistic regression. Lesions to the semantic pathway caused larger frequency by regularity interactions than lesions to the links leading directly from orthography to phonology ($t(14.037) = 3.117$, $p < 0.01$). Furthermore, regularization errors were made by

the model following lesions to the semantic layer (7.5% regularization rate averaged over high and low frequency irregular words) and the hidden layer between orthography and semantics (12.2% regularization rate), but not following lesions to the hidden layer between orthography and phonology (0.01% regularization rate) or the layer between semantics and phonology (0% regularization rate). These results demonstrate computationally that lesions at multiple points along the semantic pathway produce the classic symptoms of surface alexia. By using models to simulate individual differences in alexia, we can test treatment approaches to determine which exert the largest beneficial effect: a method to generate personalized therapy.

Topic Areas: Disorders: Acquired, Computational Approaches

Verb processing across primary progressive aphasia variants

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Primary progressive aphasia (PPA) is a degenerative disease affecting language while leaving other cognitive facilities relatively unscathed (Mesulam, Wieneke et al., 2012). The three major variants of the disease affect language in different ways. The agrammatic variant (PPA-G) is associated with grammatical impairments; the logopenic variant (PPA-L) with deficient word retrieval; and the semantic variant (PPA-S) with impaired lexical-semantic representations. Whereas most PPA studies have investigated noun (object) processing, fewer have examined verb processing, particularly in PPA-S. These studies report impaired verb production but spared verb comprehension in PPA-G. Conversely, PPA-L and PPA-S have shown relatively spared verb production and comprehension, though results are inconsistent (for review, see Thompson and Mack, 2014). Here we investigate verb processing across PPA variants and a group of age-matched (AM) healthy controls. Participants completed two tasks: a confrontation naming task for verb production and a visual world eye-tracking task of verb comprehension, which was analyzed for accuracy and eye movement patterns. In each task, half of the verbs were transitive (e.g., “smash” requires a direct object, e.g. “John smashed the vase”), and half were intransitive (e.g., “yawn” cannot take an object, e.g., “John yawned”). In the production task, participants named pictured actions and for the eye-tracking comprehension task, participants listened to a verb as they viewed an array of four action pictures and pointed to the matching picture. Results showed that, whereas all PPA groups performed more poorly (less accurate, slower) than the AM group, the PPA-S group performed significantly more poorly (less accurate, slower) than the PPA-G and PPA-L groups on both verb types, for both production and comprehension. The latter groups performed similarly in both tasks for both verb types, though the PPA-L group was significantly less accurate than the PPA-G group for verb production. In production, transitivity effects (poorer performance on transitive than intransitive verbs) were seen in all groups for RT but not accuracy, though the RT difference reached significance only for the AM group. In comprehension, significant transitivity effects were found for accuracy for all groups, and for RT for the PPA-L group (and marginally for the PPA-G group). The eye-tracking data were analyzed with a curve-fitting procedure for the proportion of target gazes over time (McMurray, 2017). The results indicated that the PPA-S group had significantly lower peaks for both verb types than the other groups, between which peak height did not differ. Differences between the AM group and the PPA groups were also found for parameters estimating the peak time and the offset slope, though not for the onset slope. These findings indicate severe verb processing deficits in PPA-S, affecting production and both offline and online comprehension, contrary to previous results, suggesting that deficits in this population extend beyond object knowledge (i.e., comprehension). Verb production and comprehension were also impacted in PPA-G and PPA-L, though with differing patterns for the two groups. These data add to the growing body of knowledge concerning the nature of the language deficits across the three variants of PPA.

Topic Areas: Disorders: Acquired, Syntax

Developmental differences in neural oscillations supporting the identification of novel word meaning from context

Poster B45 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session B.

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Word learning is accomplished from early childhood throughout the lifespan. As older children and adolescents continue to develop their language abilities, learning words implicitly from their context is a primary means of vocabulary growth. The current study investigated the neural correlates that underlie how school-aged children and adolescents identify the meaning of novel words which are embedded within several sentence contexts. A diverse cohort of children between 8-16 years of age (N=82) completed a meaning-identification task requiring participants to generate plausible word meanings for unfamiliar words embedded across a series of spoken sentence contexts. Children listened to three contextually related sentences within a trial, each ending in the same pseudoword. At the end of a trial, children attempted to verbally provide the real sentence-final word that the pseudoword was replacing, which required them to integrate word meaning using information from the relevant sentence contexts. We used a regression-based analysis to examine trial-by-trial relationships between the time-frequency dynamics of the EEG signal related to pseudoword processing and successful performance on the meaning-identification task. Furthermore, we used continuous measures of language ability, indexed by performance on a standardized language omnibus measure (CELF-5), to identify developmental trajectories in oscillatory activity that support performance on our implicit meaning-identification task. We focused on activity within the theta (3-7Hz) and low beta (14-20Hz) frequency ranges—bands that have been previously identified as displaying a protracted developmental maturation during spoken sentence comprehension (Schneider et al, 2016). Mixed-effects linear models revealed that pseudowords processed in trials where meaning was subsequently identified were associated with less beta band suppression particularly over frontal electrode locations (β= 0.13; SE = 0.06; $P < 0.025$). Successful task performance was also related to stronger power modulation in the theta frequency range, especially over the left hemisphere (β= -0.15; SE = 0.05; $P < 0.01$). Importantly, individual differences in language ability accounted for significant variance in the relationship between neural oscillations and successful task performance in both beta and theta band analyses (theta: β= 0.19; SE = 0.06; $P < 0.01$; beta: β= 0.05; SE = 0.02; $P < 0.01$). These interactions revealed that children with poorer language ability showed greater modulation of theta band activity across correct and incorrect trials, while children with superior language ability displayed stronger task-relevant differences in beta band activation. The current study provides a unique look into neural signatures underlying higher-order aspects of online speech processing and implicit language learning by delineating developmental changes related uniquely to language-specific aptitudes. Schneider, J. M., Abel, A. D., Ogiela, D. A., Middleton, A. E., & Maguire, M. J. (2016). Developmental differences in beta and theta power during sentence processing. Developmental Cognitive Neuroscience, 19, 19-30.

Topic Areas: Development, Meaning: Lexical Semantics

Language Network Areas Predict Movie-Watching versus Rest as a Function of Narrative Consistency

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Presenter Note: Happy to schedule a Zoom meeting if you missed the poster session! Please, contact me at sara.sanchez.alonso@yale.edu

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The functional network organization that characterizes cognitive states is not static, but rather changes over time. Here, we investigate functional connectivity (FC) differences between rest and movie-watching states in a

developmental sample that varies as a function of language experience (i.e., bilinguals versus monolinguals). We address the following question: To what extent do FC temporal dynamics and individual differences in language experience affect prediction of task state (movie-watching versus rest)? We analyzed FC fMRI data acquired during movie-watching and rest in a cohort of 224 children and young adults (112 bilinguals) aged 6-20 from the Healthy Brain Network dataset (Alexander et al. 2017). The dataset was preprocessed with the Human Connectome Project minimal preprocessing pipelines (Glasser et al. 2013). To isolate parcel-level and network-level signals we used the whole-brain CAB-NP parcellation (Ji et al. 2019) derived from the HCP atlas (Glasser et al. 2016). The data were analyzed using PrimeNet, a predictive modelling approach that quantifies binary and continuous phenotypic predictions from brain-wide FC patterns (Sanchez-Alonso et al., 2020). First, we identify a robust brain-wide FC pattern that predicts whether individuals are watching a movie or resting. We ran 1,000 iterations of a multi-level model to select edges (pairwise correlations) for each iteration. The edge-features selected in each iteration were used to train single-feature SVM binary classifiers using leave-one-out cross-validation. We applied the trained models to held-out data across the 1,000 iterations, achieving a high mean accuracy=89%, mean sensitivity=88.6%, mean specificity=89%, and AUC=0.93. Finally, we identified the edges across all 1,000 iterations for the main effect of state (movie versus rest). Second, we characterize predictive accuracy of the model as a function of the number of BOLD frames across two movies of different duration (3.5 min and 10 min). In the shorter movie, we find that predictive accuracy is no better for the entire movie duration than for the first minute. However, predictive accuracy in the longer movie was consistently lower than in the shorter movie. The key difference in the content of the longer movie was that it consisted of segments extracted from the overall narrative context, therefore appearing decontextualized. The highest accuracy is achieved from single coherent scenes (mean accuracy: 94%), whereas the lowest predictive accuracy is observed from decontextualized scenes (mean accuracy: 65%). Finally, we show that FC patterns in the set of edges that distinguish movie watching from rest vary as a function of language experience. Bilinguals show higher within-network FC in areas of the language network and in the coupling between language and frontoparietal areas. We report three main findings. First, we identify a set of FC patterns that can reliably distinguish movie-watching versus rest across subjects. These data provide evidence for a 'core' stable functional network organization in development that varies with cognitive state. Second, we show that contextualization of the narrative, rather than its length per se, drives the state-specific predictive accuracy. Third, the predictive set of FC patterns also shows variation as a function of language experience (bilingual versus monolingual).

Topic Areas: Development, Meaning: Discourse and Pragmatics

Structural lateralization over the course of development

Poster B48 [Poster PDF] Visit me at [Gather.Town] in the Wernicke room during Poster Session B.

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Background: The link between language and structural lateralization of the cortex has been studied extensively, yet results are not conclusive. Even less understood is this relationship between language and lateralization over the course of development. Some evidence has shown early bi-laterallity of brain structure and function for language, shifting with age. Increased understanding of structural lateralization strengthens connections with functional language abilities. Skeide and colleagues (2016) found that white matter structure paired with functional brain data was the best predictor of sentence comprehension. Our previous research found that aspects of the cortex in certain areas related to vocabulary ability. Here we examine structural lateralization during development with well-defined cortical and fiber tract ROIs. Method: This research utilized data from the Pediatric Imaging, Neurocognition, and Genetic database to examine development of structural lateralization in language areas of cortical gray matter and connecting fiber tracts. Three age groups were examined, based on research by Skeide, Brauer, and Friederici (2016), 3-4, 6-7, and 9-10 years old. Participants were excluded if they were non-monolingual English speakers, had history of head trauma, frank neurological or psychological disorder, or autism spectrum disorder. Additionally, we excluded individuals with hearing or learning problems, having received special services or speech therapy, repeated grades, or having had IEPs. Participants completed the NIH Toolbox for Cognition testing battery, including a vocabulary measure used as the language measure for this study. Measures for cortical surface area, thickness, contrast, and different DTI measures such as Fractional Anisotropy (FA) were taken for each hemisphere. There were ROIs across nine frontal, temporal, and parietal regions, and six subcortical fiber tracts that have been linked to language. There are 209 participants for which gray matter LIs were examined, though 19 did not have DTI results. Laterality Index (LI) scores were calculated for all ROIs to examine hemispheric dominance. T-tests were used to evaluate the degree of lateralization, and correlations and regressions were run to examine the relationship between LI and vocabulary. Results: Results for the LI scores of the cortical gray matter are consistent with previous research. There is consistent right lateralization of surface area in the middle temporal and pars triangularis, and thickness was primarily right dominant or bilateral. Only the supramarginal region showed group differences for any of the contrast measures. Results for white matter lateralization had more than 20% of the ROIs showing group differences. Correlations show a strong relationship ($r = .30$, $p < .001$) between vocabulary score and the cortical contrast measures for the supramarginal region. Looking at the fiber tracts, three FA and three LDC values for ROIs are significantly related to vocabulary. Results point to certain regions and measurements that may be more involved in vocabulary development. Notably, the strong relationship between cortical contrast of the supramarginal region and vocabulary. The tissue properties of the supramarginal gyrus are distinctive during this developmental stage. Also, variability in the LI values for the DTI measures indicates that there is likely more white matter development for these age groups.

Topic Areas: Development, Methods

Proactive Control during Language Comprehension: Evidence from Electrophysiology

Poster B49 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session B.

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Introduction Cognitive control is an umbrella term that refers to a number of processes that support goal-directed cognition. Among these is proactive cognitive control, which refers to the maintenance and representation over time of goals, context or rules relevant to the task at hand. While these processes are most often studied in cognitive control paradigms, the maintenance and use of context over time is also a critical element of language comprehension. The goal of this study was to examine proactive control processes during language comprehension. Specifically, we tested the hypothesis that demands for context maintenance during language comprehension modulate neural activity in the theta (4-7 Hz) and gamma (30-80 Hz) frequency bands, as has been found in studies of cognitive control (e.g. Cho et al., 2006). Methods EEG was recorded from 23 participants during a listening comprehension paradigm. The task was adapted from proactive cognitive control paradigms such as the dot pattern expectancy task, in which a cue (e.g. a particular dot pattern) precedes a probe, and can be used to guide responding to the probe if maintained over a short delay. Here, short spoken sentences served as cues, followed by a 2000 ms pause before a probe sentence was presented. Cue sentences varied in mean log word frequency; critical words in probe sentences varied in predictability based on the context provided by the cue sentences. See below for an example: Cue: Ed was upset when his laptop lost power. [Pause] Probe: He had forgotten to bring the CHARGER. ERPs were time-locked to critical words in probe sentences, and phase-amplitude coupling between theta and gamma frequency bands during the pause separating cue and probe sentences was also calculated. Results ERPs: We compared the N400 response to highly predictable (70-100% cloze probability) versus less predictable (0-30% cloze probability) critical words in the probe sentences. Results showed a significantly reduced N400 amplitude for predictable compared to less predictable critical words ($p<0.005$). EEG: We compared theta-gamma coupling during the pause following cue sentences as a function of mean log frequency of the words in those cue sentences. Results showed significant theta-gamma coupling, which was maximal at frontal electrode sites and increased after cue sentences with low mean log word frequency compared to high mean log word frequency ($p<0.05$). Conclusions The ERP results showed a significant effect of predictability for critical words in the probe sentences, demonstrating successful maintenance and use of context provided by the cue sentences. The EEG phase-amplitude coupling results showed significant theta-gamma coupling during the pause following cue sentences, which was increased for cue sentences with words of relatively low frequency compared to cues containing words of relatively high frequency (mean word frequency served as a proxy for the relative "difficulty" of maintaining the cue context over time). These results are consistent with cognitive control studies outside of the language domain, that have linked theta-gamma dynamics to proactive cognitive control engagement. This suggests that similar prefrontally-mediated proactive control mechanisms may support context maintenance during language comprehension.

Topic Areas: Control, Selection, and Executive Processes, Meaning: Discourse and Pragmatics

The effect of training in neural network language models on predicting brain activity

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In recent years, artificial neural networks (ANNs) have gained prominence as predictive models of brain activity across several sensory domains (Kell et al. 2018; Yamins et al. 2014). More recently, it has been shown that state of the art language ANN models may relate to neural responses during language processing (e.g., Toneva and Wehbe 2019; Jain and Huth 2018). Particularly relevant to this work, Schrimpf et al. (2020) have demonstrated that representations from ANNs trained on large corpora can be highly predictive of human brain activity, in addition to matching human behavioral responses. However, these models are trained on unrealistic amounts of data, equivalent to more than a lifetime of human exposure to language. Intriguingly, Schrimpf et al. (2020) also found that even untrained variants of high-performing models achieve good neural predictivity. This suggests that the architecture of the network may play a crucial role, but leaves open the question of how training data influences neural predictivity (Zador 2019; Gauthier and Levy 2019). In this work, we begin to address this open question by considering, as a test case, three variants of RoBERTa (Liu et al. 2019) – a state of the art mid-sized transformer-based language model – which were pre-trained by Zhang et al. (2020) on varying amounts of data (10M, 100M, or 1B tokens) while keeping the model's architecture fixed. We compare representations extracted from these three variants, as well as from an untrained model with the same architecture, against brain activations measured with fMRI (Pereira et al., 2018) using a cross-validated predictivity score for brain activity (Schrimpf et al. 2018). Our results show that training size improves the prediction of brain activity across all layers of the network, and that this happens in a nonlinear way: (1) the gain with training size follows a logarithmic trend, such that even 1% of the data (10M) yields a substantial gain of 45% in predictivity compared to the untrained network; and (2) while the small training dataset substantially improves predictivity in the early layers of the network, the larger datasets (100M and 1B) primarily improve predictivity in the later layers, although with diminishing returns. In addition, the early layers of the network (layers 2 and 3) achieve similar predictive power as the later layers (9 and 10). Predictability in these layers reaches 60% relative to the noise ceiling. These findings suggest that even mid-sized ANN language models trained on reasonable amounts of data, roughly corresponding to the exposure to language during childhood, may predict brain activity in the language network. Furthermore, they suggest that the early layers of the network, at least in the case of RoBERTa, may be most relevant for modeling language processing in the brain. An important direction for future research is to test how the interaction between training data and network architecture influences the model's ability to predict brain activity during language processing.

Topic Areas: Computational Approaches, Methods

Speaker Accent influences Bilingual Lexical Activation: An EEG Study on Sentence Processing of False Cognates

Poster B51 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session B.

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One major aim for bilingual cognition research is to understand the complex web of factors that modulate the dynamic nature of bilingual lexical activation (Dijkstra, Grainger, & van Heuven, 1999; Dijkstra & van Heuven, 2002; Pavlenko, 2009; Costa, Pannunzi, Deco, & Pickering, 2017; Adamou & Shen, 2019). The EEG study presented in this paper examines the degree to which social information (i.e. speaker accent) can influence activation of the non-target lexicon for bilingual listeners. Based on recent findings suggesting that the mere physical presence of another bilingual in the discourse context can increase non-target language activation in bilingual listeners (Kaan, Kheder, Kreidler, Tomic, & Valdes Kroff, 2020) and that speaker accent can influence word processing for dialect-ambiguous words in monolingual listeners (Martin, Xavier, Potter, Melinger, & Costa, 2015), the current study investigates the degree to which speaker accent might modulate bilingual lexical activation for language-ambiguous words in bilingual listeners. The preliminary data come from an EEG (N400) experiment in which Spanish-English bilinguals (n= 9) listened to sentences in English that intermittently contained false cognates from Spanish (e.g. Eng. bland used as [[soft]]; Sp. 'blando' = [[soft]]). Crucially, stimuli were presented across three speaker accents: native-, Spanish-, and Chinese- accented English. Non-selective models of bilingual lexical activation (e.g. Dijkstra & Van Heuven (2002)'s BIA+ model) predict that extralinguistic factors like speaker accent should have little or no effect on the bilingual word recognition system, while dynamic accounts of bilingual lexical activation (e.g. Grosjean (1998)'s language mode continuum) assume that a wide range of socially-constrained extralinguistic factors in the discourse context are able to dynamically modulate activation of the non-target lexicon for bilingual listeners. Regardless of speaker accent, false cognates elicited an N400 reduction effect relative to anomalous control words (e.g. Eng. bland used as [[dry]]), providing evidence of parallel lexical activation of Spanish in the bilingual listeners. The degree of those N400 modulations, however, changed slightly as a function of speaker accent. Specifically, the strongest N400 reduction effect (i.e. false cognates relative to anomalous control words) was found in response to the Spanish-accented speaker, followed by a moderate N400 reduction effect in response to native-accented speech and only a slight N400 reduction effect in response to Chinese-accented speech. These results indicate that lexical activation in bilingual listeners demonstrates a dynamic sensitivity to speaker accent, providing further evidence for dynamic models of parallel bilingual lexical activation. Additionally, responses from an offline accent evaluation survey indicate that 78% (n= 7) of the EEG subjects perceived the Spanish-accented English speaker as Latino/Hispanic/Spanish-knowing, but none attributed any such characteristics to the native- or Chinese-accented speakers. These results indicate that the bilinguals in this study increased activation of their Spanish lexicon when listening to a speaker they assumed might also know Spanish, which surprisingly included not only L2-Spanish accented speech but also native English speech. These findings support the view that bilingual lexical activation can be modulated by the speaker accent and are compatible with a dynamic model of bilingual word comprehension.

Topic Areas: Multilingualism, Meaning: Lexical Semantics

The Influence of the Bilingual Experience on Word Learning in School-Age Children: An ERP Study

Poster B52 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session B.

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There has been a recent surge in interest in word learning differences between bilingual and monolingual individuals. Initial studies focusing on word learning have identified group differences in word learning accuracy, leading to findings that other factors involved in novel word learning also differ in bilinguals (e.g., Kaushanskaya & Marian, 2009; Kaushanskaya & Rechtzigel, 2012). For example, bilingual infants show enhanced attentional control during novel word learning compared to monolingual infants (Singh, Fu, Tay, & Golinkoff, 2018). Moreover, bilingual adults engage in deeper semantic processing during word learning compared to monolingual adults (Kaushanskaya, 2018). Identifying these factors has provided a greater understanding of the relation between the bilingual experience and word learning. Further insight into this relation would be gained by examining factors that are unique to bilingual individuals, such as L2 proficiency. Another way to elucidate the relation between bilingualism and word learning is to focus on childhood when each factor is still developing. The importance of the childhood period is further exemplified by socioeconomic status (SES)-related differences in the neural indices of word learning in school age children (Ralph, Schneider, Abel, & Maguire, 2020) and the influence of bilingualism and SES on vocabulary size in children (Chiat & Polišenská, 2016). The findings on both word learning and bilingualism in childhood drive a need for further investigation into factors that are associated with word learning in school-age children. This study expands on the extant literature by utilizing EEG to investigate the relation between the bilingual experience and word learning in school-age children. Thirty bilingual speakers of English and Spanish (10-15 years of age) completed standardized language and cognitive assessments and an experimental word learning task in English. In the word learning task, participants read 100 sets of 3 sentences that collectively implied one unique meaning for a novel word in one condition and did not provide one unique meaning in the other condition. After each sentence set, children were asked to identify if the novel word had a meaning and, if so, to provide the meaning. ERPs for the word learning task were time-locked to the novel word onset. Analyses will focus on the P200 and N400 components, related to attention and semantic processing, respectively. Presently, all the data have been collected and are being processed and analyzed. Linear mixed- effects models will be run for each ERP component and will include the following variables: L2 proficiency, SES, and condition. In addition, interactions will be run on condition and L2 proficiency and SES for each component. Based on previous literature, we predict that L2 proficiency and SES will be significant predictors of the P200 and N400, suggesting an influence of these factors on word learning in bilingual school-age children. Due to the limited research on this topic, we do not anticipate any significant interactions.

Topic Areas: Multilingualism, Meaning: Lexical Semantics

Toward dissociating general reading experience and domain-specific knowledge sources during RSVP reading: An exploratory rERP data analysis

Poster B53 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session B.

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How do individuals' specific knowledge and experiences shape language processing in real time? Troyer and colleagues (2018, 2019, 2020) demonstrate that variation in (fictional) knowledge of the narrative world of Harry Potter (HP) has a near-immediate influence on word processing during sentence (about HP) reading, modulating N400 effects of sentential support (i.e., "correct" vs. incorrect sentence completions) as well as related anomalies (i.e., anomalous/incorrect words related versus not to the sentence contexts): greater HP knowledge is associated with reduced N400 potentials to supported/related words. In these studies, however, results hinged on a knowledge measure estimated from a multiple-choice quiz; they did not directly examine how variation in knowledge types may impact neural processing. Moreover, results were mainly based on analyses in pre-defined time periods, thereby blind to other event-related brain potential (ERP) effects. Here, we capitalize on recent advances in ERP analysis (the regression ERP, or rERP approach, combined with AIC model comparison; Smith & Kutas, 2015, Urbach et al., in press) to compare how various measures of knowledge and experience relate to millisecond-by-millisecond ERP timecourse data recorded as individuals read sentences one word at a time. We examined how quiz-based HP scores, reported HP-book-reading experience and movie-watching experience, an aggregate HP experience measure, and general reading experience each impacted ERPs to critical words completing two-sentence contexts about HP. Critical words were correct, incorrect-and-unrelated to sentence contexts, or incorrect-but-related to sentence contexts. Given, 'Sybill Trelawney is a Hogwarts Professor. She teaches {Divination/Transfiguration/basilisk},' 'Divination' is correct; 'Transfiguration' is related to 'Divination' by virtue of being from the same category (a magical school

class); and ‘basilisk’ is unrelated to the specifics of the sentence. Human ratings and computational tools verified differences among these relations (Troyer & Kutas, 2020). When considered separately, slope rERPs showed that all four HP measures had their primary association with effects of contextual support (unrelated vs. correct words) and related anomaly (unrelated vs. related words) on centroparietal channels in the N400 window (~250-500 ms). Importantly, inferences from model comparison revealed that each HP measure better explained these N400 effects relative to general reading knowledge. Across all of the measures we considered, self-reported experience with HP movie-watching best explained N400 related anomaly effects. That is, N400 effects for (incorrect) related vs. unrelated words were modulated more by HP movie-watching experience than by HP book-reading experience or ability to answer HP trivia questions correctly. Results from these exploratory analyses lead us to hypothesize that the rich multimodal experiences of watching movies may, at least in some cases, accelerate knowledge use during language understanding compared to purely linguistic experiences of reading. These findings would seem to run counter to theories on which meaning is based on linguistic experience alone, implicating multimodal contributions. We plan to assess this hypothesis by designing experiments to examine the roles of different sources of knowledge on language processing. More generally, these analyses illustrate how exploratory model set comparisons and continuous variable rERPs may yield new insights into the time course of information processing during reading.

Topic Areas: Meaning: Discourse and Pragmatics, Methods

Testing semantic compositionality in low-frequency neural oscillations

Poster B54 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session B.

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INTRODUCTION: Recent studies have shown that low-frequency neural oscillations in the delta band (0.5 - 4Hz) can be entrained to abstract linguistic structures (Ding et al. 2016, 2017). However, whether delta oscillations are modulated by syntactic information or semantic information is unclear. In addition, the few studies that have linked delta oscillations with semantic processing vary in how they probe semantics (e.g. Brunetti et al. 2013; Mai et al. 2016). The current study uses a broad range of different factors to test whether semantic properties might modulate delta oscillations. METHODS: Native speakers of Mandarin Chinese listened to trials consisting of ten 4-syllable adjective-noun phrases during EEG recording. Each phrase consists of 4 monosyllabic Mandarin words generated individually using a computer speech program. Each syllable lasted 250 ms and thus 1 sentence is 1s in duration. The stimuli varied across four semantic variables: (i) plausibility, which represents the consequence of semantic composition and world knowledge; (ii) conceptual specificity, which reflects the outcome of composition itself; (iii) predictability, which captures statistical association between words; and (iv) semantic similarity, which represents the lexical-level semantic relationship between words. First, plausibility and specificity were used to define a 2x2 experimental design: (1) [+spec +plaus] e.g. English gloss: “father pluck fresh tomato”, (2) [-spec +plaus] “father pluck fresh vegetable”, (3) [+spec -plaus] “father pluck newly-appointed tomato”, and (4) [-spec -plaus] “father pluck newly-appointed vegetable”. Predictability was obtained from the Google Chinese BERT model by masking the last character of the stimuli. Semantic similarity was computed from cosine similarity by extracting word vectors from Wikipedia2vec (Yamada et al. 2020). As plausibility typically correlates with predictability and semantic similarity, these norming values can be used to tease apart which of these related variables best explains variation in oscillatory power that tracks with the “plausibility” experimental factor. The first phrase from each trial was excluded to avoid potential EEG responses to sound onset. Data were manually cleaned of artifacts, filtered from 0.1-25 Hz, and re-referenced offline to common average. For each condition, we compute evoked power (EP) and inter-trial phase coherence (ITPC) from 0.5 to 10 Hz in increments of 0.111 Hz. Conditions were compared via two-way ANOVA for each measure. RESULTS: Due to COVID-19, we report intermediate results from N=11 here: A NP-level peak at 1 Hz is found in all conditions for both EP and ITPC and stronger oscillatory power is found in the non-specific conditions, compared to the specific conditions. No differences are observed as a function of plausibility (or, by extension, predictability or semantic similarity.) These results are not statistically reliable in the partial sample of N=11 reported here.

Topic Areas: Meaning: Combinatorial Semantics, Syntax

Predicting long-term treatment-related gains in language ability in individuals with aphasia

Poster B55 [Poster PDF] Visit me at [Gather.Town] in the Wernicke room during Poster Session B.

Presenter Note: For questions, feel free to contact me at basilaka@mailbox.sc.edu Additional information about this poster, as well as code used to complete analyses, can be found here: https://github.com/abasilkennedy/analyses_for_SNL2020

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Current estimates indicate that over two million individuals are living with aphasia in the United States. Stroke patients with chronic aphasia are often told to expect their recovery will "plateau" within 6 to 12 months after stroke; however, recent studies (Holland et al., 2017; Hope et al., 2017), including data from our group (Johnson et al., 2019), have shown that individuals with chronic aphasia experience continued improvement in language function, even years beyond stroke onset. Although treatment has been shown to yield improvement over time, the aforementioned studies observed change in archival samples; therefore, the effects of treatment on longitudinal change could not be directly examined. Accordingly, the current study evaluated N=38 participants at least one-year after they completed six weeks of speech and language therapy, with the goal of classifying long-term 'improvers' versus those who either remained stable or declined ('non-improvers'). Given that prior studies have implicated the role of brain health in recovery, the extent of leukoaraiosis (i.e., pathological white matter) as well as commonly reported demographic and behavioral factors (e.g., education, age, and baseline aphasia severity) were hypothesized to predict long-term improvement. Preliminary results from ongoing analyses are reported here. Methods: N=38 individuals with chronic aphasia (mean age=61.1, SD=11.7, 9 females) were recruited from a sample of individuals who were at least one-year post-treatment (mean follow-up interval=16.3 months, SD=6.9 months). Participants completed a battery of tests at treatment baseline and follow-up, including the Western Aphasia Battery-Revised (WAB-R) and a neuroimaging workup. Improvement in aphasia severity was the primary dependent variable examined. Improvement was defined as a binary variable where those with a change in WAB Aphasia Quotient scores of >=3 points were classified as 'improvers,' and all others were classified as 'non-improvers.' Independent variables included change in white matter hyperintensity scores, baseline aphasia severity, education, and duration of follow-up interval. Given that this is a preliminary analysis, these predictors were chosen as prior literature has suggested they are important for aphasia recovery. A support vector machine (SVM) analysis was conducted to determine whether the chosen variables could predict improvement in this sample. Analyses were conducted in R using the 'e1071' package. Results: One participant was unable to undergo MRI scanning at follow-up and was removed from the SVM analysis. N=15 participants demonstrated a clinically significant improvement, while 6 declined and 17 remained stable. The SVM model was trained on 80% of the sample (n=30) and revealed 96.6% prediction accuracy. Out of sample prediction (n=7) was 71% accurate, with 100% accuracy for classifying non-improvers and only 33% accuracy for classifying improvers. Discussion: Preliminary results show that accuracy for predicting those who will demonstrate long-term improvement is much lower than predicting who either remain stable or decline. To refine this model, planned analysis of other neuroimaging variables (e.g., lesion size, damage to key language regions, and network connectivity measures), along with behavioral factors, will be conducted to investigate further the factors predictive of improvement. The goal of this wok is to inform models of longitudinal recovery in chronic aphasia.

Topic Areas: Disorders: Acquired, Language Therapy

The contribution of concussion status, semantic processing speed, educational attainment, and corpus callosal microstructure on scholastic achievement in collegiate athletes: A pilot study

Poster B56 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session B.

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INTRODUCTION: Research suggests the long-coursing axons that comprise the corpus callosum (CC) are particularly susceptible to damage following concussive insult. These injuries should result in long-term deficits in interhemispheric processing speed, as efficient reaction time relies on integrity of white matter pathways. However, investigations of the effects of repeated concussion rarely include tasks linked to CC integrity. Thus, the present study evaluated semantic processing speed following repetitive concussion in a sample of collegiate athletes on a task previously linked to integrity of the genu of the CC. Moreover, since efficiency of processing speed is necessary for keeping pace in an academic environment, we also investigated the link between semantic processing speed, CC FA, and concussion status on college and graduate GPAs. METHODS: 43 collegiate athletes underwent a HYDI scan, and completed the word-matching portion of the split-field task described in Davis and Cabeza (2015) in which participants decided if two words were semantically related. These words were presented either unilaterally (both words within one visual hemifield) or bilaterally (each word in a different visual field). A measure of interhemispheric cross-talk was obtained by computing participants' bilateral processing advantage (word-BPA). Subsequently, probabilistic tractography was performed in FSL to extract the genu and splenium. Both regular and free-water corrected FA (FAt) were obtained. The latter was extracted using a DIPY free-water elimination pipeline. Next, participants' concussion status was determined based on the Ohio State University Traumatic Brain Injury Identification screener. Last, scholastic achievement was assessed based on a self-report questionnaire in which participant's current and/or graduating GPAs were collected. Education level was also collected. RESULTS: Two 3-step hierarchical multiple linear regressions were computed - one with regular FA and one with FAt. At level 1 current GPA was estimated based on control variables, including years in school, and splenium FA or FAt. Next, at level 2, the behavioral and clinical variables of interest were added, which included concussion and word-BPA. Finally, at level 3 either genu FA or FAt was added. Neither model was significant at step 1, though both models became significant at steps 2 and 3. Years of education, concussion, and word-BPA were all either significant or trending predictors in both models at levels 2 and 3, while neither genu FA or FAt accounted for any additional variance. That is, in both models there was a significant change in R2 between levels 1 to 2 (FA: $F[2,41]=5.006, p<0.05$; FAt: $F[2,41]=5.083, p<0.05$) but not between 2 to 3. At level 3, the FA model accounted for 23% of the variance, while the FAt model accounted for 21.96%. DISCUSSION: Our results suggest that more efficient interhemispheric processing of semantic information and lower concussion rate independently contribute to higher scholastic achievement. However, the lack of contribution of genu microstructure to our models suggests that this tract may not underlie the interhemispheric semantic processing that is critical for distinguished GPA attainment. Further data collection is required to further elucidate these trends.

Topic Areas: Disorders: Acquired, Methods

Examining longitudinal leukoaraiosis change in primary progressive aphasia during frontotemporal dementia and its relation to language change

Poster B57 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session B.

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The contribution of brain health (i.e., not dementia-related pathology) in explaining the devolution of language skills over time in primary progressive aphasia (PPA) remains unclear. In this study, we leverage a longitudinal database (frontotemporal lobar dementia neuroimaging initiative), predicting language change from leukoaraiosis (white matter abnormality). The primary goal was to examine the extent to which leukoaraiosis changed longitudinally, and the relationship of leukoaraiosis with language devolution. A secondary goal was to establish a sensitive perceptual rating method for determining leukoaraiotic change, as most perceptual rating scales (e.g., Fazekas) are not optimized for longitudinal designs. Methods: We plan to conduct parallel linear mixed effects models, predicting language change. Each subject had different time intervals between assessments. Therefore, for the purposes of this abstract, we provide an overview for two time bins: Time1 (first scan through one year) and Time2 (1 year - 2 years). When performing linear mixed effects modelling, we will use participants as a fixed factor, thereby not binning results. Preliminary Results: We report descriptive statistics for a subset of the data, from subjects with nonfluent variant PPA (nPPA) and with semantic variant PPA (svPPA). FLAIR images for each time-point were de-identified for scoring. Leukoaraiosis was rated on axial slices for two anatomical areas (periventricular [PVH] and deep white matter [DWMH]) in two ways: (1) a categorical scale from 0 (no leukoaraiosis) to 3 (severe leukoaraiosis), and (2) Euclidean distance along either the X-axis (PVH) or along either X- or Y-axes (DWMH). Language ability was measured using two tests: the Boston Naming Test (BNT) and Verbal Letter Fluency (DCORR). Both PPA groups showed decreasing performance longitudinally, for the BNT (max score=15) (svPPA, Time1 [N=37]: M=5.27±3.47; Time2 [N=32]: M=3.88±3.69; nPPA, Time1 [N=34]: M=12.23±3.04; Time2 [N=24]: M=11.07±SD: 3.89) and DCORR (no max score) (svPPA, Time1: M=8.18±4.25; Time2: M=6.74±4.27; nPPA, Time1: M=6.43±5.26; Time2: M=5.14±SD: 5.72). Leukoaraiosis was relatively consistent across time, with considerable intra-group variability. This was the case for categorical rating, for PVH (svPPA, Time1 [N=10]: M=1.32±0.58; Time2 [N=10]: M=1.42±0.79; nPPA, Time1 [N=7]: M=1±0.82; Time2 [N=7]: M=1.1±SD: 0.74) and for DWMH (svPPA, Time1: M=1.21±0.79; Time2: M=1.17±0.72; nPPA, Time1: M=1.31±1.32; Time2: M=0.9±SD: 1.20). This was also the case for Euclidean distances, for PVH (svPPA, Time1: M=7.21±3.61; Time2: M=8.58±4.74; nPPA, Time1: M=7.04±4.21; Time2: M=7.3±SD: 4.06) and for DWMH (svPPA, Time1: M=8.61±9.56; Time2: M=8.42±8.32; nPPA, Time1: M=7.46±8.09; Time2: M=5.8±SD: 6.97). We have not yet modeled the relationship of leukoaraiosis, and its change, with language change. We plan to conduct these analyses prior to the conference. Descriptive statistics provided above highlight the language devolution in this group alongside relatively stable, mild-moderate leukoaraiosis, which may suggest that brain health factors are not as relevant for explaining behavior change in this group. These results will identify brain health changes in frontotemporal lobar dementia, clarify how symptoms of PPA are explained by brain health in addition to dementia pathology, and improve perceptual rating methods for longitudinal designs. This project will advance the literature in primary progressive aphasia, especially in understanding language devolution longitudinally.

Topic Areas: Disorders: Acquired, Methods

Poster Session C

Semantic association judgments of homographs with noun and verb meanings in Parkinson's disease

Poster C1 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session C.

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Homographs are words that have more than one meaning for a single written form. The different meanings can make the homograph alternatively belong to the category of verbs/actions (e.g., drop: to let something fall) or nouns/objects (e.g., drop: a small quantity of liquid). The noun and verb meanings can either be dominant (more frequent and more easily accessible) or subordinate (less frequent and less easily accessible). Semantic association judgments of words paired with homographs require the inhibition of one meaning in order to access the meaning required by the task. Patients with Parkinson's disease have more difficulty with verbs and may show different patterns of performance when asked to retrieve the verb meaning of homographs. Twelve patients with Parkinson's disease (PD) and 17 controls completed semantic association judgments of 120 word pairs. Stimuli included 60 pairs with homographs that elicited positive answers, and 60 filler pairs that elicited negative answers. Fifteen homographs with "noun-dominant/verb-subordinate" meanings and 15 homographs with "verb-dominant/noun-subordinate" meanings were presented twice, i.e., once with a word associated with the dominant meaning and once with a word associated with the subordinate meaning. Accuracy and response time were analysed using generalised linear mixed models (GLMM) and linear mixed models (LMM), respectively. Significance was tested using Wald's test (GLMM) and likelihood ratio tests (LMM). Group, meaning dominance, and meaning type (verb or noun) were included as fixed factors. All fix factors were centered. Random effects included random intercepts and slopes for items, and random intercepts for participants. For each participant, 1mm isotropic anatomical brain scans were collected on a 3T Siemens Prisma scanner and analysed using FreeSurfer 6.1. Overall, accuracy was different between groups, with high variability in the retrieval of dominant verb meanings in PD. The analysis showed a main effect of group (control better than PD) and meaning dominance (dominant better than subordinate), but no effect of meaning type. There was also a significant interaction between group and meaning dominance, but no other significant interactions. In terms of response time, there was no effect of group, but the effect of meaning dominance was significant, with a facilitation for dominant meanings. The effect of meaning type can be considered as a trend (facilitatory for nouns, $p = 0.057$). There was no significant interaction. In controls, the capacity to access dominant verb meanings was positively correlated with the area, thickness and volume of the left inferior temporal gyrus and left posterior dorsolateral prefrontal cortex (DLPFC). Those associations were not found in the PD group. PD patients had more difficulty inhibiting dominant meanings to access subordinate meanings. Although there was no significant effect of meaning type, the larger variability in accuracy for the verb-dominant condition in the PD group, as well as the positive association between this condition and markers of cortical integrity in areas responsible for semantic and executive control in the control group, are coherent with the idea that verb meanings are multidimensional and flexible, which makes their processing more complex and context-dependent.

Topic Areas: Disorders: Acquired, Control, Selection, and Executive Processes

Predicting and explaining individual responses to a treatment for anomia

Poster C2 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session C.

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INTRODUCTION: Stroke is a leading cause of disability, and language impairments (aphasia) after stroke are both common and particularly feared. Most stroke survivors with aphasia exhibit anomia, or difficulties with naming common objects, but while many therapeutic interventions for anomia have been proposed, treatment effects typically vary, substantially, across patients. Here, we asked whether that variation might be predictable from pre-treatment data alone. METHODS: 18 patients, each >6 months post-stroke, engaged in a computerised treatment for their anomia for 6 weeks. Using pre-treatment behavioural, structural and functional MRI data, we developed Partial Least Squares regression models to predict the patients' improvements after treatment, and tested them in cross-validation. Behavioural data were scores from a broad battery of standardised assessments of language and other cognitive skills. Structural MRI data were pre-processed into lesion load variables, representing the proportion that each patient's lesion destroyed of a series of anatomically defined brain regions. And functional MRI data were encoded as the mean activation in brain regions defined by the same (publicly available) atlas, when the patient engaged in confrontation naming in-scanner (naming > rest). To these data, we further added the hours of therapy actually undertaken by each patient. We employed a novel 'data perturbation' method to interpret the learned models by shuffling independent variables and observing the consequent effect on the models' predictions. And we further explored what unique prognostic value might be conveyed by regional (structural and functional) brain data, once the pre-treatment behavioural data had been taken into account. RESULTS: Our models were all significantly better than the null model, in which the prediction for each patient was simply the mean treatment effect of the group. All models also benefited, significantly, from access to the number of hours of therapy each patient undertook: i.e. predicting the likely benefit of increasing time devoted, rather than a simple outcome irrespective of that time. The best model combined hours of therapy with pre-treatment behavioural data: RMSE = 11.8 ±1.27; r(predicted vs. empirical treatment response) = 0.64. This model could be further improved by adding brain data from specific brain regions, most significantly: (i) lesion damage in the left insula (predicting lesser treatment response; and (ii) fMRI signal in the right middle occipital gyrus (predicting better treatment response). DISCUSSION: These results imply that individual variation in these anomia treatment responses are systematic and predictable, at least to some extent, and that inferences from pre-treatment behavioural data can be complemented by information derived from structural or functional brain data. Our best prognostic models predicted a likely rate of improvement for hours devoted to the therapy, rather than a simple outcome, and those hours were not themselves predictable from any of the pre-treatment data. Our methods provide a straightforward basis on which to design and interpret analogous models in future studies, and specific hypotheses concerning what features of patients, pre-treatment, might predict faster improvement during a treatment for anomia.

Topic Areas: Disorders: Acquired, Language Therapy

Factors that Determine Aphasia Severity

Poster C3 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session C.

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Introduction Prior studies have investigated demographic factors related to overall language impairment post-stroke, including handedness, sex, age, and education. More recently, comorbid conditions, brain health, and cognitive reserve have emerged as factors that may impact aphasia severity. Overall lesion volume, however, is the most consistent factor that often explains much of the variance in aphasia severity. In the present study, we investigate these factors to understand what determines aphasia severity after accounting for lesion load to critical cortical language regions. This is the first study, to our knowledge, that utilizes a rich dataset of descriptive demographic variables to explain the variance that lesion load, alone, cannot. Methods Overall aphasia severity (as determined by the Western Aphasia Battery; WAB-AQ) and neuroimaging data were available for 224 participants. A lesion symptom mapping analysis using the Johns Hopkins University neuroanatomical atlas was performed to determine what brain regions are most associated with WAB-AQ. Only regions lesioned in ≥ 5 participants were included. One-tailed statistical tests were applied based on the assumption that lesioned tissue will lead to impairment, not improvement. Regions with a $p \leq 0.05$ with permutation thresholding (5000 permutations) were considered regions of interest to be used in future analyses. Proportion damage of the two surviving regions (superior longitudinal fasciculus and posterior insula) was calculated for all participants. Following, a linear regression between WAB-AQ and proportion damage to both regions was calculated and residuals were saved to be used as the dependent variable in the subsequent analyses. Variables entered into the model to predict AQ included: age at stroke, age at assessment, education, amount of exercise post-stroke, diabetes, sex, cognitive reserve (WAIS matrices), and a white matter hyperintensities (WMH) score. WMH scores were available for 53 participants of our original cohort. All other variables were available for at least 97 participants. For this reason, we created two models: a larger model (Model 1) without WMH (N=97); and an exploratory model (Model 2) including WMH with the rest of the behavioral variables (N=53). Results Model 1: Consistent with prior work from our group, age at stroke was a significant predictor of aphasia severity when lesion damage was factored out (p=.04). Additionally, WAIS matrices score was also associated with language severity (p=.03). Interestingly, an interaction between diabetes and exercise approached significance (p=.07) suggesting that those with diabetes who exercise have a higher WAB-AQ than those who have diabetes but do not exercise. Model 2: Similar to the previous model, age at stroke and the interaction between diabetes and exercise were significantly related to aphasia severity (p=.01

for both factors). Also consistent with prior work from our group, periventricular WMH scores were related to aphasia severity (p=.005), suggesting that those with greater hyperintensities surrounding the ventricles have lower WAB-AQ scores. Summary Results from this study add to the growing literature suggesting that demographic variables, specifically age at stroke, diabetes and exercise, cognitive reserve, and brain health (measured as WMH score) are associated with aphasia severity after accounting for lesion load to critical language regions.

Topic Areas: Disorders: Acquired, Language Production

A New Battery For Assessing Speech Perception In Dementia: The Queen Square Tests Of Auditory Cognition (QSTAC)

Poster C4 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session C.

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Background: Hearing impairment has emerged as a potent association of cognitive decline in dementia and a promising treatment target. To realise this promise, we need to resolve fundamental questions concerning the roles of peripheral versus central auditory deficits in different dementias. Methods: Using a novel psychoacoustic battery – the Queen Square Tests of Auditory Cognition (QSTAC) – we combined pre-existing and novel measures of 'peripheral' and 'central' speech perception designed to characterise discrete 'speech phenotypes' across dementia syndromes. Customised auditory symptom questionnaires (completed by patients' caregivers) were used to capture daily-life hearing-related disability and care burden. Patient groups: Alzheimer's disease, frontotemporal dementia, primary progressive aphasia (PPA) and control. Results: Syndromic signatures of peripheral and central speech dysfunction were identified. Alzheimer's disease was associated with prominent impairments of auditory scene analysis and dichotic listening. PPA syndromes and behavioural variant FTD (BvFTD) were principally associated with deficits of sound pattern analysis, sound identity, emotion recognition and degraded speech perception, which stratified according to sub-syndromes (logopenic, semantic, nonfluent). Conclusions: These initial findings suggest that major dementias have characteristic and differentiated speech phenotypes, reflecting a complex interplay of peripheral hearing and auditory cognitive dysfunction.

Topic Areas: Disorders: Acquired, Perception: Auditory

Connected speech analysis reveals delayed sound encoding in aphasia

Poster C5 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session C.

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People with aphasia (PWA) often need more time to speak or understand language. Even though such delays may go behaviorally unnoticed in milder cases of aphasia, distinctive neural response patterns have been found with EEG (Becker & Reinvang, 2007). Early event-related potential (ERP) components, such as the N1 and P2 peaks that are important for detection and encoding of the sound, have shown distinctive responses in PWA (Martin, Tremblay & Korczak, 2008). Aerts and colleagues found increased N1 and P2 latencies in PWA compared to controls during an auditory lexical detection task (2015). However, during a syllable detection task

Becker and Reinvang did not observe such results (2007). The common ground is that both studies use isolated, artificial stimuli detached from their context. A recent trend in neuroscience is to work with natural, connected speech, however this approach has not yet been applied to PWA (Kandylaki & Bornkessel-Schlesewsky, 2019). Therefore, we here investigate early components in response to a story in 4 PWA in the chronic phase after stroke (mild symptoms), 13 younger adults and 13 older adults. Method: Participants listened to a 30-minutes long story while EEG was recorded. After extracting the amplitude envelope from the stimulus, the weights between EEG data and envelope were modeled over time (integration window: -100 to 800 ms). The resulting temporal response functions (TRF) were averaged over 19 temporal, central and frontal channels. Peak latencies of the TRFs were analyzed in an automatic way via a custom-made MATLAB script. The output was visually inspected and few peaks had to be adjusted manually. Results: For the N1 peak, no significant differences were found between groups (PWA/younger: $t=1.92$; $p=.078$; PWA/older: $t=1.44$; $p=.17$; younger/older: $t=1.27$; $p=.21$). However, we found significantly increased latencies at the P2 peak in PWA compared to older controls ($t=-2.19$; $p=.047$) but not for the other group comparisons (PWA/younger: $t=-1.74$; $p=.1$; younger/older: $t=0$; $p=1$). The relative latency between N1 and P2 peaks revealed a significant increase in PWA compared to younger controls ($t=-2.35$; $p=.036$) but not for the other group comparisons (PWA/older: $t=-1.96$; $p=.071$; younger/older: $t=-0.99$; $p=.33$). Discussion: The N1 and P2 were observed in a recent TRF study in response to an attended speech stream (Fiedler et al., 2019). We observed a similar peak response for all groups. However, it is difficult to draw solid conclusions, not only because of the small sample sizes, but also because this is the first time that a TRF analysis to connected speech has been conducted in PWA. Conclusions from ERP studies using isolated stimuli are however valuable to interpret the observed TRFs to connected speech. PWA included here showed only mild aphasia symptoms. Nonetheless, a delayed P2 component and an increased relative latency between peaks was found in PWA. Accordingly, the TRF latency analysis of the envelope might present a potential new biomarker for aphasia. Moreover, other speech features encompassing phonological and semantic information can be investigated using the same data, possibly revealing new insights about higher order language processes in aphasia during connected speech.

Topic Areas: Disorders: Acquired, Speech Perception

The contributions of white matter tracts to specific language domains in primary progressive aphasia: Changes with disease progression

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Introduction: Previous research on Primary Progressive Aphasia (PPA) indicates that integrity of specific white matter (WM) tracts is associated with distinct language functions, such as the uncinate fasciculus with semantic processing[1-2] and the inferior fronto-occipital, superior longitudinal and arcuate fasciculi with syntactic processing[2-4]. However, very little is known about the relationship between WM integrity and spelling performance, a function substantially affected in PPA[5-7]. Additionally, no previous work has investigated how disease progression affects the relationship between tract integrity and language performance. Using a cross-sectional design, this project examines these issues. Methods: Participants: 34 individuals (17 female) with clinically diagnosed PPA and time since diagnosis ranging from .5 to 10.5 years. Behavioral evaluations of spoken naming, syntactic processing and spelling were administered, and T1-weighted images and DTI data were collected and WM integrity measures were calculated (FA, MD, RD and AD). ExploreDTI[8] was used for manual segmentation of right and left hemisphere: inferior fronto-occipital fasciculus (IFOF), inferior longitudinal fasciculus (ILF), uncinate fasciculus (UF) and the long, anterior and posterior segments of the arcuate fasciculus (AF). Anterior AF also corresponded to component II of superior longitudinal fasciculus (SLF-II). Linear mixed-effects models (LMEM), one per bilateral tract, were used to evaluate whether the three language measurements and their interactions with disease progression and hemisphere could predict unique variance of the FA, MD, RD, and AD values. The models included random effects by-participants, and covariates controlling for age and atrophy. These models were followed by regular linear regression to test hemisphere-specific effects when appropriate, with Bonferroni corrections for multiple comparisons. Results: Spoken naming: Higher UF integrity was associated with better naming performance (FA: β= 0.051 $p<0.001$; MD: β=-0.116 p=0.001; RD: β=-0.125 $p<0.001$). This association was significantly greater in the L compared to the R hemispheres for MD and RD (MD: left: β=-0.156; right: β=-0.076, p=0.007; RD: left: β=-0.169; right: β=-0.081, p=0.003). Hemisphere-specific effects showed that higher left UF integrity was associated with better naming performance (FA: β=0.072 $p<0.001$; AD: β=-0.132 p=0.004). However, there was no significant interactions with disease progression. Syntactic processing: With disease progression, there was a stronger association with the integrity of the left IFOF compared to the right IFOF (FA: left: β=-0.023, right: β=0.005, p=0.002; MD: left: β=0.042, right: β=0.004, p=0.008; RD: left: β=0.049; right: β=0.001, p=0.001). A hemisphere-specific effect showed that there was stronger relationship between left UF integrity and syntactic processing later in the disease (RD: β=0.061 p=0.003). Spelling: With disease progression, there was a stronger association with integrity of anterior AF/SLF-II, but this effect was not associated with a specific hemisphere (FA: β=0.03 p=0.004; RD: β=-0.044 p=0.008). Discussion: The results extend previous findings of associations between WM tract integrity and naming and syntactic processing in PPA by providing evidence of a significant association between the WM integrity of anterior AF/SLF-II and spelling performance. Additionally, we report, for the first time, that disease progression in PPA is associated with specific changes in the relationships between language functions and the specific WM tracts that support them.

Topic Areas: Disorders: Acquired, Writing and Spelling

The verbal, nonverbal and structural bases of functional communication abilities in aphasia

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The ability to communicate, functionally, after stroke or other types of acquired brain injury is crucial for the person involved and the people around them. Accordingly, assessment of functional communication is increasingly used in large-scale randomized controlled trials as the primary outcome measure. Despite the importance of functional communication abilities to everyday life and their centrality to the measured efficacy of aphasia interventions, there is little knowledge about how commonly-used measures of functional communication relate to each other, whether they capture and grade the full range of patients' remaining communication skills and how these abilities relate to the patients' verbal and nonverbal impairments as well as the underpinning lesions. Going beyond language-only factors is essential given that nonverbal abilities can play a crucial role in an individual's ability to communicate effectively. The current study, based on a large sample of patients covering the full range and types of post-stroke aphasia, addressed these important, open questions. The investigation combined data from three established measures of functional communication with a thorough assessment of verbal and nonverbal cognition as well as structural neuroimaging. The key findings included: (a) due to floor or ceiling effects, the full range of patients' functional communication abilities was not captured by a single assessment alone, limiting the utility of adopting individual tests as outcome measures in randomized controlled trials; (b) phonological abilities were most strongly related to all measures of functional communication; and (c) nonverbal cognition was particularly crucial when language production was relatively impaired and other modes of communication were allowed, when patients rated their own communication abilities, and when carers rated patients' basic communication abilities. Finally, in addition to lesion load being significantly related to all measures of functional communication, lesion analyses showed partially overlapping clusters in language regions for the functional communication tests. Moreover, mirroring the findings from the regression analyses, additional regions previously associated with nonverbal cognition emerged for the Scenario

Test and for the Patient Communication Outcome after Stroke rating scale. In conclusion, our findings elucidated the cognitive and neural bases of functional communication abilities, which may inform future clinical practice regarding assessments and therapy. In particular, it is necessary to use more than one measure to capture the full range and multifaceted nature of patients' functional communication abilities and a therapeutic focus on nonverbal cognition might have positive effects on this important aspect of activity and participation.

Topic Areas: Disorders: Acquired, Control, Selection, and Executive Processes

Total small vessel disease burden and response to language therapy in people with post-stroke aphasia

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Introduction: Sporadic cerebral small vessel disease (SVD) is a common neuropathological process affecting diffusively small arteries and arterioles in the brain and is associated with various lesions on brain imaging. Although these lesions might be clinically silent on their own, the combination of lesion types has a cumulative effect on brain health and hence is associated with cognitive impairment, dementia, increased risk of stroke, and worse outcome after stroke (Wardlaw et al., 2019). The objective of this study is to investigate whether the SVD burden predicts how well people with aphasia (PWA) will respond to language therapy, independently from aphasia severity, demographics and other stroke-related factors (i.e., lesion volume and time post onset). Methods: Participants were 30 chronic PWA (10F, age: mean=61years, range=40–80 years, education: mean=15 years, range=12–18, time post stroke: mean=52 months, range=8–170 months) with a single left hemisphere stroke (volume: mean=135.21cm3, range=11.66–317.07cm3) who completed up to 12 weeks of semantic feature analysis treatment for word retrieval deficits. Mean baseline aphasia severity from the Western Aphasia Battery–Revised (WAB-AQ quotient) was 59.83 (range=11.7–95.2). Baseline T1- and T2–FLAIR-weighted MRI scans were rated for four major SVD biomarkers, including white matter hyperintensities (WMH), enlarged perivascular spaces (EPVS), lacunes and global cortical atrophy (GCA), using validated visual rating scales. We rated the total burden of SVD on an ordinal scale from 0 to 4, by counting the presence and severity of each of the four biomarkers. A point was awarded for each of the following: (a) confluent deep WMH (Fazekas score 2 or 3) or irregular periventricular WMH extending into the deep white matter (Fazekas score 3), (b) moderate to severe EPVS in the basal ganglia (grade 3-5 on Wardlaw et al. scale), (c) presence of one or more lacunes (Wardlaw et al., 2013), and (d) moderate to severe GCA (grade 2-3 on Pasquier et al. scale). The proportion of the potential maximal gain (PMG; Lambon Ralph et al., 2010), assessed immediately after treatment [(mean post-treatment score – mean pre-treatment score)/(total number of trained items – mean pre-treatment score)] was the primary dependent variable, and the total SVD score the main predictor in our ordinal regression model. AQ, total lesion volume, time post onset, age and education were also entered into the model as covariates. Results: The multivariable ordinal regression analysis showed that the SVD burden (odds ratio=0.30, 95% CI=0.11-0.82, p=0.019) and AQ (odds ratio=1.07, 95% CI=1.02-1.13, p=0.006) were independently associated with the PMG. Higher SVD scores were associated with lower odds of responding well to language therapy, whereas higher WAB-AQ (i.e., less severe aphasia) was associated with higher odds of responding well to language therapy. Conclusion: Our findings indicate that the total SVD score has independent predictive value for response to language therapy, and further suggest that markers of brain health – to date largely ignored in the aphasia literature– may affect treatment outcomes. Given the multifactorial nature of treatment-induced recovery in PWA, these results highlight the utility of co-examining these biomarkers in aphasia recovery and rehabilitation research.

Topic Areas: Disorders: Acquired, Language Therapy

Differences in subcortical structures in children with developmental language disorder

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Seven percent of children have unexplained difficulties acquiring their first language and meet diagnostic criteria for developmental language disorder (DLD). Children with DLD perform poorly on tasks dependent on corticostriatal learning systems, such as sequential procedural memory tasks (Krishnan et al., 2016). Previous studies report structural abnormalities in the striatum in DLD (Badcock et al., 2012; Lee et al., 2013; Pigdon et al., 2019). In contrast, performance on episodic and semantic memory tasks, dependent on the integrity of the medial temporal lobe, appear relatively unimpaired in DLD (Krishnan et al., 2016). As part of the Oxford BOLD study, we collected structural and functional MRI data in the largest sample of children with DLD to date. Here, we measured the volumes of subcortical structures via automatic segmentation of T1-weighted scans in Freesurfer. We predicted that the dorsal striatum (caudate nucleus and putamen) would be abnormal in children with DLD and that the medial temporal lobe (amygdala and hippocampus) would be unaffected. A total of 122 children aged 10–15 years had usable segmentations following automated quality control (Klapwijk et al., 2019). Of those, 51 met criteria for DLD (age-appropriate non-verbal IQ and performance of >1 SD below the mean on at least two of five standardized language assessments) and 71 were typically developing (TD). An additional 27 children had a history of speech and language difficulties but did not meet criteria for DLD currently (HSL). Volumes of subcortical structures were normalized by total intracranial volume (ICV). Adjusted volumes were compared between TD and DLD groups with linear mixed models with hemisphere, group, and their interaction as factors and participant as a random factor. The volume of the right caudate nucleus was significantly smaller in DLD compared with TD (significant interaction hemisphere × group, $p=.008$). No other structures were significantly different between the groups, although all showed a trend (group or hemisphere × group, $p<.06$). To explore whether these subthreshold differences were discriminative when considered together, support vector machine classifiers (linear SVM; 5-fold cross-validation) were trained using volumes and ICV as predictors. The relevance of each predictor was assessed via recursive feature extraction, and significance was determined via permutation testing. Maximum classification accuracy was achieved with four subcortical volumes: right caudate nucleus, right amygdala, left caudate nucleus, and left hippocampus (66.5% accuracy, $p=.0004$). Interestingly, a classifier trained only on the medial temporal lobe volumes achieved similar above-chance accuracy to that of the optimal classifier (64.5% accuracy, $p<.002$). The optimal classifier largely classified the individuals in the HSL group as TD rather than DLD (21:6), suggesting that their brain volumes corroborate the behavioral results in which they did not meet DLD criteria. In summary, univariate measures of subcortical volumes suggest that there are structural differences in the caudate nucleus in children with DLD, consistent with previous findings and predictions. Multivariate analyses, however, suggest patterns of differences in both the striatum and medial temporal lobe may exist in DLD. Further analyses will focus how these data relate to language and motor measures.

Topic Areas: Disorders: Developmental, Development

Automatic analysis of natural speech in patients with Alzheimer's disease

Poster C10 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session C.

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INTRODUCTION: Language impairments seen in patients with Alzheimer's disease (AD) have been often discussed in the literature, yet not many studies looked at both lexical and acoustic aspects at the same time, leaving a gap in our understanding of the linguistic profile of AD patients. In this study, we characterized both lexical-semantic and acoustic characteristics of patients with pathologically determined AD using a natural language processing (NLP) tool and a speech activity detection (SAD) system. METHODS: We analyzed the Cookie Theft picture descriptions from AD patients (n=49, 28 female, mean age=62.68yrs, mean MMSE=20.35) who were either autopsy confirmed or pathologically confirmed with their cerebrospinal fluid level (pTau/Abeta ratio0.09; Lleó et al. 2018) and healthy elderly controls (n=35, 18 female, mean age=64.67yrs, mean MMSE=291) who were matched on age, sex, and education level. With spaCy, an NLP library in Python, we tagged part-of-speech (POS) categories of all words in all participants' picture descriptions and calculated POS counts per 100 words and the total number of words. We also rated all words for concreteness, semantic ambiguity, word frequency, number of phonemes, syllables, morphemes, age of acquisition, and word familiarity. With SAD, we segmented speech samples into speech and pause segments and calculated mean speech and pause segment durations, speech and pause segments per minute, total speech duration, total pause duration, total duration (speech + pause), speech to pause ratio, and percent of speech over total time. We compared groups with t-tests and tested correlations of the language measures with MMSE scores for the AD group. RESULTS: AD patients' total number of words was lower (p=0.015), and patients' total speech duration was shorter (p=0.001) than those of controls. The words that AD patients produced were more frequent (p=0.002) and earlier-acquired (p=0.004) and had fewer phonemes (p<0.001), syllables (p<0.001) and morphemes (p=0.036), compared to the words that controls produced. Patients with AD produced significantly fewer adjectives (p=0.017) and prepositions (p<0.001), and they produced more adverbs (p=0.038), conjunctions (p=0.007), and particles (p=0.039) per 100 words than controls. AD patients produced shorter mean speech segment durations (p<0.001), and patients' total pause duration was longer (p=0.023) with higher pause rates (p<0.001), than controls. Patients' percent of speech (p<0.001) and their speech to pause ratio were lower (p=0.004) than those of controls. We found that patients' MMSE scores were negatively correlated with adverb counts (p=0.013), pause rate (p=0.02), and total pause duration (p=0.047), but positively correlated with prepositions (p=0.017), number of phonemes (p=0.003), syllables (p=0.009), mean speech segment duration (p=0.03), and percent of speech (p=0.025). CONCLUSION: Picture descriptions of patients with AD were different in both lexical-semantic and acoustic aspects from those of healthy controls. Patients with lower MMSE scores produced fewer prepositions with reduced speech segment duration and percent of speech, and their words had fewer phonemes and syllables. However, AD patients produced more adverbs with an increased pause duration and pause rate. Our study shows that automated NLP and SAD programs can reveal language markers that distinguish AD patients from healthy seniors.

Topic Areas: Language Production, Computational Approaches

The role of the basal ganglia in inflectional encoding: An fMRI study of producing the past tense

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According to a prominent account of inflectional encoding (Pinker & Ullman, 2002), regular forms are encoded by a rule-governed combination of stems and affixes, whereas irregular forms are retrieved from memory while inhibiting rule application. Previous research has suggested that the basal ganglia play a role in rule application as well as in domain-general inhibition. Ullman et al. (1997) observed that patients with Parkinson's disease had difficulties with regulars, suggesting a rule application problem. However, Macoir et al. (2005) found no specific difficulties with regulars in these patients. Moreover, whereas Oh et al. (2011) observed in an fMRI study the left caudate to be more active in regular than irregular production, Desai et al. (2006) found the opposite. In a previous series of behavioral experiments, we tested whether domain-general inhibition, involved in task and language switching, is also involved in irregular production. We found a cost in reaction times for switching from inflecting to reading but not from irregulars to regulars. However, we employed an indirect measure of inhibition, since we measured its effect on subsequent trials. In our current ongoing fMRI experiment we replicated the design of our behavioral experiments. In the inflection-only part, participants alternated between producing regular and irregular past tenses in Dutch. The infinitive form of a verb was presented on a screen and participants had to produce the first-person singular past-tense form of the verb as quickly and accurately as possible. The verb type changed every second trial. In the task-switching part, participants alternated between inflecting and reading aloud. The procedure was similar to the inflection-only part, with the addition of a colored frame around the word cuing participants which task to perform. The task changed every second trial. Regulars and irregulars were presented in small mini-blocks of 24 trials of the same regularity type, hence switch costs in the task-switching part concern task and not verb regularity. Our preliminary (n = 8) analysis of the inflection-only part showed that irregulars recruit the right middle frontal gyrus, and regulars the left superior temporal gyrus. Moreover, the regularity of the previous verb seems to modulate the cortical response, with repeat trials recruiting the pre-SMA and switch trials showing SMA activation, especially for irregulars. At a behavioral level we had observed that the inflection of a verb is not affected by the regularity of the previous verb (Ferreira et al., 2020). However, at a neuronal level, our preliminary results suggest that regular and irregular production rely on different cortical structures. Our preliminary results did not show significant basal ganglia involvement in any of the contrasts, but data collection is still ongoing. Furthermore, results of the inflection-only part will be compared with those of the task-switching part, which will shed light onto whether the same cortical and subcortical regions are involved when switching between tasks and verbs.

Topic Areas: Language Production, Morphology

Timeline of monitoring during semantic and phonological interference in word production

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In word production, both semantic and (non-onset) segmental overlap between target and competitors can lead to interference. However, the timeline of semantic vs. phonological activation is still unclear, although it would provide arguments towards a modular or interactive framework for speech production. On the other hand, while situations of interference admittedly prompt higher monitoring, it is still debated whether the locus of monitoring is post-phonological or if monitoring intervenes at every step of the word production process. We recorded EEG from 29 participants in a 2-item blocked cycling naming task, manipulating semantic (cake/pie) and phonological (tie/pie) similarity, with unrelated (hair/pie) pairs as control. Independently of the similarity manipulation, in half of the blocks, called the “reverse” blocks, when prompted with one item, participants had to say the name of the other item of the pair. Behaviorally, significant semantic and phonological interference was observed on response durations, but not on accuracy or reaction times. Stimulus-locked ERPs revealed semantic and phonological effects between 230-350 ms post-stimulus, with a slightly later onset for the phonological effect. Both related conditions also showed differences from the unrelated before and around response generation in response-locked analyses. Over stimulus- and response-locked ERPs, monitoring processes, indexed by the difference between “reverse” and “straight” conditions, are widespread, and active both at early and late stages of response selection. Distinct peaks for semantic and phonological similarity support a certain level of modularity to the production process. At the same time, both semantic and phonological contexts also induced effects in later and earlier stages of processing than their peaks, suggesting cascading and feedback, respectively. The timeline of monitoring that we describe is consistent with online monitoring over the course of production, as opposed to post--phonological processes.

Topic Areas: Language Production, Control, Selection, and Executive Processes

Automatic Analysis of Natural Speech in Lewy Body Spectrum Disorders with Alzheimer's Disease Co-Pathology

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INTRODUCTION: Lewy Body Spectrum Disorders (LBSD) are a group of neurodegenerative diseases that are neuropathologically characterized by the accumulation of misfolded alpha-synuclein protein inclusions. While LBSD syndromes are phenotypically-diverse and include Parkinson's Disease (PD), PD with Dementia (PDD), and Dementia with Lewy Bodies (DLB), they share cognitive, psychiatric, autonomic, and pathologic features. Up to 50% of LBSD patients at autopsy have co-occurring Alzheimer's Disease (AD) pathology which is associated with reduced survival time, greater temporal lobe pathologic burden, and worse cognitive-linguistic impairments. In vivo identification of AD co-pathology in LBSD is crucial for delivering targeted clinical care and recruitment into therapeutic trials; this is currently supported through invasive cerebrospinal fluid (CSF) AD biomarkers and/or molecular PET imaging. There remains a need for robust, non-invasive, inexpensive measures that can serve as screening tools for AD co-pathology in this phenotypically-diverse spectrum. In this study, we examined automated acoustic and lexical-semantic characteristics of semi-structured narrative speech in LBSD with biologically-confirmed AD (LBSD+AD) versus those without (LBSDnoAD). METHODS: We analyzed digitized Cookie Theft picture descriptions from 28 LBSD+AD patients (6 females, mean age = 71±7.2 years), 39 LBSD-AD patients (12 females, mean age = 78±7.3 years), and 43 age-matched healthy controls (HC). AD co-pathology was confirmed using autopsy-validated CSF AD biomarker cut-points and/or neuropathological diagnosis. Clinical and neuropsychological assessment revealed no group differences for disease duration, motor disease severity (UPDRS III), global cognition (MoCA), executive functioning (verbal fluency), visuoconstruction (Rey Copy), confrontation naming (BNT), nor memory (MoCA memory subscore). Automated acoustic analyses quantified durational parameters such as speech segment duration and pause duration, and lexical selection for parts-of-speech. Linear regressions tested between-group comparisons (Tukey's HSD adjustment) across biologically-defined groups (LBSD+AD vs. LBSDnoAD vs. HC, covarying for sex) and clinical phenotypes with dementia (DLB vs. PDD, covarying for age and sex). Discriminatory performance was determined by training a naïve Bayes classifier with leave-one-out cross-validation; features were selected with t-test ($p<0.05$). We reported the average accuracy of all cross-validation folds. RESULTS: Compared to LBSDnoAD, LBSD+AD produced significantly shorter mean speech segment durations (mean speech, p=.02), spent a larger proportion of time pausing versus speaking (%speech, p=.006), and had a slower speaking rate (words per minute (WPM); p=.007). LBSD+AD also produced significantly greater number of unique nouns per 100 words (p=.03). Speech features did not differ between DLB and PDD clinical phenotypes. The predictive accuracy of the naïve Bayes model for LBSD+AD vs. LBSDnoAD was 70% (AUC=.77); selected features included mean speech, %speech, WPM, mean pause duration, total pause time, and number of interjections and unique nouns per 100 words. CONCLUSION: Automatic speech features during picture descriptions of biologically-confirmed LBSD+AD were different in both acoustic and lexical-semantic aspects from LBSDnoAD, while neuropsychological scores did not differ between groups. Speech features were not different between DLB and PDD phenotypes. Alone, lexical-acoustic speech features modestly distinguished LBSD+AD from LBSDnoAD with 70% accuracy. Our study shows that automatic analysis of a 1-minute natural speech task can be useful as a screening tool in the identification of AD co-pathology in LBSD.

Topic Areas: Language Production, Computational Approaches

Individualized Response to Different Types of Aphasia Rehabilitation in Stroke

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Introduction Attempts to personalize post-stroke aphasia treatment to the extent where we can reliably predict individual response to a particular treatment paradigm have yielded inconclusive results.1-6 In the current study, we aimed to (1) compare the effects of phonologically- vs. semantically-focused naming treatment at the group-level and, (2) examine biographical and neuropsychological factors predicting response to each treatment paradigm. Methods 68 individuals with chronic post-stroke aphasia underwent three weeks of phonologically-focused treatment and three weeks of semantically-focused treatment in an unblinded cross-over design. Participants underwent extensive neuropsychological testing prior to treatment initiation, including the WAB-R7, PNT8, and several measures of semantic and phonological processing, auditory short-term memory, and reasoning skills. PNT served as the primary outcome measure, assessed as proportion of maximum potential gain (PMG). A linear mixed-effects model (LMM) was used to compare the effects of treatment type on proportional change in correct naming on the PNT across groups. Correlational analysis and stepwise regression models were used to examine biographical and neuropsychological predictors of response to phonological and semantic treatment across all participants. Last, general linear models incorporating select predictors were leveraged to examine the extent to which we could predict treatment response. In line with best-practice guidelines, the same analyses were additionally carried out for raw change in naming. Results No significant differences were found for biographical and neuropsychological variables across groups (phonological vs. semantic treatment first; all p-values <.05). Both groups improved significantly after semantic treatment (p<.01), while neither group improved after phonological treatment (p>.05; see Table 1). Treatment group Assessment timepoint Two-tailed p-value Tx 1 PMG (p-value) Tx 2 PMG (p-value) Phonological first .015 (.345) .077 (.007) .144 Semantic first .080 (<.001) -.005 (.419) .023 Table 2. Change by treatment order across treatment groups. Our LMM revealed that semantically-focused treatment was more effective at the group-level, regardless of treatment order (p=.008). Overall, milder speech and language impairment predicted good response to semantic treatment (Bonferroni-corrected r-range: .406-.511 across neuropsychological tasks). The WAB-R Spontaneous Speech (WAB-SS) score emerged as the strongest predictor of treatment response (R2=.260). Sex emerged as the only predictor of phonological treatment response (R2=.051). Nonfluent participants responded better to phonological treatment than fluent participants (PMG: .050 vs. -.041, p=.049), while fluent participants responded better to semantic treatment (.122 vs. .037, p=.018). Correspondingly, participants with anomic aphasia and conduction aphasia responded significantly better to semantic than phonological treatment (PMGs: .206 vs. -.083, p=.026 and .089 vs. -.012, p=.032, respectively). A rationalized general linear model incorporating eight predictors of interest (WAB-AQ, WAB-SS, TALSA9 rhyming triplet score, PALPA10 subtest 8 (nonword repetition), presence/absence of apraxia of speech, sex, fluent/nonfluent speech, and aphasia type) explained 60% of variability in response to phonological treatment and 47% of variability in response to semantic treatment. Conclusions Our results suggest that semantic treatment may be more beneficial than phonological treatment at the group-level. Overall, participants with relatively mild impairments responded better to semantic treatment, while phonological treatment benefitted participants with more severe impairments.

Topic Areas: Language Therapy, Disorders: Acquired

Joke processing and Theory of Mind: evidence from the P600

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In terms of cognitive models, humor comprehension is a complex process involving two stages, incongruity detection and incongruity resolution, with the latter capitalizing on pragmatic inferential processes and varying across types of jokes [1]. Consistently, previous EEG/ERPs studies found evidence of serial processing, involving early negative deflections and later positivities (e.g., P600, previously linked with pragmatic inferential mechanisms [2]). In addition, other approaches emphasized the role of Theory of Mind (ToM) abilities in humor comprehension [3]. Here we tried to reconcile these perspectives, aiming to investigate the interplay between pragmatics and ToM in processing different types of jokes. We hypothesized that jokes requiring specific inferential activity would trigger different P600 effects (Hyp1); ToM abilities might have greater involvement in jokes about mental states, in which inferences are focused on mental aspects (Hyp2). Materials included 124 jokes, paired with non-humorous counterparts: phonological jokes (incongruity involving sound similarity, n=64) and mental jokes (incongruity between belief/thoughts attributed to one character, n=60). 35 healthy right-handed participants took part in the EEG experiment. Three ToM measures were collected: Autism-Quotient [4], Read the Mind in the Eye Test [5], and Animation Task [6]. Single-trial ERPs were analyzed with LMM, focusing on Longitude (Frontal, Central, Centro-Parietal electrodes) and 3 time-windows (300-500ms, 500-700ms, 700-1100ms). Results showed a Condition*Type*Anteriority interaction between 500 and 700ms ($F=8.98$; $p<.001$): compared to non-humorous counterparts, phonological jokes triggered a greater P600 across all Longitudes ($M \geq +2.32\mu V$, $ps \leq .001$), while mental jokes showed a higher positivity over Central and Centro-Parietal sites ($M \geq +1.07\mu V$, $ps \leq .019$). Also, phonological jokes elicited a more positive response than mental jokes across all Longitudes ($M \geq +1.52\mu V$, $ps \leq .030$), greater over Central and Centro-Parietal regions. Concerning the role of ToM, a marginal interaction between Autism-Quotient and condition emerged over Central electrodes ($\Delta\beta=-0.92$, $p=.080$). Despite this mild difference, higher autistic-like traits were associated with a significant reduction of P600 amplitude for jokes only (simple effect, $\beta=-1.09$, $p=.014$). We found a P600 effect for jokes, which confirmed previous findings and supports the view that joke resolution is based on pragmatic inferences [2]. Remarkably, phonological and mental jokes triggered a different P600, matching Hyp1. The P600 modulation might illustrate the different inferential activity, with the greater positivity for phonological jokes signaling more straightforward and conclusive inferential paths. Social skills a-specifically modulated the P600 for jokes, thus not meeting Hyp2. Specifically, participants with more autistic-like traits spent less effort during the incongruity resolution stage. We argue P600 reduction in participants with lower social skills might have also led to less conclusive inferences, also preventing a complete comprehension. Overall, these findings point to a distinction between inferential processes for different types of jokes and show a limited effect of ToM abilities on verbal humor processing. [1] Attardo et al. HUMOR, 15(1), 3–46 (2002). [2] Canal et al. BRAIN COGNITION, 132, 41-55 (2019). [3] Samson et al. SOC NEUROSCI, 3(2), 125-140 (2008). [4] Baron-Cohen et al. J AUTISM DEV DISORD, 31(1), 5–17 (2001). [5] Baron-Cohen et al. J CHILD PSYCHOL PSYC, 42(2), 241–51 (2001). [6] Abell et al. COGNITIVE DEV, 15(1), 1–16 (2000).

Topic Areas: Meaning: Discourse and Pragmatics, Phonology and Phonological Working Memory

What makes metaphors more engaging? Insights from neuroimaging and physiological measures

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Initial neuroimaging research from our lab showed that metaphorical formulations, e.g., She looked at him sweetly, engage readers at the emotional neural level more strongly than literal renderings (She looked at him kindly). Stronger left amygdala activation in response to taste metaphors was observed while participants

silently read for comprehension, with no awareness of the experimental manipulation. This finding was replicated in following studies by (1) using metaphors from other sensory domains, (2) simulating more natural reading processes -reading of short stories, and it was generalized to idioms. Crucially, literal and metaphorical versions of the stimuli were equal on a range of psycholinguistic properties, contained the same amount of emotive content, and were rated as highly similar in meaning. Yet, silently reading the metaphorical formulation of a sentence/story led to stronger emotive neural response. These findings importantly advance previous behavioral work based on self-reported emotive reactions. However, what remains unclear is what makes figurative expressions more engaging. Pupil dilation, a measure of physiological arousal (engagement), was recorded during listening to metaphorical expressions embedded in sentences, e.g., sweet compliment, their abstract literal counterparts, i.e., kind compliment, and concrete literal expressions, i.e., sweet candy, which also contain sensory words. These were equal in psycholinguistic and affective properties. Metaphorical expressions showed larger pupil dilations than both literal expressions, suggesting that stronger physiological responses are elicited by the multiple semantic representations evoked by metaphors, rather than their sensorimotor features. These results will be interpreted and discussed in light of extant theories of metaphor processing.

Topic Areas: Meaning: Lexical Semantics, Meaning: Discourse and Pragmatics

Word learning and semantic integration: the role of memory reactivation as a mechanism for building and updating the mental lexicon

Poster C17 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session C.

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Learning the meaning of new words is an important aspect of human language. But after learning, we must also be able to recall these meanings and integrate them with other lexical items. Upon reactivation, a stabilized memory transiently destabilizes and may become susceptible to disruption, enhancement and modification. In the present study we hypothesize that reactivating a novel word´s meaning could be a key mechanism for a successful lexical integration and modification of a lexical trace. We performed a series of online studies analyzing the contribution of memory reactivation to: lexical integration (Study 1) and updating of a word's meaning (Study 2). Native speakers of Spanish (18-35 years) learned low-frequency words (average 0.03 in EsPal) within their language (e.g. 'Citole') and their corresponding definitions ('Ancient musical instrument'). The following day, Reactivation groups were exposed to a reminder consisting of the list of words they learnt the previous day, but without their definitions (thus generating a prediction error). In addition, participants provided a measure of the subjective degree of reactivation for each word. Non- Reactivated groups, on the other hand, did not receive any reminder. In Study 1, memory retention was evaluated 48 h after training using a cued-recall test (N=120) or a semantic judgment task (N=59). In Study 2, participants learned a new information (INFO) for each of the words' definitions that could either be congruent (N=26) or incongruent (N=31) with the previous definition. Retention for the INFO memory was evaluated 48 h after training using a cued-recall test. The statistical analysis was performed using generalized linear mixed models with binomial distribution. Results of Study 1 show a significant enhancement of words' memory and semantic recognition speed in the Reactivation groups respect to the Non-Reactivated ones. Besides, the effects were graded according to the reactivation strength reported by participants: strongly reactivated words lead to faster reaction times in the semantic judgment task. Regarding memory updating, Study 2 reveals a significant enhancement of the new information's memory that increases according to the reactivation strength of each word. In addition, congruency with an existing memory schema was required for updating a novel word's meaning. These results reveal the importance of memory reactivation for constructing and updating our mental dictionary.

Topic Areas: Meaning: Lexical Semantics, Control, Selection, and Executive Processes

Task-dependent effective connectivity during conceptual processing

Poster C18 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session C.

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Conceptual knowledge is central to human cognition, coding the meaning of objects, events and abstract thoughts. Previous neuroimaging research indicates that conceptual processing involves both modality-specific perceptual-motor areas and multimodal convergence zones (Binder and Desai, 2011; Kiefer and Pulvermüller, 2012). However, it remains unknown whether and how modality-specific and multimodal areas interact during conceptual tasks. Here, we asked 1) whether modality-specific and multimodal areas are functionally coupled during conceptual processing, 2) whether their coupling depends on the task, 3) whether information flows top-down, bottom-up, or bidirectionally, and 4) whether their coupling is behaviorally relevant. We measured brain activity in 40 participants using fMRI, while they performed three different tasks—lexical decision, sound judgment, and action judgment—on words with a high or low association to sounds and actions. In a two-stage analysis approach, we combined whole-brain, data-driven psychophysiological interaction (PPI) analyses with dynamic causal modeling (DCM). PPI tested for task-dependent changes in functional coupling between auditory, motor, and multimodal seed regions with the rest of the brain (thresholded at a voxel-wise $p<0.001$, cluster-wise $p<0.05$ FWE-corrected). The results informed a DCM analysis that assessed the direction of information flow between modality-specific and multimodal nodes. We found that functional coupling between modality-specific and multimodal areas strongly depended on the task, involved both bottom-up and top-down information flow, and predicted conceptually-guided behavior: A multimodal region in the left posterior inferior parietal lobe (pIPL) showed increased coupling with left primary motor and somatosensory cortices (M1/S1) selectively when action knowledge was task-relevant. Conversely, multimodal pIPL increased its functional interaction with the left auditory association cortex (AAC) selectively when sound knowledge was task-relevant. DCM analyses further revealed that multimodal pIPL was bidirectionally connected with AAC, and sound knowledge modulated both the top-down and bottom-up connections. In contrast, M1/S1 was unidirectionally connected to pIPL, and action knowledge specifically modulated this bottom-up connection. Crucially, coupling between multimodal pIPL and motor or auditory cortices correlated with participants' personal action and sound associations with concepts, respectively. These results suggest that functional coupling in the conceptual system is extensive, reciprocal, task-dependent, and behaviorally relevant. Our findings support theories that assume conceptual processing to rely on a flexible multi-level architecture grounded in the perceptual-motor systems (Fernandino et al., 2016; Kuhnke et al., 2020). References Binder, J.R., Desai, R.H., 2011. The neurobiology of semantic memory. Trends Cogn. Sci. 15, 527–536. https://doi.org/10.1016/j.tics.2011.10.001 Fernandino, L., Binder, J.R., Desai, R.H., Pendl, S.L., Humphries, C.J., Gross, W.L., Conant, L.L., Seidenberg, M.S., 2016. Concept Representation Reflects Multimodal Abstraction: A Framework for Embodied Semantics. Cereb. Cortex 26, 2018–2034. https://doi.org/10.1093/cercor/bhv020 Kiefer, M., Pulvermüller, F., 2012. Conceptual representations in mind and brain: Theoretical developments, current evidence and future directions. Cortex 48, 805–825. https://doi.org/10.1016/j.cortex.2011.04.006 Kuhnke, P., Kiefer, M., Hartwigsen, G., 2020. Task-Dependent Recruitment of Modality-Specific and Multimodal Regions during Conceptual Processing. Cereb. Cortex 30, 3938–3959. https://doi.org/10.1093/cercor/bhaa010

Topic Areas: Meaning: Lexical Semantics, Multisensory or Sensorimotor Integration

Timecourse and convergence of abstract and concrete knowledge in the anterior temporal lobe.

Poster C19 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session C.

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INTRODUCTION Hub-and-spokes models of semantic cognition proposed the anterior temporal lobe (ATL) as a crucial semantic hub, integrating both abstract and concrete conceptual features according to a dorsal-to-medial gradient. Empirical support for a graded ATL hub mainly stems from fMRI studies. However, due to the poor temporal resolution of hemodynamic signals, several questions about abstract and concrete semantic representations in the ATL remain unanswered. For instance, it is unclear how such an organization emerges during conceptual retrieval. One possibility is that abstract and concrete dissociations depend on the long-range connectivity profile of different subparts of the ATL. That is, the medial-ventral ATL responds more to concrete concepts by virtue of having greater connectivity to occipitotemporal visual areas (ventral route); whereas the dorsal-lateral ATL contributes more to abstract concepts by virtue of its greater connectivity with the posterior temporal language system and the orbitofrontal emotional cortex (dorsal route). To date, however, there is no direct evidence that concrete and abstract information travels along these cortical routes during conceptual retrieval. Aim of the present magnetoencephalography (MEG) study was to investigate the spatiotemporal organization of abstract and concrete semantic information in the attempt to shed some light on when and how graded semantic representations emerge in anterior temporal brain regions. METHODS We recorded MEG signals from thirty participants performing a semantic categorization task on 438 spoken words. Each word referred to a concept that was independently rated across 65 feature dimensions. Principal component analysis (PCA) was implemented in order to reduce dimensionality and create high-level abstract and concrete semantic predictors. We then used a combination of multiple linear regressions analysis and source reconstruction methods to assess the spatiotemporal dynamics of abstract and concrete semantic information processing. RESULTS Source-reconstructed cortical responses evidenced that, at late processing stages, abstract and concrete semantic information was organized in the ATL according to a dorsal-to-medial gradient. Furthermore, using a region of interest approach, we were able to show that the earliest observable responses to concrete and abstract semantic information laid, respectively, in the fusiform gyrus and in the posterior STG. Notably, the encoding of abstract and concrete semantic information progressively engaged more anterior regions, travelling along two separate streams (one dorsal and one ventral) eventually culminating in the ATL. CONCLUSION In line with previous studies, we provide corroborative evidence that, during conceptual retrieval, abstract and concrete semantic information is represented in the ATL along a dorsal-to-medial gradient. Furthermore, the present findings support a dual-route model of semantic retrieval by showing that, during early stages of conceptual processing, concrete and abstract features are encoded in posterior temporal regions and, at later time points, converge into the ATL along separate cortical streams.

Topic Areas: Meaning: Lexical Semantics, Speech Perception

Simulated attack reveals relationships between left-hemispheric anatomical network topology and post-stroke aphasia

Poster C20 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session C.

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Understanding the brain basis of aphasia outcomes requires considering how lesion damage affects residual network organization and considering how individual differences related to premorbid brain organization or reorganization after stroke affect outcomes. To date, studies examining relationships between global network topology and aphasia outcomes have not clearly distinguished between the direct effects of lesions on network topology, and the individual differences in premorbid brain organization or post-stroke reorganization that affect un-lesioned network components. Here, we applied a simulated attack approach to understand the influence of lesions on network properties, and the relationship of lesion-induced changes to clinical language scores (the WAB-AQ). We then compared the actual observed network properties of each individual stroke survivor to the simulated attack models to test how individual differences in the topology of spared networks contribute to aphasia outcomes. To accomplish this goal, we identified network lesions due to stroke in probabilistic connectomes constructed from diffusion weighted imaging in 41 survivors of left-hemisphere stroke. Then, we simulated the network effects of each patient's observed lesion on each of 36 healthy subjects' connectomes. These simulated network effects comprised a personalized null model for each stroke subject, which allowed us to distinguish effects observed in an individual patient's real results from effects expected to occur on average from the same lesion. We estimated the effects of simulated lesions on several measures of global network organization thought to support overall brain function (network density, the number of disconnected network components, transitivity, global path length, and small world propensity), and examined the relationships between these measures and WAB-AQ. This approach isolates the effects of lesions on network topology to determine how these effects relate to aphasia outcomes. We found that the expected network density after virtual lesions was associated with aphasia quotients ($r = 0.29$, $p = 0.0001$), with the number of disconnected network components accounting for variance above and beyond density alone ($r = 0.45$, $p = 0.001$). Then, we calculated the difference in the actual observed network properties of each stroke survivor from their individual null distribution lesion effects to determine if these individual differences in spared network properties contributed additional variance beyond network density to WAB-AQ. Individual differences in transitivity relative to the null expectation within the spared network contributed additional variance to aphasia severity beyond simulated network density ($r = 0.09$, $p = 0.01$). Right-hemisphere network measures did not account for the variance in aphasia scores. Our results suggest that significant global dysconnectivity of the network is a major driver of clinical language impairments and local anatomical connectivity within the left hemisphere (i.e., identified by network transitivity) but not the right hemisphere. These findings could represent premorbid resilience in network topology or post-stroke variance in plasticity or deafferentation related to behavioral sequelae. Future studies could examine longitudinal changes or employ multimodal imaging to test these possibilities.

Topic Areas: Methods, Computational Approaches

Theory-driven classification of individuals with and without reading difficulties using Bayesian latent-mixture models

Poster C21 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session C.

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Introduction: Decades of research resulted in numerous observations of differences in the neurofunctional organization of individuals with and without reading disabilities (RD), leading to several competing theories regarding the neural contributors to impaired reading. Researchers however have a limited set of tools to directly compare these theories, as most current analytical methods aim to either test singular predictions (e.g. Univariate statistics) or detect patterns in a data-driven manner (e.g. Machine Learning). The goal of the current work is to fill this gap and offer an approach that transparently translates theoretical claims into models and directly assesses and compares theories' ability to differentiate between individuals with and without RD. We do so by adopting a Bayesian latent-mixture approach, a sub-type of generative modeling where classification models are constructed in a theory-driven manner (e.g. [1,2]). We build a series of latent-mixture models, each reflecting one theoretical claim regarding markers of RD in fMRI data: (1) mean-activation models (e.g. more activation in the right hemisphere and less activation in the left in RD readers); (2) heterogeneity-based models (e.g. individuals with RD are more heterogeneous); and (3) intra-subject variability models (e.g. RD individuals show more variability between regions). Importantly, models are fitted to fMRI data only (i.e. are blind to actual RD status). This enables us to examine which models produce group classification that fits participants' actual group membership, thus estimating their discriminatory power. Methods: We use data of n=127 adolescents and young adults (age: 13.5-25.2 years, M=19.9) from a fMRI localizer task where participants are passively exposed to sequences of printed or spoken words [3]. The data fed into the models are estimated beta values per subject reflecting print versus fixation contrast in 262 regions-of-interest (from [4]). Each model was built (using JAGS, [5]) to reflect one theory of RD by employing constraints on relevant parameters. Actual (i.e.

behavioral) group membership was defined using a conventional in-study criterion of <90 standard score in either word or pseudo-word naming sub-tests in TOWRE-II. Results: Models based on mean-activation and heterogeneity produced classification that did not fit the behavioral classification. In contrast, classification based on intra-subject inter-region variability matched participants' actual RD status: We observed a significant difference in the group classification latent parameter between individuals with and without RD (MRD=0.55, MTD=0.35; t(125)=2.61, p=0.01; RD individuals classified as more variable) and above-chance dichotomous classification success rate (61.4%, p=0.01). Conclusions: Our data indicates that intra-subject inter-region variability is a better network-level marker of RD than mean activation and inter-individual heterogeneity. As such, the results highlight the importance of considering intra-subject neural variability. We will present follow-up analysis examining the source of the differences in intra-subject variability and in particular its relation to functional connectivity. More broadly, the usefulness of latent-mixture modeling in comparing theories regarding neural contributors to language disorders will be highlighted and discussed. References: [1] Ortega et al., 2012, Arch Clin Neuropsych [2] Siegelman et al. 2019, Cognition [3] Malins et al. 2016, Neuropsychologia [4] Power et al. 2011, Neuron [5] Plummer, 2003, DSC Proc

Topic Areas: Methods, Reading

Modelling the temporo-parietal hierarchy of speech prediction with artificial neural networks

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When listening to natural speech, the brain resolves semantic context into distinct timescales which are represented along a temporo-parietal processing hierarchy. But does this hierarchy also engage in the prediction of speech by coding for the predictive power of single timescales and ultimately integrating information across timescales into a final prediction? With the emergence of artificial neural networks designed to inform word-by-word predictions by multiscale semantic context, it has become feasible to model the information flow within different network architectures. This allows to test how closely these artificial networks match behavioural and neural representations of predictive power in human listeners. Here, we trained two versions of a long short-term memory network (LSTM) with five layers (representing different timescales) and a window of 500 words (representing semantic context) on a large corpus of German stories: a “regularly-updating LSTM” where information is fed to a higher layer with each upcoming word, and a competing “sparsely-updating LSTM” where information is fed to a higher layer only at the end of a timescale. In a 3-T functional magnetic resonance imaging (fMRI) experiment, 34 young and healthy participants listened to a one-hour narrative incorporating a multitude of timescales while confronted with competing resynthesized natural sounds. We regressed vertex-wise cortical BOLD activity onto the output from the trained language networks, specifically the LSTM-derived surprisal (i.e., negative logarithm of word probability) of each word in the narrative given all semantic context. In line with the previous literature, temporal regions showed increased sensitivity to surprisal of speech derived from both LSTM models. In a next step, we will read out the predictive power of single timescales from “lesioned” LSTM models by iteratively removing an increasing number of layers from the model, starting from the top layer (representing the longest timescale). Using the resulting five timescale regressors in an encoding framework, we expect that shorter timescales are coupled to activity in lower-order temporal regions, whereas longer timescales are coupled to activity in higher-order parietal regions like the angular gyrus. To compare the explanatory power of both LSTMs, we will run a decoding analysis where we expect the hierarchically organized and computationally more efficient sparsely-updating LSTM to outperform the regularly-updating LSTM. Finally, we will test the behavioural relevance of the semantic timescales using response times recorded in 25 additional participants performing a self-paced reading task on a text version of the narrative. Taken together, we hope to elucidate how the human brain dynamically orchestrates complex—

and oftentimes outdated, contradictory or irrelevant—information represented on different timescale to build up predictions on upcoming speech.

Topic Areas: Computational Approaches, Perception: Auditory

Towards a tailored approach to neuroplasticity enhancement based on brain and behavioral predictors of language learning success

Poster C23 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session C.

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Individual differences in the functional and morphological architecture of the dorsal and ventral language pathways may explain part of the variability observed in the ability to learn new words in healthy population and in language recovery of persons with aphasia (PWA). Aphasia is characterized by an impairment or loss of linguistic skills (comprehension and/or production) that arises as a consequence of acquired brain damage, most often a stroke involving the left hemisphere. The traditional gold-standard of aphasia rehabilitation is speech and language therapy (SLT), yet in many cases its effectiveness is limited and aphasic subjects are left with enduring deficits. More recent studies suggest that benefits of SLT can be boosted by the use of additional therapeutic approaches that potentiate brain plasticity such as cognitive-enhancing drugs or non-invasive-brain stimulation (transcranial direct current stimulation, tDCS). Despite promising results, the use of tDCS is still limited in clinical settings, among other causes due to the great heterogeneity in the results obtained in previous studies. Currently, there are no well-defined biological or behavioral markers to identify the optimal brain regions that can assume the lost function in a given person and therefore, it is unclear which areas of the brain should be modulated with therapeutic interventions (e.g.,tDCS, SLT). To bridge this gap, the present project seeks to identify brain, linguistics and cognitive predictors of treatment response that guide the choice of the language pathway (i.e. dorsal or ventral) and hemisphere (left or right) that must be potentiated to maximize individual benefits. For this, the implication of the dorsal and ventral pathways will be modulated with two validated word-learning tasks: phonological word-learning task (relying on the activity of the dorsal stream) and contextual word-learning task (relying on the activity of the ventral stream). Further, the activity of the left or right cerebral hemispheres will be modulated by using three different tDCS conditions. This project will be implemented through two studies in two different samples: (i) thirty healthy adults, and (ii) ten PWA, which will allow not only the identification of brain predictors but also exploring if such predictors can be translated from healthy to brain-damaged subjects. Both studies will follow the same within-subject design. Each subject will participate in 3 sessions separated by a week. In each session, subjects will receive a different tDCS stimulation condition (left anodal stimulation, right anodal stimulation, and sham) and will be required to perform the two learning tasks. Three different versions of each task will be created to prevent learning across sessions. A brain magnetic resonance imaging session will be acquired at baseline to obtain structural and functional information. In addition, several tests aimed to measure attention, memory and working memory will be performed to explore potential cognitive predictors. The results of this project will further illuminate theories on variability of language performance in the healthy brain and will provide helpful hints for making decision in the selection of therapeutic algorithms for tDCS as well as for the selection of tailor-made SLT for a given aphasic individual.

Topic Areas: Language Therapy, Meaning: Lexical Semantics

Representing roots: A neural decoding study of the representation of Arabic root morphemes

Poster C24 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session C.

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Introduction: The complicated relationship between phonology and morphology plays a critical role in linguistic theory and psycholinguistic accounts of word recognition and morphological productivity. This relationship is particularly challenging in non-concatenative languages like Arabic that produce word forms (e.g. janna 'garden') by the infixation of wordform patterns (e.g., C1VC2C3V) into triconsonantal roots (e.g. [j.n.n]). A key question is whether these word formation processes inform online spoken word recognition. If they do, one would expect that roots would have privileged representational status. Several functional anatomical models predict that that such representations would be localized in the posterior middle temporal gyrus. A further question is whether such morphological representations would be spatially dissociable from non-morphological representation of wordform. Aim: To determine whether and where patterns of localized spatiotemporal brain activity can be used to decode classes of words that share a common triconsonantal root versus as incidental triconsonantal pattern spanning a prefix and portion of a root morpheme. Methods: Simultaneous 306-channel MEG and 70-channel EEG data will be collected in native Arabic speakers while they complete an auditory lexical decision task. WORD stimuli in this task will include multiple fully infixed forms derived from three productive triconsonantal roots ([m.l.w],[t.b.l] and [t.m.r]), and matched words in which the same consonant sequences are produced by appending a prefix (m- or t-) to different roots that share the same first two consonants ([w.l.d], [b.l.d] or [m.n.r]). We will create sourcespace reconstructions of these data using individual subject MRI anatomical priors for each trial. These will be spatially segmented into large sets of regions of interest by algorithm. We will then use multiple timeseries from each ROI to train a support vector machine to discriminate between different phonological patterns, triconsonantal root patterns, and critically actual roots versus matched incidental consonant sequences. Once trained these classifiers will be tested on withheld data from the same subject. If localized brain regions show differential ability to encode phonological versus morphological patterning, we will use a Kalman-filter based implementation of Granger causality analysis to examine patterns of interaction between those regions. Predictions: We predict that activity in the supramarginal gyrus will effectively decode phonological patterns, but will not show differential encoding of familiar root morphemes. In contrast, we predict that the posterior middle temporal gyrus will decode distinctions between roots and phonologically matched multimorphemic sequences. Strong interactions are expected between these regions. Summary: The purpose of this work is to: (1) determine whether Arabic roots have privileged neural representation, (2) localize such representations, and (3) establish the potential spatial dissociation and interaction between brain regions involved in morphological and non-morphological representations of wordform. These results will be examined in the light of linguistic, neural and psycholinguistic accounts of the relationship between morphological and phonological processing.

Topic Areas: Morphology, Phonology and Phonological Working Memory

Effect of speaker accent on auditory cognate processing by L2 learners of English

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Translation equivalents that have a similar form between languages—meaning, cognates, such as 'elephant' and 'elefante' between English and Spanish—are processed faster than words with dissimilar form—i.e., non-cognates, such as, 'cloud' and 'nube'. This is commonly known as 'the cognate effect'. A large amount of literature supports this effect, but most of these studies are based on orthographic similarity. Given the strength of the cognate effect and the common assumption that the two languages are co-activated at both the orthographic and the phonological level, phonological similarity between languages may also influence word processing in bilinguals. In a previous study, we found an inhibitory orthographic similarity effect in the auditory modality, such that greater orthographic similarity between languages led to slower response times. One possible explanation for this effect is that, in fact, the pronunciation of the cognate words said by a native speaker of the foreign language differs more from the participants' representation of the word, as compared to non-cognates. Another possibility is that the auditory stimuli are activating incorrect orthographic representations. In other words, this could be due to a mismatch (1) between the phonological representation and the auditory stimulus or (2) between the constructed and real orthographic representations, or possibly a combination of both. The aim of the present study is to explore these possibilities and explain the inhibitory orthographic cognate effect in the auditory modality. To test these, we designed an auditory lexical decision task in which participants decided whether the strings they heard produced by two different speakers were real words. One of the speakers had a native accent (Standard American as in the prior experiment) and the other had an accent closer to that of the participants (L1 Spanish speaker from Spain). We then presented a transcription task in which participants typed what they heard—produced by either the native or the non-native speaker. We tested highly proficient Spanish (L1)-English (L2) bilinguals in their L2 in two sessions. We manipulated orthographic and phonological similarity orthogonally and included a group of perfect cognates and one of perfect non-cognates. Therefore, participants heard a total of 300 words and pseudowords distributed in 6 groups: orthographic cognate-phonological cognates, orthographic cognate-phonological non-cognates, orthographic non-cognate-phonological cognates, orthographic non-cognate-phonological non-cognates, perfect orthographic cognates, and perfect orthographic non-cognates. Data collection is still ongoing and results are preliminary. We expect to find a facilitatory orthographic similarity effect of cognates for the non-native speaker condition, but an inhibitory effect with the native speaker (as in our previous findings). We expect participants to produce more accurate strings (measured using ALINE distance) when they hear words with a non-native accent than when they hear them with a native accent, particularly for cognates.

Topic Areas: Multilingualism, Speech Perception

Perception of Degraded Paralinguistic Signals in Alzheimer's Disease and Frontotemporal dementia

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Introduction: The speech we hear on a daily basis occurs under non-ideal listening conditions, and thus 'degraded' through competing sounds or the idiosyncratic vocal characteristics of other speakers and more, all of which change over time. While perception and comprehension of degraded speech is normally automatic and effortless, it depends on integrative, dynamic and adaptive processing across distributed neural networks, rendering it potentially vulnerable in neurodegenerative diseases. However, little is known about how the processing of degraded speech is affected in major dementias – and particularly how these diseases affect the processing of paralinguistic information that is often critical for communication in the world at large. The following experiments look to explore how certain forms of degraded paralinguistic signals are affected in two forms of dementia: Alzheimer's Disease (AD) and semantic variant primary progressive aphasia (svPPA). Methods: We assessed nine patients with typical AD and seven patients with svPPA of mild to moderate severity in relation to healthy age-matched controls, on two different forms of degraded paralinguistic signal identification: accents (Southern Standard English, American or Russian) in spoken English sentences after sinewave transformation and ii) canonical vocal emotions (sadness, anger or surprise) in spoken three-digit numbers after noise vocoding with different numbers of channels. Results: Both patient groups performed significantly worse than healthy controls on both tasks. AD patients also performed significantly worse than controls in identifying 'natural' accents and emotions prior to degradation (suggesting a more fundamental perceptual deficit), whereas svPPA patients were relatively more susceptible to the effects of degrading paralinguistic information (suggesting a deficit of 'top-down', predictive decoding). Conclusion: Perception of degraded paralinguistic signals is impacted relatively early by dementia and differentially between neurodegenerative syndromes, with implications for understanding real world communication in different neurodegenerative diseases.

Topic Areas: Perception: Auditory, Disorders: Acquired

The syntactic processing during reading in children at risk for Developmental Language Disorder: an ERP study.

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The syntactic processing during listening and reading is usually marked by the P600 ERP component occurring in the occipital and parietal regions (Gouvea et al., 2010). P600 reflects sequential word analysis in a sentence and restoring utterance logic after grammatical errors (Kaan et al., 2000). Children with Development Language Disorder (DLD) are known to have difficulties in sentence processing and differentiation of sentences conveyed by grammatical contrasts (Hsu & Bishop, 2014). The current study aims to investigate the P600 responses to visually presented sentences varied by the grammar structure and syntactic distance in children with DLD. Here we summarize preliminary results on data collected from children at risk for DLD (we will collect the data from children with typical language development for comparison at a later time). The participants were 19 native Russian-speaking children of 13—18 years [M (SD) = 15.73 (1.28), 12 males] from a rural population with an atypically high prevalence of DLD (Rakhlin et al., 2013). Here, we investigate the effects of language development on the P600 response in this sample. The children's language skills were measured with the Standardized language test ARFA-RUS (Kornilov et al., 2019). We used a composite score derived from Sentence Repetition, Pseudowords, Sentence Comprehension, and Synonyms subtests that reflect the expressive and receptive levels of language development. In the EEG study, we considered the effects of embedded complement clause varying by the grammar structure (Grammatical (G) and Ungrammatical (U)) and the distance between the syntactic head and its dependent (short-distance (SD) – immediately after the verb, long-distance (LD) – before the verb). The experiment had 2 x 2 factorial design with 4 combinations: SDU, SDG, LDU, LDG. Each condition had 35 trials; 70 unique verbs were used. Participants read sentences in a self-paced manner and performed grammaticality judgment. EEG signal was recorded using 128 Ag/AgCl electrodes and preprocessed via BrainVision Analyzer software (Brain Products, Inc). Based on the visual screening and previous research (Goueva et al., 2010), we selected two time-windows for P600 analysis: 500-800 ms and 800-1000 ms. Linear Mixed Models were used to investigate the effects of language development scores in interaction with experimental condition on the P600 mean amplitude in the left, midline and right parietal electrode clusters. Random intercepts were included for participants. Our results did not register any differences between the conditions, suggesting the P600 amplitudes in our sample did not reflect changes in sentence structure. That may indicate that P600 responses of children at risk of DLD are not sensitive to syntactic violations (Haebig et al, 2017). We found no dependency on P600 responses on the level of language development. We assume our measurement of language development may be insensitive to DLD, and subsequent investigation will include a detailed analysis of narrative language samples to overcome this limitation. We will further recruit a typical developmental group to examine deep mechanisms of the sentence processing and syntactic integration in the P600 responses in different conditions between groups. Funding: Russian Science Foundation grant № 18-18-00451 (PI: Grigorenko E.L.).

Topic Areas: Reading, Meaning: Lexical Semantics

Identifying individual profiles in the processing of morpho-syntactic violations: An ERP study on German regular and irregular plural forms

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It has been claimed that the bi-phasic LAN-P600 pattern commonly elicited by morpho-syntactic violations is in fact a by-product of inter-individual variability and that individual participants, rather than showing a bi-phasic pattern, vary on a continuum between negativity-dominant and positivity-dominant responses (e.g. Tanner, 2019; Tanner & Van Hell, 2014). To test this claim, we examined ERP responses to violations of regular and irregular German plural nouns with the aim of identifying individual profiles elicited by morpho-syntactic violations. We also addressed the question of whether individual profiles (positivity-dominant or negativity-dominant) vary as a function of the type of morphological forms being tested. Following previous ERP studies on German plurals (e.g. Lück et al., 2006; Regel et al., 2019), we tested two types of violations: 'over-regularizations', in which the regular plural affix '-s' was attached to irregular nouns (e.g. *Planets vs. Planeten, 'planets'), and 'irregularizations', in which the irregular plural affix '-(e)n' was attached to regular nouns (e.g. *Baguetten vs. Baguettes, 'baguettes'). Plural nouns were embedded in sentences. The experiment included 480 trials, 240 testing over-regularizations and 240 testing irregularizations. Forty native speakers of German were asked to read the sentences, presented word by word, while their EEG signal was recorded. Data analysis was performed by fitting linear-mixed effect models to the amplitude of the signal in each trial, averaged in pre-selected time-windows (early window: 300-500 ms; late window: 600-1,000 ms). The group-level analysis revealed a left anterior negativity (LAN) in the early time-window for over-regularizations but not for irregularizations. Furthermore, for both types of violations, we found a positivity in the late time-window (P600). Strictly following Tanner and Van Hell's (2014) procedure, two subgroups of individuals were identified for each type of violation, those with a positivity-dominant response and those with a negativity-dominant response. For the positivity-dominant participants, we found a distributed (mostly posterior) late positivity for both types of violations (over-regularizations and irregularizations). For the sub-groups of participants showing a negativity-dominant profile, we found a left-hemisphere response in the case of over-regularizations which was significant at left-anterior sites (LAN), and a widespread negativity, compatible with a N400, in the case of irregularizations. These results indicate that morpho-syntactic violations vary as a function of the type of morphological form (irregularizations = N400 and P600; over-regularizations = LAN and P600). At a more general level, we conclude that analyses of individual ERP profiles contribute to a more detailed understanding of brain responses to morpho-syntactic violations and may additionally reveal brain responses that are otherwise (i.e. from a group-level analysis only) not visible, as was the case for the N400 for irregularizations.

Topic Areas: Morphology, Reading

Hemodynamic Correlates of Speech Processing in Monolingual and Bilingual Infants

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A bilingual learning environment has been shown to affect behavioural and brain responses during spoken language processing as early as infancy. In a bilingual learning environment, infants are exposed to the linguistic regularities to not one, but two inputs simultaneously. In addition, while bilingual infants' overall language exposure should be comparable to that of monolinguals, bilingual infants likely receive less exposure to each of their languages, compared to their monolingual peers, because their exposure time is split between two inputs. It has been observed that monolingual infants display a behavioural preference towards their native language, whereas bilingual infants seem to allocate more attention to unfamiliar linguistic stimuli (Bosch and Sebastián-Gallés, 1997; Molnar et al., 2014). This differential processing might also be reflected in their functional responses towards speech stimuli. In order to track specific properties of speech such as linguistic rhythm, bilingual infants might need to recruit different neural mechanisms (Nácar-García et al., 2018) and involve additional brain regions in the right hemisphere (Mercure et al., 2020). The aim of this work is to examine the effect of a bilingual learning environment on functional brain activation patterns during native language processing in 4-month-old infants. Spanish monolingual (n = 21) and Spanish-Basque bilingual (n = 26) infants' brain responses to speech (forward, FW) and non-speech (backward, BW) were measured using functional near-infrared spectroscopy (fNIRS), relying on a dataset with a large number of trials per infant and condition (>18 trials). Using general linear model-based analyses, brain regions activated by the presentation of FW and BW speech stimuli were assessed and the shape of the corresponding hemodynamic responses were estimated. Results across oxy- and deoxyhemoglobin (HbO and HbR) were consistent with the operational definition of cortical activation for fNIRS data, i.e., an increase in HbO and a decrease in HbR (Obrig and Villringer, 2003). At the group level, functional brain activation to FW and BW speech stimuli was observed bilaterally in classical language and auditory regions in the superior and middle temporal gyrus, with activation patterns showing a higher lateralization towards the left hemisphere. Between-group comparisons revealed that monolingual infants showed a more left-lateralized pattern of brain activation for speech stimuli of their native language, whereas bilingual infants showed a more bilateral activity over temporal regions and a less marked preference towards speech (FW) vs. non-speech (BW) condition. These results fit previous observations showing dissimilar developmental pathways between bilingual and monolingual infants during the earliest stages of language acquisition. Considering language processing, these bilingual adaptations might manifest as differential functional responses to familiar vs. unfamiliar auditory stimuli and as an additional involvement of right hemispheric regions, alternatively, a decreased left-hemispheric specialization.

Topic Areas: Multilingualism, Speech Perception

Functional specialisation and plasticity of language systems: converging evidence from language learning experiments

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Functional specialisation and plasticity are fundamental organising principles of the brain, and the human capacity for language requires a delicate balance between the two. Since the mid-1800s, language has been known to be hemispherically lateralised, but the provenance and flexibility of hemispheric specialisation for language remain open questions. Though language is classically considered to be left-lateralised, the neuropsychological, psycholinguistic, neuroimaging, and surgical mapping evidence suggest that this is not always the case even in right-handers (e.g. Marchman, Miller & Bates 1991; Vilasboas et al. 2017), and that comprehension in particular is quite weakly lateralised (Rogalsky et al. 2020). The present study investigated different language systems, i.e. reading, speech comprehension, and verbal production, in the same subjects. The subjects were late language learners at different levels of proficiency, allowing us to examine lateralisation in their native language (modality-specific specialisation) and track lateralisation changes concomitant with increasing proficiency in their non-native language (learning-dependent plasticity). Further, we examined the evolving relationship between the native and non-native languages in late language learners, and how this differed in each system. The study presents results from two separate fMRI experiments, one cross-sectional and one longitudinal, involving distinct populations and languages. Experiment I was a cross-sectional study of thirty-four adult (mean age = 46.5 years; 17 male) native speakers of Spanish, who were at either intermediate or advanced levels of learning Basque, while Experiment II was a longitudinal study of twenty-four adolescent (mean age = 17.2 years, 16 female) sequential bilingual speakers of Spanish and Basque, who underwent intensive 3-month language training in intermediate-level English. Spanish and Basque come from distinct language families but are phonetically and orthographically similar, while Spanish and English have overlapping roots, but are phonetically and orthographically different. In both experiments, participants carried out classical comprehension and production tasks in the MRI scanner in their native (L1) and non-native (Ln) languages.

Three corroborating analyses of lateralisation revealed a highly consistent pattern of results across the two experiments, showing that (i) in both L1 and Ln, while language production was left-lateralised, lateralisation for language comprehension was highly variable across individuals, and (ii) with increasing Ln proficiency, production showed negligible change and remained left-lateralised in both L1 and Ln, while reading and speech comprehension displayed substantial changes in hemispheric dominance, with languages tending to lateralise to opposite hemispheres. Thus we found that while the left hemisphere appears to specialise for language production, language comprehension is more plastic well into adulthood and able to flexibly recruit both hemispheres. These convergent results from two highly contrasting experiments shed light on the long-standing debate of neural organisation of language by establishing robust principles of lateralisation and plasticity of the main language systems. Going further, these differences between the language systems may (i) explain the comprehension-production asymmetry in language acquisition and learning, and (ii) suggest that lateralisation and plasticity of each language system may be tied to their respective sensorimotor cortices.

Topic Areas: Multilingualism, Reading

Neural tracking of attended speech in monolingual and bilingual children

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Bilingualism has been shown to modulate the neural mechanisms of selective attention, with differences between monolinguals and bilinguals observed even when they display equivalent behavioural performance(1). This suggests that the crucial consequence of learning and using multiple languages might be that it triggers neuroplastic adaptation that allows bilinguals to achieve optimal performance under increased processing demands. To date, many of these studies have focused primarily on adults and it is therefore unclear to what extent such changes affect the mechanisms of selective attention in bilingual children. One possibility is that the demands of competition and inhibition between co-activated languages reconfigure the patterns of attentional processes right from the onset, such that the effects can be clearly discerned by the time children can respond to selective attention tasks. Alternatively, these modifications might have a protracted maturation dependent on the length of exposure to the demands of bilingualism, in which case they would be much more evident in adults than in children. To address this question, we used EEG to track the neural encoding of attended continuous speech in 24 monolingual and 24 bilingual children aged 7-12, in the context of different types of acoustic and linguistic interference. Participants attended to a narrative in English while four different types of interference were presented to the unattended ear: a different narrative in English, a narrative in Latin (a language unknown to the listener), a well-matched non-linguistic acoustic interference (Musical Rain), and no interference. The neural encoding of attended and unattended steams was assessed by reconstructing their speech envelopes from the EEG data in each condition, using the mTRF toolbox(2). Results showed more accurate reconstruction of the attended envelopes than ignored ones across all conditions for both bilinguals and monolinguals. We also saw that the type of interference significantly modulated the accuracy of stimulus reconstruction of attended speech for monolinguals. Data for bilingual children on the other hand displayed equivalent reconstruction accuracy of the attended envelopes in every condition, replicating the pattern of results previously observed using complementary techniques in adults(1). These findings indicate that, even when behavioural responses are equivalent, monolingual and bilingual children exhibit different patterns of neural entrainment to attended speech envelopes. This suggests that the reconfiguration of the neural mechanisms of selective attention in bilinguals is not dependent on the full maturation of selective attention by adulthood(3), but is established by the time children can reliably respond to selective attention tasks. 1. Olguin, A., Cekic, M., Bekinschtein, T. A., Katsos, N., & Bozic, M. (2019). Bilingualism and language similarity modify the neural mechanisms of selective attention. Scientific Reports, 9(1), 8204. 2. Crosse, M. J., Di Liberto, G. M., Bednar, A., & Lalor, E. C. (2016). The Multivariate Temporal Response Function (mTRF) Toolbox: A MATLAB Toolbox for Relating Neural Signals to Continuous Stimuli. Frontiers in Human Neuroscience, 10. 3. Ridderinkhof,

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Topic Areas: Multilingualism, Development

Might Abstract Sound Symbolism Emerge From Hand Action Knowledge?

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Few hypotheses have tried to explain the mechanism behind the human-specific ability of matching pseudowords to shapes, known as sound symbolism1. One prominent theory is the synaesthetic articulatory account2, where the authors explain that the sharp edges of a shape mimic the sharp phonemic inflections and the sharp movement trajectory of the tongue on the palate when for example uttering the pseudoword "kiki". However, an examination of articulography data does not reveal sharp or round articulatory movements while producing speech sounds that are consistently classified as sharp or round in rating studies, thus ruling out this putative account as an explanation of sound symbolism. In contrast, other body parts, such as our hands, could provide an explanation behind the links of pseudowords to shapes. During hand movements, perceptual and motor information of these movements can be associated in the brain in Hebbian learning process3. These same sensorimotor representations could provide the basis of crossmodal exchange and of sound symbolism. To explore a possible link between actions and sound symbolism, we tested 24 healthy subjects on a two-alternative forced choice task in two conditions. In the 'sound-symbolic' condition, subjects had to match a 'sharp' or a 'round' pseudoword to a curved or edgy shape. In the 'action sound-shape' condition, subjects had to match 'sharp' or 'round' sounding hand actions to curved or edgy hand action shapes. The action sounds/shapes were recorded, while the experimenter drew with a pen curved/edgy shapes. The two conditions were crossed. Subjects detected significantly above chance the mappings between both sounds and shapes in the first two as well as in the crossed conditions. Moreover, the congruency performance of the subjects was positively correlated across conditions. Analysis of the acoustic properties of both 'sharp' and 'round' action sounds and pseudowords, revealed similarities between the two categories. Similarly, the visual products of the actions resembled the edgy or curved shapes of sound symbolism. These results suggest that human sound symbolic ability is intrinsically related to the knowledge about the sounds of actions and the shapes of the trajectories of such movements. This knowledge is best explained by associative learning between manual actions and the observed shapes and sounds they produce, next to the visual and auditory similarities between action and sound symbolic stimuli. At a neurobiolgical level, the knowledge of the actions and of their perceptual products can be stored in the brain by distributed neuronal circuits linking auditory, visual and motor cortices to multimodal areas3. To conclude, it is plausible that these same circuits that carry sensorimotor knowledge of hand actions could support the iconic links between pseudowords and shapes.

Topic Areas: Multisensory or Sensorimotor Integration, Perception: Speech Perception and Audiovisual Integration

Cortical language processing flexibly adapts to perceptual and contextual properties of speech

Poster C36 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session C.

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Temporal regularities of natural connected speech allow for optimised bottom up speech signal processing while top-down semantic predictions help to integrate words into sentential context. Together these processing mechanisms allow for rapid and fluent speech comprehension. It is, however, unclear how these processing strategies adapt to the challenges presented by everyday communication such as sudden unpredictable changes in speech speed or semantic content. In this study we asked how reducing the temporal regularity of spoken sentences affects their cortical processing strategies, specifically lower-level phonological analysis and higher-level semantic predictions. To do so we analysed time-resolved brain activity (MEG) while participants listened to spoken sentences that varied in the degree of semantic constraint and the temporal regularity of the speech signal. We disrupted the temporal regularity of the natural speech by introducing temporal jitter - randomly speeding up and slowing down the audio signal of the sentence. To ensure that our sentences were maximally natural, and represented a range of semantic constraints similar to that of spontaneous speech, we built a neural network to select stimuli from a large online corpora. Both normal and temporally jittered sentences were successfully comprehended by the listeners - for all sentences follow up comprehension questions showed 80% and above accuracy. Despite this, the two conditions engaged markedly different cortical processing strategies. First, we evaluated online cortical parsing of speech by calculating coherence between cortical signals and the entire sentence auditory envelope. Introducing temporal jitter predictably interfered with parsing - coherence was reduced in the theta band (5-8 Hz) in the right temporal sensors. Simultaneously, temporal jitter reduced listeners' ability to use context to generate top-down predictions when processing individual words. For target words preceded by jittered speech context the left fronto-temporal sensors showed reduced N400 effects for unpredictable words as well as reduced model-fit for lexical Surprisal (RSA analysis - Surprisal is an index of context-based lexico-semantic prediction updating). Finally, weaker contextual effects for temporally jittered speech also coincided with stronger effects of phonological analysis for individual words, as evidenced by better fit (RSA analysis) of the model encoding information about words' phonemes. We argue that temporal regularity of the speech signal improves parsing, thereby reducing the perceptual processing cost, and in doing so releases resources for higher-order linguistic processes such as contextual analysis. Deterioration of temporal cues impedes speech parsing, degrades contextual effects and at the same time re-focuses the processing strategy to the extraction of phonological information. We therefore show that the cortical language circuits flexibly adapt their processing strategies to the perceptual and contextual properties of incoming speech.

Topic Areas: Perception: Auditory, Meaning: Lexical Semantics

Seeing The Face Of The Talker Improves Comprehension For Some Words More Than Others

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Comprehension of noisy speech improves substantially when the face of the talker is visible (Sumby and Pollak, 1954; Peelle and Sommers, 2015). Which visual speech cues are important? As the most visible part of the vocal apparatus, the talker's lip movements allow visual discrimination of articulatory phonetics (Gick et al., 2018; Van Wassenhove et al., 2005; Vatakis et al., 2012). Other cues include the temporal relationship between auditory and visual speech (Karas et al., 2019) and word familiarity and frequency (Cleland et al, 2006). To understand the relative influence of these factors, we assessed participants' recognition of noisy auditory-only speech (AO) and combined with the face of the talker (noisy audiovisual, AV). Participants verbally reported their perception of each word. Accuracy was calculated as the number of matching phonemes between the participant's response and the target word and converted to odds-ratios for analysis with generalized linear mixed-effects models (GLMM; Karas et al., 2019) containing three fixed effects: place of articulation of the initial phoneme (lip vs. non-lip); word frequency; and mouth/voice asynchrony.Word and participant were random effects. In Experiment 1, 10 participants reported their percepts of 297 words recorded from 12 talkers, each word presented in AO and AV formats. Seeing the face of the talker resulted in a greater than two-fold increased in the likelihood of a correct response vs. auditory-only presentation (GLMM odds-ratio 2.55, p = .0003; raw accuracy of 23% for AO vs. 56% for AV). The model fit positive effects for place of articulation (odds-ratio 1.57, p = 10-12) and word frequency (odds-ratio 1.14, p = 10-4) but not for mouth/voice asynchrony (odds-ratio 1.00, p = .93). In Experiment 2, 45 participants were presented with 40 words selected for extremes of performance in Experiment 1 (10 words each with every combination of low/high AO performance and low/high AV benefit). With this selected stimulus set, there was a larger AV benefit (odds-ratio 4.12, p = 10-10) and a positive effect for initial phoneme place of articulation (odds-ratio 1.31, p = .004). In contrast to the full stimulus set, there was a positive effect for mouth/voice asynchrony (odds-ratio 1.07, p = .003) but no effect of word frequency (odds-ratio 0.98, p = .72). Across experiments, there was large variability in the benefit of seeing the face of the talker. Some words received no benefit (odds-ratio of 0.48 for the word "vogue") while other words received a very large benefit (odds-ratio of 33 for the word "theme"). Neural responses to AV speech and AO speech are very different, making it difficult to discern which neural responses are most related to the perceptual benefit of visual speech. A stimulus battery containing words with more or less AV benefit can be used to study the relationship between a particular neural signature and perception.

Topic Areas: Perception: Speech Perception and Audiovisual Integration, Speech Motor Control

Disruption of the left posterior inferior frontal gyrus impairs grammatical processing guided by prosodic cues

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Auditory sentence processing involves semantic, syntactic and prosodic information. Prosodically guided sentence processing has been shown to involve the left inferior frontal gyrus (IFG). Prosodic cues are known to interact closely with both syntax and semantics, and these processing domains in turn have been attributed to two different subregions within the left IFG: based on neuroimaging studies, the anterior part is associated with semantic processing and syntactic processing is ascribed to the posterior part. Yet, the causal role of this regional specialisation remains unclear. The current study used focal perturbations induced by repetitive transcranial magnetic stimulation (rTMS) to probe the causal role of the posterior IFG for syntactic processing and the anterior part for semantic processing in prosodically varied sentences. Since the interpretation of a pitch accent in the sentence was essential for successful task performance, we additionally were able to assess the involvement of left IFG in sentence processing when crucial information was conveyed by prosody. Healthy participants performed a sentence completion task with a syntactic and a semantic decision. The pitch accent in the truncated spoken utterance cued which determiner and noun (presented visually) would form the most suitable sentence ending, which were selected by button-press. Healthy participants underwent three sessions with 10 Hz rTMS bursts being applied over either anterior or posterior left IFG, or vertex (control region). rTMS was applied 100 ms after onset of the presentation of the determiners (syntactic condition) or nouns (semantic condition). Although we found no significant interaction between rTMS site and decision type, a main effect of rTMS site indicated decreased task accuracy in both decision types after posterior IFG stimulation versus vertex. Considering the lack of interaction effect, we suggest the use of participant-specific functional localisers in future TMS studies to further investigate the specific contribution of different IFG subregions in sentence comprehension. The decreased accuracy after posterior IFG stimulation in both the syntactic and semantic decisions may be explained by impaired processing of the grammatical roles in the sentence, which was required for successful task performance in both conditions. Therefore, we interpret these results as evidence for the functional relevance of the left posterior IFG in grammatical processing guided by prosodic cues.

Topic Areas: Prosody, Syntax

Brain lateralization during reading in deaf adults is not influenced by cochlear implantation.

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Most hearing people are left lateralized for language processing and reading. The phonological mapping hypothesis proposes that, as reading development progresses, visual word recognition becomes increasingly left lateralized due to mapping of orthographic forms onto the already left lateralized phonological representations of speech (e.g. Maurer and McCandliss, 2008). In line with this, greater phonological awareness has been linked with stronger left lateralization for visual word processing (Sacchi & Laszlo, 2016). Phonological processing is challenging for the majority of profoundly deaf readers, whose phonological representations of speech might be underspecified. Indeed, while the majority of deaf people are also left lateralized for sign language processing (e.g. Gutierrez-Sigut et al., 2016), there is recent evidence of bilateral brain activity for word recognition in deaf readers (see Emmorey, 2020). One possibility is that deaf readers do not establish strong links between the orthographic representations of written words and corresponding phonological representations of spoken words, resulting on more bilateral brain activity for reading. It is assumed that cochlear implants (CIs) provide better access to speech sounds, and therefore could facilitate the creation of better phonological skills in CI users than those without. If this is the case we would predict stronger left lateralization for deaf adults with CI during reading, than those without CI. Here we investigate lateralization in adult congenitally profoundly deaf participants using functional transcranial Doppler sonography (fTCD). Specifically, we measured the laterality indices (LIs) of 18 deaf adults who had an early fitted CI (< 9 years old), 18 deaf adults with no-CI and 18 hearing adults during three language tasks: semantic fluency, reading of short stories and rhyme judgement. For each task, we contrast the LIs and accuracy and investigate the relationships between LI and reading ability. Semantic fluency: as expected, the three groups were predominantly left lateralized. Reading: Only the hearing group was significantly left lateralized. The LIs were higher for the hearing group than for both groups of deaf readers, who did not differ significantly from each other. This was consistent with the lack of behavioral differences (comprehension question accuracy and reading ability) between the deaf CI and non-CI groups. Rhyme judgement: the hearing and the deaf no-CI deaf group were significantly left lateralized while the CI group was not. The LIs were higher for the no-CI than for the CI group. This was consistent with the behavioral data, which surprisingly showed significantly lower rhyme judgement accuracy for the CI than the no-CI deaf group. There were no correlations between the strength of lateralization and behavior in any of the tasks. However, accuracy during the rhyme judgement task was correlated with reading ability for the CI group. These findings are consistent with studies showing bilateral brain activity for reading in deaf readers (see Emmorey, 2020). The pattern of results for the deaf groups also highlight that better access to auditory input by itself does not necessarily translate into better phonological processing, nor better reading. Future studies with those with earlier CIs are necessary to examine this issue further.

Topic Areas: Reading, Signed Language and Gesture

Better readers show larger N400 effects during naturalistic listening

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Individuals with decoding-based reading disability (also known as dyslexia) often exhibit deficits in phonological processing (Shaywitz, 1996), including deficits in tasks requiring processing of speech sounds (Schulte-Körne & Bruder, 2010; Vellutino et al., 2004) and in low-level auditory processing more generally (Giraud & Ramus, 2013; Lehongre et al., 2011). Although reading disability is commonly associated with lower-level speech sound processing impairments and can leave higher-level oral language processes relatively spared, many children with

reading disability also have higher-level language difficulties (Adlof & Hogan, 2018; Sabisch et al., 2006). To date, however, the majority of research concerning language processing in reading disability has focused on lower-level aspects. In the present study, we used a naturalistic stimulus – stories read aloud (audiobooks) – to investigate the relationship between reading ability and semantic integration in a reading-disabled population. METHOD: Participants (n=58) were students with reading disability attending schools specialized in remediating language- and reading-based disabilities (mean age=10.8 years, SD=1.8 years, range=7.5–15.5 years). To measure word reading ability, participants were administered the Woodcock-Johnson 4 Letter-Word Identification subtest, an untimed test of word decoding (population mean standardized score (controlling for age)=100; sample M=89, SD=11, range=63–120). Participants' EEG was recorded as they listened to audiobook excerpts for ~11 minutes. Overlapping epochs (300 ms baseline + 1000 ms post-stimulus period) were time-locked to the onset of each content word. Individual effects of word frequency were computed by regressing µV on log word frequency at every latency and channel, in models that also controlled for the frequencies of adjacent words. Data were submitted to cluster-based permutation testing (Pernet et al., 2016) to identify spatiotemporal clusters at which participants' effects of word frequency were related to their Letter-Word ID scores while controlling for familywise error rate. RESULTS: A significant spatiotemporal cluster was observed over central channels between 200 ms and 725 ms post-word onset. Within the cluster, participants with higher word reading scores showed a positive relationship between content word frequency and µV, whereas participants with lower scores showed a negative relationship or no relationship. Given the effect's topography (central), time window (peaking around 400 ms), and polarity (more negative to lower-frequency words), this indicates that better readers showed a larger – and more adult-like (Brennan & Hale, 2019) – N400 effect of word frequency during auditory sentence comprehension. DISCUSSION: Within a sample of children with reading disability, better readers showed larger N400s to lower-frequency words in a naturalistic listening task. This is consistent with some previous research on printed sentence processing, which has demonstrated smaller N400 effects in children with reading difficulties (e.g., Shulz et al., 2008). These findings are relevant for better understanding the complex relationship between language and reading in children with reading disability.

Topic Areas: Reading, Disorders: Developmental

Silent words and invisible signs: cross-language activation in bimodal bilinguals

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Presenter Note: I'd be happy to take questions about the poster in English, Spanish, LSE (Spanish Sign Language) or International Sign. If you can't make it to Poster Session C, please feel free to look for me in Gather.Town or to contact me: b.costello@bcbl.eu Some work in this poster is already published: Villameriel, S., Costello, B., Dias, P., Giezen, M., & Carreiras, M. (2019). Language modality shapes the dynamics of word and sign recognition. Cognition, 191, 103979. doi: 10.1016/j.cognition.2019.05.016

Brendan Costello[1], Saúl Villameriel[1,2], Marcel Giezen[1], Manuel Carreiras[1,2,3]; [1]BCBL (Basque Centre on Cognition, Brain and Language), [2]Universidad del Pais Vasco/ Euskal Herriko Unibersitatea, San Sebastian, Spain, [3]Ikerbasque, Basque Foundation for Science

When accessing the words of one language, bilinguals co-activate the words of their other language. This study investigated language co-activation across spoken and signed modalities, and examined the role of sub-lexical units in this cross-modal, cross-language lexical access. We ran a series of eye-tracking experiments on parallel activation in 56 hearing bimodal bilinguals of spoken Spanish and Spanish Sign Language (LSE) using the visual world paradigm. In each experiment of 30 critical trials, participants heard a word or saw a sign while viewing on-screen images of objects, two of which had different types of phonological overlap with the stimulus. Two experiments examined within-language co-activation; two looked at cross-language co-activation. In Experiment 1, participants heard a Spanish word (e.g. 'estrella' [star]) and we measured looks to images corresponding to onset competitors (e.g. sword ['espada']), rhyme competitors (e.g. bottle ['botella']) and unrelated distractors. In Experiment 2, participants saw a LSE sign (e.g. CARROT, signed with a closed fist at the mouth); images

depicted handshape competitors (e.g. noose, signed with a closed fist by the neck), location competitors (e.g. duck, signed with a flat hand at the mouth) and unrelated distractors. Experiments 3 and 4 switched the language of stimulus presentation to look at activation of lexical items of one language by those of the other: Experiment 3 included LSE stimuli with images for Spanish phonological overlap (e.g. STAR → sword/bottle); Experiment 4 had spoken Spanish stimuli with competitor images for LSE phonological overlap (e.g. 'zanahoria' [carrot] → noose/duck). Growth Curve Analysis of the data provided information about the size of the effects and also the relative time course of looks to each type of competitor. Results for within-language co-activation showed stronger and earlier activation of onset compared to rhyme competitors in Spanish (Experiment 1), reflecting the temporal structure of the spoken stimulus. For LSE (Experiment 2), activation of location preceded but was also weaker than activation of handshape competitors, which is a perceptually more complex feature than location, even though it typically appears before location in the articulation of signs. The cross-language results revealed that LSE signs co-activated only onset (but not rhyme) competitors in Spanish (Experiment 3). Spanish words co-activated both handshape and location competitors in LSE, with earlier co-activation of location than handshape competitors (Experiment 4). These findings reveal the role and time course of activation of sub-lexical information in within- and cross-language contexts in both modalities. The results suggest that within-language sub-lexical co-activation is driven by the physical properties of the linguistic signal (onset precedes rhyme in the temporal structure of words; handshape is a perceptually more complex feature of signs than location). In contrast, the cross-language setting attenuates the influence of physical properties of the linguistic signal on sub-lexical co-activation (only activation of Spanish onset competitors through LSE; similar strength of activation of LSE handshape and location competitors through Spanish). Finally, the results provide evidence that bilinguals' languages – whether spoken or signed – co-activate each other, even in the absence of phonological overlap between the two languages.

Topic Areas: Signed Language and Gesture, Perception: Speech Perception and Audiovisual Integration

Who is to blame? Source monitoring during speech production

Poster C42 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session C.

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Sensory feedback plays a major role during speech production. For example, speakers monitor their articulation in order to avoid or correct speech errors. However, in order to be used for self-monitoring, speakers need to distinguish between self-produced and external sensory signals (this is termed 'source monitoring'). The aim of the current study was to investigate the role of conscious source monitoring in speech motor control. Previous studies have shown that speakers tend to compensate when their auditory feedback is unexpectedly pitch-shifted. Here, we investigate whether source monitoring modulates these compensatory responses. If conscious source monitoring is associated with compensatory responses to altered feedback, we predict that ascribing pitch shifts to an external source would lead to smaller responses to said pitch shifts. In a pre-registered study, sixty participants were instructed to vocalize /e/ for 4s after a visual cue. In every vocalization, the feedback's pitch was shifted briefly (200 ms) up or down by 25 or 100 cents. This occurred up to three times in each vocalization. Pitch shift onsets were separated by intervals between 600 to 800ms. The participants were not informed of the manipulations beforehand. After one block of 100 vocalizations, participants were questioned in a semi-structured interview, in order to determine whether they noticed the pitch changes in the feedback, and whether they thought these were self-produced or not. After the interview, participants were informed that pitch shifts had occurred and that these were experimentally induced, and a second block followed. If conscious source monitoring plays a role in speech motor control, we expect that whether participants considered the pitch shifts to be self-generated or not should affect their responses to pitch-shifted auditory feedback. Blaming the pitch shifts on an external source should be associated with smaller responses. The results showed that half of the participants were self-blamers (thinking the pitch shifts were self-produced in the first block), the other half other-blamers. Although not strictly speaking significant, an analysis of participants' response magnitudes showed a trend of an interaction between Group (self-blamers vs. other-blamers) and Block, suggesting that informing speakers about the manipulation led to reduced responses in block 2 for the self-blamers, but not for the other-blamers. These results are in line with a limited association between conscious source monitoring and altered auditory feedback processing. Although the predicted interaction was not significant, the results show clear indications that auditory-driven articulatory responses are at least partially modulated by conscious source monitoring. In addition, the results show that there is individual variability in how speakers ascribe externally pitch-shifted feedback to themselves vs. an external source, which may be driven by variability in vocal abilities and experience.

Topic Areas: Speech Motor Control, Multisensory or Sensorimotor Integration

Increased vowel contrast induced by adaptation to a non-uniform auditory perturbation in speech

Poster C43 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session C.

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When auditory feedback is perturbed in a consistent way, speakers learn to adjust their productions to compensate, a process known as sensorimotor adaptation. Typically, feedback perturbation experiments employ a transformation that targets a single vowel, or that affects all vowels in the same way, resulting in a uniform change across the vowel space (e.g., raising the first formant). Here, we examine speakers' ability to compensate for a non-uniform perturbation field which was explicitly designed to affect vowel distinctiveness, applying a shift that depended on the vowel being produced. We hypothesized that speakers could adapt to the applied feedback shift by learning to produce greater contrast between vowels, resulting in an expansion of their working vowel space. Twenty-five participants were exposed to a "vowel centralization" feedback perturbation in which the first two formant frequencies were shifted towards the center of each participant's vowel space, making all vowels sound more like schwa. Each participant also completed a control session with an identical procedure but with no alteration to feedback. Speakers adapted to this non-uniform shift, learning to produce corner vowels with increased average vowel spacing (AVS) to partially overcome the apparent centralization. This increase in AVS occurred without a concomitant increase in vowel duration, and remained significant after the feedback shift was removed, persisting even after a 10-minute silent period. These findings show that speakers are capable of adapting to non-uniform shifts of vowel formants. Furthermore, they establish the validity of sensorimotor adaptation paradigms to lead to increases in vowel contrast, an outcome that has the potential to enhance intelligibility.

Topic Areas: Speech Motor Control, Multisensory or Sensorimotor Integration

Speech perception under adverse condition: A possible role for rapid perceptual learning?

Poster C44 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session C.

Presenter Note: Questions? email Karen @ kbanai@research.haifa.ac.il or visit our lab @ https://sites.google.com/welfare.haifa.ac.il/theauditorycognitionlab/home?authuser=1 For further details on study 3 check out Rotman et al., (2020) in Trends in Hearing https://doi.org/10.1177/2331216520930541

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Perceptual learning, defined as improved stimulus processing following experience or practice, occurs under various situations in which speech is delivered under adverse conditions and in different populations of listeners. But whether perceptual learning truly serves to facilitate speech perception under ecological conditions remains unclear because although perceptual learning remains functional from infancy to old age, and across various conditions, it is often highly specific and fails to generalize across the variants that are characteristic of natural speech (e.g., across different talkers or accents). Therefore, past learning is unlikely to support future perception through generalization and consolidation. Instead, we hypothesize that rapid perceptual learning (also known as adaptation) is an individual characteristic that supports ongoing speech perception when listeners encounter new challenges. If this is the case, even highly specific learning could support perception. Recent work from our lab on the rapid learning of time-compressed speech will be presented to shed light on facets of this hypothesis. In study 1, we tested the assumption that even rapid learning is highly specific. 205 listeners were tested on the recognition of time-compressed speech and natural fast speech after different types of previous experience (no exposure, exposure to 20 sentences produced by a single talker, exposure to 20 sentences produced by different talkers). Compared to the no exposure group, either type of exposure yielded rapid perceptual learning. This learning was maintained for at least 7 days, but was specific to the trained talker and did not generalize to a new talker or to natural fast speech. In study 2 (n = 100), we asked whether individual differences in rapid perceptual learning and in speech perception were correlated and whether correlations could be attributed to other sensory or cognitive factors. Rapid perceptual learning of time-compressed speech accounted for unique variance in the recognition of natural-fast speech and speech in noise. This was true even after accounting for the potential contribution of hearing thresholds, working memory and vocabulary as well as for the correlations between perception of time-compressed and the other forms of speech. Furthermore, in this study speech-rates were matched to yield initially similar performance across younger listeners and older listeners with hearing impairments. Yet, learning was slower in older adults, commensurate with their perceptual difficulties when compared to young adults without matching speech rates. Together, these data suggest that despite its specificity, rapid learning of time-compressed speech is associated with the perception of other forms of degraded speech and that this association is not accounted for by a number of potentially confounding factors (hearing, general speech perception, cognitive factors). They are also consistent with recent studies from other labs showing correlations between the perception of different types of degraded speech, all of which exhibit rapid learning (e.g., Kennedy-Higgins et al., 2020). Although all these studies are correlational in nature, the idea that rapid learning is one of the factors involved in ongoing speech perception under adverse conditions is a parsimonious account of currently available data.

Topic Areas: Speech Perception, Perception: Auditory

Different memory retrieval processes for newly learned voices and phonemes: an EEG study.

Poster C45 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session C.

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Linguistic and voice-related information are intertwined in the speech signal, but they can be selectively extracted to achieve different goals. Active recognition processes of native speech and familiar voices are thought to be functionally dissociated (Schall et al., 2015). However, it is not clear if such dissociation also characterizes automatic memory retrieval processes. To this aim, we ran a longitudinal ERP study to investigate memory retrieval processes of newly learned voices and phonemes. We focused on the Mismatch Negativity (MMN) response as its modulation appears to index the activation of such processes. Two groups of 15 Italian native speakers with no prior knowledge of German were involved in an MMN experiment that was repeated before and after different training procedures. In the MMN experiment, responses to an unfamiliar German-speaking voice vs to a German phoneme were tested. The syllable /piː/ produced by native German-speaking talker A served as the standard stimulus and was repeatedly presented via headphones with fixed ISI while EEG was recorded. The standard stimulus was infrequently replaced by two different deviant stimuli. In the voice-change condition, the deviant stimulus was the same syllable but produced by the native German-speaking talker B. In the phoneme-change condition, the deviant stimulus was the syllable /pyː/ produced by talker A. After the first EEG recording, one group of participants was involved in a talker identification training and learned to identify the previously unfamiliar voice of talker B. The other group was enrolled in a syllable identification training and learned the new phoneme /yː/, which is not present in the Italian phonological repertoire. At the end of the training procedure, the EEG experiment was repeated and MMN responses of pre-

training and post-training recordings were compared. Consistently with previous studies, results showed that learning a phoneme enhanced the amplitude of MMN, reflecting the retrieval process of the memory trace for the learned phoneme. Differently, the presentation of the learned voice reduced the amplitude of MMN. This reduction was interpreted as induced by the activation of an average voice representation acquired during training. It was shown that voice-specific neurophysiological responses elicited by identity-typical voices are weaker than the ones elicited by identity-atypical ones. In the post-training session, the learned voice possibly appeared as more identity-typical with respect to how it was perceived the pre-training session thus eliciting reduced MMN. Considering these differentiated electrophysiological patterns, the automatic processes underlying the memory retrieval for voice-related vs. linguistic information appear to be differently modulated by experience, suggesting a functional dissociation between the two types of information since the early stages of speech perception.

Topic Areas: Speech Perception, Phonology and Phonological Working Memory

Depth of Speech Processing for Unattended Speech

Poster C46 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session C.

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Speech processing requires analysis of auditory input at multiple acoustic and linguistic levels, and a long-standing research question is which stages of speech processing require attention. As suggested by the infamous “Cocktail Party” effect (Cherry, 1953), as well as the “Irrelevant Sound Effect” (Beaman et al., 2007), at least some unattended content seems to be fully analyzed and can affect behavior. We set out to study this question using a hierarchical frequency-tagging approach (Ding et.al, 2015; Makov et al. 2017) in which distinct linguistic levels are uniquely associated with specific frequencies (syllables, words, phrases and sentences). This approach allows differentiating neural responses to the different linguistic levels from the recorded neural signal. Participants (n=30) attended to natural speech presented to one ear, while to-be-ignored hierarchical speech was presented concurrently to the other ear. Specifically, two types of distractors were used: Random sequences of Hebrew syllables (Non-Structured Distractor) which yield meaningless speech, and syllables constructed such that they formed coherent Hebrew speech, structured hierarchically into words, phrases and sentences (Structured Distractor). Importantly, this design perfectly controls for all low-level attributes of the two conditions, as the sole difference between them is in the order of the syllables. In contrast to a previous study (Ding et al. 2018), to-be-attended speech was presented at a natural rate, which more closely simulates the type of listening challenges faced in every-day situations. We recorded neural activity using Magnetoencephalography (MEG) and tested whether there is evidence in the neural signal for representation of non-acoustic linguistic levels when the distractor was Structured (vs. Non-Structured). Indeed, we found evidence for a phrase-level response to Structured distractors, localized to left inferior frontal regions, providing an indication that at least some syntactic structure-building is applied to distractor speech. We further tested whether the neural encoding of the attended speech itself was affected by the linguistic structure of task-irrelevant speech, using speech-tracking analysis. We found that when the distraction was Structured, the speech-tracking response to attended speech was enhanced, an effect observed over left-hemisphere sensors and localized to left inferior frontal regions. This result suggests that higher listening effort is required when distractor speech is comprehensible, in line with load theories of attention. These results contribute to the ongoing debate regarding the ability to process several speech inputs in parallel, and shed light on the nature and neural mechanisms underlying the inherent bottlenecks for speech processing.

Topic Areas: Speech Perception, Perception: Auditory

Neural Indices of speech processing of consonant cluster word onsets in English, Korean, and Spanish listeners

Poster C47 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session C.

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The aim of this study is to examine how first language experience modulates neural processing of American English consonant clusters (blow) versus unstressed onsets (e.g., below). Korean does not include stop-liquid consonant clusters in syllable onsets; in contrast, Spanish allows such clusters, but does not have unstressed vowels (e.g., schwa in below). Neural measures to nonsense words (bli, beli with a 30-ms vowel and be:li with a 60-ms vowel) were recorded in an oddball paradigm in which attention was directed to a muted movie. Preliminary results with seven Korean, three Spanish, and five native English speakers revealed that Korean and Spanish listeners were poor at categorizing whether a stimulus was "bli" or "beli" in an AXB task, whereas English listeners clearly categorized the endpoints (bli versus be:li-60 ms). All groups showed neural discrimination (Mismatch Negativity, MMN) for be:li-60 ms compared to bli. The groups showed different patterns dependent on which stimulus was the standard. For example, English and Korean listeners showed a larger MMN when bli was the frequent stimulus (standard), whereas Spanish listeners showed a larger MMN when beli-60 ms was the standard. In addition, none of the groups showed MMN to beli-30 ms versus be:li-60 ms. These results suggest that both acoustic-phonetic and phonological factors modulate discrimination of speech patterns and contribute to the observed asymmetries in relation to stimulus probability.

Topic Areas: Speech Perception, Perception: Auditory

Seeing is Hearing: Can visual rhythms replace acoustic envelope information in speech perception?

Poster C48 [Poster PDF] Visit me at [Gather.Town] in the Wernicke room during Poster Session C.

Presenter Note: Feel free to contact us and follow on Twitter the Neurolinguistics lab lead by Alexis Hervais-Adelman. @NeuroSLAMlab diana.krasovskaya@uzh.ch alexis.hervais-adelman@uzh.ch

Diana Krasovskaya[1], Alexis Hervais-Adelman[2]; [1]Department for Comparative Language Studies, University of Zurich, [2]Neurolingusitics, Department of Psychology, University of Zurich

Scalp-level magneto- and electrophysiological recording has repeatedly shown that the patterns of cerebral activity track the amplitude envelope of speech signals, in different frequency ranges that reflect these features. The most prominent among these is the Theta band (4-8Hz), which corresponds to the syllable rate of speech. A dominant proposal (Ghitza, 2012; Giraud and Poeppel, 2012) is that acoustical modulations in the theta range entrain brain activity at that frequency, thereby contributing to a cascade of processes that result in efficient syllable parsing and processing. Ghitza (2012), demonstrated that removing modulations in a speech signal in the range 2-9Hz reduced the intelligibility of speech (from approximately 100% to 64%) and that it could be partly restored (to 71%) by inserting broadband noise bursts at the mid-vowel points of the speech signal. Here we set out to reproduce Ghitza's (2012) findings and to extend them to a cross-modal condition to establish whether temporal cues in the theta frequency range presented visually could restore the intelligibility of speech that had theta band amplitude modulations removed. Twenty Swiss-German native speakers were presented with Swiss-German matrix sentences, comprising a carrier sentence with three keyword positions each having four possible values. Participants were asked to listen to sentences and to report the keywords they heard. Accuracy was scored according to all three correctly reported keywords. Sentences were presented in five conditions (64 sentences each): A control condition (NV), 16-channel noise vocoding (extraction of 16 quasi-logarithmically spaced amplitude envelopes using the Hilbert transform, convolution of the envelope and band-pass filtered noise in each band and recombination). A “No Theta” (NT) condition in which the 16 extracted amplitude envelopes were filtered with a 2-9Hz band-stop filter to remove syllable-rate amplitude modulation. The mid-vowel points of the sentences were extracted and converted to a series of 100ms broad-band noise-bursts (AB) and a series of visual “bursts” (VB) consisting of a small white circle on a black background whose diameter expanded at each mid-vowel point. The three further conditions were NT+AB, NT+VB and NV+VB. LME analysis revealed a significant effect of condition (comparison against the null model: $X2(4, N = 20) = 277.94$, p <

.001). Post hoc pairwise comparisons were executed to elucidate the effects. Removing syllable rate amplitude modulation had a significant impact on comprehension (NV mean=95%, SE=+/-.009, NT mean= 69. SE=%+/-.041, z=-9.593, p<.0001). However, adding AB to NT lead to a significant decrease in accuracy (NT+AB mean=42%, SE=+/-.045, z=-5.385, p<.0001). Visual information did not significantly improve performance (NT+VB mean=69%, SE=+/-.04, NV+VB mean=96%, SE=+/-.009). Contrary to previous reports, reinstating an approximate theta rhythm in speech that has had the syllable rate modulations removed did not lead to an improvement in comprehension. Given the lack of utility of AB, it was not surprising that VB did not positively contribute to comprehension. The deleterious effect of AB and not VB suggests that it disrupted participants' auditory, not temporal, processing. Further investigation of the precise parameters of amplitude modulation cue that contribute positively to speech perception is needed.

Topic Areas: Speech Perception, Perception: Speech Perception and Audiovisual Integration

Decision strategies during Mandarin tone category learning relate to different networks of emerging representations

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Introduction. Learning to categorize speech sounds is critical for speech perception and communication. Little is known about the nature of emerging neural representations during novel category learning, where learners demonstrate substantial individual differences in performance and decision strategies. For instance, learners may use 'rule-based' strategies that rely on hypothesis testing and selective attention to separate the categories, which may involve attention and working memory networks in frontal and parietal regions. Learners may also use 'integration' strategies that use multiple dimensions in a way that is difficult to verbalize, which is thought to rely on subcortical mechanisms. Learners may also randomly guess or inconsistently apply multiple strategy types. We examine how decision strategies during learning relate to the emerging neural representations of Mandarin tone categories by combining decision-bound computational modeling and multivariate representational similarity analysis (RSA). Methods. Across two previous functional magnetic resonance imaging (fMRI) experiments (Feng, Yi, & Chandrasekaran, 2019; Yi, Mumford, Maddox, & Chandrasekaran, 2014), 53 native English participants learned to distinguish four non-native Mandarin tone categories across 240 trials with feedback. These tone categories are lexically meaningful in Mandarin and are distinguished by different pitch patterns. We applied decision bound computational models (Ashby, 1992; Ashby & Maddox, 1993) to assess learners' decision strategies (rule-based, integration, or inconsistent) in the early stage (first half) and late stage (second half) of learning. To assess how these strategies might relate to the neural encoding of Mandarin tone categories, we correlated the multi-voxel pattern dissimilarities with stimulus category dissimilarity patterns during stimulus presentation, as assessed through multivariate RSA. We compared the neural representation patterns for the rule-based, integration, and inconsistent strategies. Results. As expected, participants used a variety of strategies during learning (early stage: 4 rule-based, 11 integration, 38 inconsistent; late stage: 14 rule-based, 16 integration, 23 inconsistent). Early in learning, there were no significant differences in the tone category neural representations across any of the strategies. Late in learning, different decision strategies related to different representational networks. When learners applied rule-based strategies, a broad network of temporal, parietal, and frontal regions contributed to the emerging tone category representations. Relative to inconsistent strategy users, this rule-based network included angular gyrus, inferior frontal gyrus, precuneus, cingulate gyrus, and superior temporal gyrus (STG). STG is thought to be a locus of representation of native speech categories. When learners applied integration strategies, a less distributed network contributed to emerging representations and was limited to frontal regions (left medial frontal gyrus). Summary. We investigated where representations emerge over the course of speech category learning and how this relates to decision strategies. These results demonstrate that neural networks supporting emerging representations of novel speech categories relate to the decision strategies learners use in the last half of learning. Specifically, for those using rule-based strategies, representations are widely distributed. Our results provide insights on the sources of emerging neural representations during speech category learning.

Topic Areas: Speech Perception, Perception: Auditory

Decoding of syntactic structure during sentence production

Poster C51 [Poster PDF] Visit me at [Gather.Town] in the Wernicke room during Poster Session C.

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Background: Language allows for different ways of saying the same thing. A paradigmatic example is the dative alternation: Double-Object (DO: Kate gave Rita the pencil) and Prepositional-Object (PO: Kate gave the pencil to Rita) that vary minimally in syntactic complexity and meaning but must nevertheless be distinguishable in the brain. We used representational similarity analysis (RSA) to decode syntactic structure during naturalistic sentence production. This multivariate pattern analysis can detect relevant regions that could be missed by univariate contrasts. Methods: Participants (N=24) completed two sessions on two days. In session 1, they saw videos of transfer actions and heard and repeated corresponding dative sentences. Ten verbs appeared 12 times each. Four verbs appeared only in DO (DO-only), four only in PO (PO-only), and two equally in both (Equal-DO-PO) (counterbalanced across participants). In session 2, participants watched videos and described them on their own as brain images were acquired using sparse sampling (2 runs, 70 trials per run). The same verbs from session 1 were used but the videos were different, necessitating sentence generation and production. For the RSA analysis, t-maps for each syntactic structure (DO/PO) and verb type (DO-only/PO-only/Equal-DO-PO) compared to a baseline non-sentence task (six t-maps per participant) served as input. In the model representational dissimilarity matrix (model RDM), 0s were assigned to pairs of conditions with the same produced structure and 1s to those with different structures. High correlations between the model and neural RDM are expected in regions whose multivoxel patterns reflect syntactic structure. We conducted both ROI and searchlight analyses. ROIs were obtained from intersecting a univariate Sentences>Baseline contrast with anatomical Harvard-Oxford atlas regions, including pars opercularis + pars triangularis (Broca's area), anterior and posterior superior temporal gyrus (STG), anterior cingulate cortex, and occipital lobe, which have been linked to syntactic processing and/or sentence production in a visual context. Spearman rank correlation coefficients between the model and neural RDMs were fisher z-scored and tested against zero (one-tailed t-test because negative correlations are neither expected nor interpretable). We also conducted whole-brain searchlight analysis. Results: ROI analyses revealed significant decoding of syntactic structure in Broca's area (ρ=0.139, $t(23)=2.066$, $p<.05$) but not other regions. Searchlight analysis yielded four significant clusters (threshold = 0.005, pFDR-corrected<.05), with the largest in the left inferior frontal cortex (220 voxels). There was no overlap (0 voxels) between this searchlight cluster and the Broca's area ROI derived from the univariate analysis. Conclusions: 1) Broca's area can decode syntactic structure during sentence production, consistent with previous comprehension results. 2) Null results in STG suggests a potential difference between production and comprehension modalities. 3) Searchlight analyses revealed additional relevant regions in the left inferior frontal cortex that did not show significant Sentences>Baseline activation in the univariate analysis. Echoing conclusions in other domains (e.g., vision and working memory), this suggests that regions not activated specifically for language can nevertheless contain relevant information about language structure. Syntactic structure can be decoded from large-scale and local population codes that can be unearthed using a combination of univariate and multivariate techniques.

Topic Areas: Syntax, Language Production

Sources of participant and item variance in neural activity during reading: A preliminary presentation

Poster C52 [Poster PDF] [Poster Tour] Visit me at [Gather.Town] in the Wernicke room during Poster Session C.

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This project will investigate sources of variance across items and participants in the neural systems that support word and pseudoword reading. Ginger-ALE meta-analysis (Eickhoff et al., 2016) reveals consistent differences in the brain regions engaged by the contrasts [words > pseudowords] and [pseudowords > words] (Taylor, Rastle, & Davis, 2013; Gwilliams, Shapiro, Davis, & Taylor, in prep). However, the contributing fMRI/PET studies use standard statistical inference that only tests generalisation to the population of participants, ignoring between-item variance. A goal of the present study is to compare by-participants and by-items analyses of a new fMRI dataset (71 participants) of word and pseudoword reading (180 items). A second aim is to examine how brain activity and structure in these 71 participants relates to individual differences in reading and language. 71 adults read aloud 60 regular words, 60 irregular words, and 60 pseudowords, whilst neural activity was measured using sparse sampling fMRI. The results of a by-participants analysis of the fMRI data were largely consistent with those of the meta-analyses. The [word > pseudoword] contrast activated bilateral angular gyri, paracingulate cortex, left middle frontal gyrus, left middle temporal gyrus, and left anterior fusiform. The [pseudoword > word] contrast activated bilateral inferior frontal gyri, occipitotemporal and parietal cortices, although left-lateralisation of activity was stronger in the meta-analysis than in our data. We plan to compare these results to a by-items analysis, in which single event models will be constructed for each subject, yielding item-specific parameter estimates, to be averaged across subjects for the group analysis. The same participants also undertook resting state and diffusion tensor imaging scans and completed tests of word and pseudoword reading fluency, spelling, vocabulary, nonword repetition, spoonerisms (phoneme manipulation), rapid letter/number naming, and lexical decision with pseudohomophone and pseudomorpheme distractors. To determine the underlying sources of variance in participant performance, principal components will be extracted from the behavioural data. These will be covaried with neural activity during [word > pseudoword] and [pseudoword > word] reading to determine how recruitment of lexical and sublexical neural systems is modulated by language and reading skills. We will further examine whether individual differences in neural activity persist in the resting state scan and how they relate to white matter tract properties. Findings will reveal whether lexicality effects on neural activity are observed across all, or only a subset, of participants or items. Individual difference analyses will reveal the reasons for any observed variation across subjects, helping to resolve inconsistencies among previous studies in the literature. We seek to make this rich dataset publicly available and are keen to gain advice on optimal analysis approaches!

Topic Areas: Reading, Methods

Behavioral and neural responses to American Sign Language avatars

Poster C53 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session C.

Lorna Quandt[1], Athena Willis[1], Kaitlyn Weeks[1]; [1]Gallaudet University

This work in progress will assess behavioral and neural responses to different types of avatars communicating in American Sign Language (ASL). The project will analyze user ratings and EEG responses collected while deaf fluent ASL signers and hearing non-signers imitate signs produced by three different signers: a human, a computer-synthesized avatar, and a biological motion avatar. We created the biological motion signing avatar using motion capture of a native fluent deaf signer, resulting in movements that closely represent natural human signing. We aim to analyze how people respond to these biological motion avatars, in comparison to less-human computer-synthesized avatars, and compared to videos of live human signers. Our findings will be used to inform and develop interactive signed language technology, while addressing the role of embodied cognition in signed language communication. Our pre-registered hypotheses are that in both signing deaf and hearing non-signing groups, videos of human signers and signing avatars with biological motion will both elicit significantly better ratings of natural motion and acceptance than the synthesized motion avatar. From the planned EEG study, we predict significant differences in brain activity (e.g., sensorimotor EEG rhythms and attention) between groups in response to the synthesized motion signing avatar because the signing deaf group will be able to draw on their ASL experience to produce accurate action representations of the sign motions. For the EEG study, we will recruit 30 right-handed hearing non-signing adults and 30 native ASL signing deaf adults. Participants will be shown videos of ASL signs in three conditions in an imitative paradigm that separates sign observation, imagery, and production. In order to evaluate subjective responses to the different types of signing avatars, we are currently conducting a large online user rating study (planned N = 450) to gather ratings about the appearance, attitudes, and movements of the three different types of signers. We are surveying non-signers, signed language learners, and deaf native signed language users. The results from this study will be presented at the meeting and possible implications for the EEG study of signed language expertise and embodied cognition will be discussed. The behavioral results will also be used to inform the planned EEG study with the same set of stimuli. The goal of the research proposed here is to conduct the first neuroscience study of signing avatars to better understand how people respond to varying types of signing avatars.

Topic Areas: Signed Language and Gesture, Speech Motor Control

Feedback-based alterations of vowel formant production: an analysis of speech produced under delayed auditory feedback

Poster C54 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session C.

Matthias Heyne[1], Monique C Tardif[2], Vincent J Pennetti[2], Jason W Bohland[1]; [1]University Pittsburgh, [2]Boston University

Introduction: Delayed auditory feedback (DAF) causes disfluencies and prolonged, distorted sound productions (Yates, 1963). Modern speech production models include feedback controllers that can steer productions when auditory feedback differs from expectations. To date, little work has focused on how the acoustics of speech signals produced under DAF are related to concurrent feedback (but see Davis & Brajot, 2019). Here we asked if vowel formant production under DAF can be explained by feedback-based alterations driven by auditory input. Methods: Our preliminary dataset is from six speakers, each producing 100 sentences from the TIMIT database in two sessions. Sentences were presented orthographically and aurally; participants were asked to reproduce the auditory exemplar's timing under DAF (0, 150, 200, 250ms delays). Recordings were manually transcribed and segmented using the Montreal Forced Aligner. Vowel formants were estimated using Praat's Burg algorithm. Vowels <100ms or >700ms in duration, or with implausible formant estimates were eliminated. F1 and F2 values were then resampled using smoothing splines and transformed to Mels. We computed F1 and F2 differences between the feedback signal and simultaneous speech signal 25% into each vowel production, providing a measure of "auditory error." We then computed F1 and F2 differences between the produced formants 25% and 75% into the vowel, providing a measure of how production was altered throughout the vowel. We chose these times to minimize influences of coarticulation. Finally, we calculated cosine similarity scores between these two difference vectors, which summarize the direction of formant alterations relative to the early "auditory error." Positive values indicate that participants opposed (steered away from) the feedback, while negative values suggest they followed (steered toward) the feedback. Results: For stressed monophthongs, cosine similarity values were generally negative (mean across 698 tokens = -0.109). This value was a statistical outlier (p = 0.017) when compared to an empirical null distribution generated by randomly permuting (N=10,000) pairings of auditory error and production changes across trials. The negative cosine similarity suggests that speakers tended to steer their productions toward the feedback rather than opposing it. A linear mixed-effects model found no significant effect of delay (150-250ms) or vowel duration on cosine similarity. Within speakers, 2 of 6 participants showed a statistically significant, negative cosine similarity (range across speakers: -0.226 to +0.048). Similar patterns were not evident for unstressed monophthongs. Ongoing secondary analyses reveal considerable sensitivity to the choices of specific timepoints and intervals/lags used in the analysis. Conclusions: Results suggest some speakers steer productions under DAF toward sounds heard early within a vowel. This contrasts with model predictions and responses to spectral perturbations. Work based on speech with concurrent external inputs (Roon and Gafos, 2017), however, suggests how auditory inputs can alter output plans in a manner consistent with these results. We hypothesize DAF signals may be treated as external inputs due to temporal decoupling with the production system. While preliminary results are based on a small sample, our approach may help explain how auditory inputs affect speech output and how we segregate internal vs. external signals during speech.

Topic Areas: Speech Motor Control, Language Production

Motor planning of high-frequency and low-frequency non-speech gestures

Poster C55 [Poster PDF] Visit me at [Gather.Town] in the Wernicke room during Poster Session C.

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The relationship between speech and other types of oromotor behaviors is a matter of debate in the literature. Some authors propose a specialized motor control system for speech (Ziegler et al., 2003) whereas some others suggest a shared system for speech and other related motor tasks (Ballard et al., 2003). In a previous study, we have investigated whether the production of speech and non-speech sequences involve the same neurophysiological activities (Lancheros et al., 2020). Speech stimuli included words, composed of high frequency syllables, and pseudo-words, composed of low frequency syllables, which were carefully matched with sounded non-speech oral sequences. The ERP results suggested different dynamics of the same activated brain networks between non-speech and high frequency speech gestures, whereas infrequent speech gestures were found to be somehow intermediate between highly frequent speech stimuli and non-speech stimuli. Those results suggest that the same neural networks are differently involved in planning the speech motor codes for high versus low frequency syllables, which are closer to the planning of non-speech sequences. We therefore wonder whether the same difference observed for high frequency and low-frequency speech gestures (syllables) is also observed for overlearned versus less frequently produced non-speech sequences. In the present study, we aim to investigate the neural correlates of the motor planning of high and low frequency non-speech gestures using high density electroencephalographic (EEG) ERPs. We were able to carefully match, in terms of acoustic and somatosensory targets, high and low-frequency syllables to high- and low-frequency non-speech gestures. Speech and non-speech stimuli will be produced in a delayed production task, where speakers prepare an utterance, but produce it overtly only after a cue appearing after a short delay -Experiment 1-. This type of task allows targeting the “latest” stages of production processes, where the linguistic message is transformed into the corresponding articulated speech. Additionally, to avoid the preparation of the motor speech (and non-speech?) plans within the delay, in Experiment 2 the latter one will be filled with an articulatory suppression task in half of the participants (Laganaro & Alario, 2006). We are currently collecting the EEG data on 20 participants per experiment, which are expected be completed by the end of August. Results will be presented in October.

Topic Areas: Speech Motor Control, Language Production

A TMS investigation of left middle-MTG involvement in lemma access in speech production and comprehension

Poster C56 [Poster PDF] [Poster Tour] Visit me at [Gather.Town] in the Wernicke room during Poster Session C.

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According to a prominent account, lemmas are abstract word representations that act as central relay hub for accessing conceptual, phonological, and syntactic representations linked to a word (Levelt et al., 1999). They are crucial for both speaking, accessing phonological representations from conceptual input, and listening, accessing conceptual representations from phonological input. Since lemmas are at the core of any language process, and linked to differing representations, it is difficult to study them in isolation. Converging evidence points towards the mid portion of the left middle temporal gyrus (mMTG) as the likely candidate region underlying lemma access (Indefrey & Levelt, 2000, 2004; Indefrey 2011; Piai et al., 2014). Recently, Garg et al. (in preparation) designed an fMRI study to investigate this notion. The authors utilized two language production tasks and two language comprehension tasks. Overlapping activity among all four tasks was found in the left mMTG, providing further evidence for this region underlying modality-indifferent as well as representation-indifferent lemma access. In order to further investigate mMTG's involvement in lemma access across both language comprehension and production, we have designed a TMS experiment targeting the coordinates found in the Garg et al. (in prep) study, during both semantic classification of spoken words (comprehension) and picture naming (production). We are further interested in the specific time-windows in which the left mMTG is likely to carry out lemma access in each of these tasks. To this end, we have chosen three, post-stimulus onset, time windows each for the production and comprehension task during which to stimulate. These are based on temporal estimates from both word production (Indefrey & Levelt, 2000, 2004; Indefrey, 2011; Schuhmann et al., 2012) and word comprehension findings (Cibelli et al., 2015; Indefrey & Levelt, 2004). Since the temporal estimates for picture naming are more robust, we have chosen to disrupt activity in a 50 ms time-window as opposed to a 100 ms time-window for the semantic classification task. We will look at reaction time (RT) for the respective tasks across the different time windows. Any RT effects specific to stimulation in a certain time-window may hint at left mMTG's time-specific contribution in the respective task. To further control for any TMS peripheral effects that may influence RTs, a control condition utilizing pseudo items has also been included. Any effect difference between the active and control condition should therefore reflect cortical stimulation and not TMS peripheral effects. Our predictions vary by task. We expect to disrupt lemma access in picture naming by stimulating the left mMTG between 225-275 ms post-picture onset. For semantic classification, we predict that stimulating the left mMTG between 325-425 ms post-word onset will interfere with lemma access. We expect there to be a difference in RTs across the time windows for the real items but not for the pseudo items. Such a pattern would provide evidence of both the spatial and temporal aspects of lemma access.

Topic Areas: Speech Perception, Language Production

Overt exception word reading lateralization differences between left and right temporal lobe epilepsy: An fMRI activation and DTI structural connectivity comparison

Poster C57 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session C.

Josh Neudorf[1], Shaylyn Kress[1], Layla Gould[1], Katherine Gibb[1], Marla Mickleborough[1], Ron Borowsky[1]; [1]University of Saskatchewan

In cases of brain disease such as temporal lobe epilepsy (TLE), damage may lead to functional reorganization and a shift in language dominance to homologue regions in the other hemisphere. If the effects of TLE on language dominance are hemisphere focused, then brain regions and connections involved in word reading should be less left lateralized in left temporal lobe epilepsy (lTLE) than right temporal lobe epilepsy (rTLE) or healthy controls, and the opposite effect should be observed in rTLE patients. A group of 14 lTLE patients, 8 rTLE patients, and 14 healthy controls participated in an overt exception word (e.g., 'yacht') reading task in the fMRI, and a DTI scan. All preprocessing and statistical analyses for functional images were performed using FSL. For the laterality analysis, precise cortical reconstruction and volumetric segmentation was performed with the Freesurfer image analysis suite (http://surfer.nmr.mgh.harvard.edu/). The regions of interest (ROI) were pars opercularis and the fusiform gyrus. A novel t statistic laterality index (tLI) was calculated as a t test of the RH minus the LH ROI activation. For the group analysis, the group level contrasts were calculated comparing the

word reading activation between each group. For the DTI analysis, DSI Studio's (http://dsi-studio.labsolver.org/) deterministic tracking algorithm that uses quantitative anisotropy as the termination index was used to produce structural connectivity matrices of streamline count for the Brainnectome 246 region atlas. The network based statistic was used to find a DTI brain network component that was significantly different between lTLE and rTLE patients. Multivariate distance matrix regression was also performed on the DTI structural connectivity matrix to determine whether there were voxels that showed differing connectivity profiles between patient groups. In our study, functional magnetic resonance imaging (fMRI) showed that patients with rTLE had more strongly lateralized left hemisphere activation than lTLE patients and healthy controls in language related brain regions (pars opercularis and fusiform gyrus). Corresponding with this difference, diffusion tensor imaging (DTI) found differences in connectivity indicative of lTLE patients having greater tract integrity than rTLE patients in the right hemisphere uncinate fasciculus (UF), inferior longitudinal fasciculus (ILF), and inferior fronto-occipital fasciculus (IFOF) using the network based statistic analysis method. Both UF and IFOF tract integrity have previously been associated with lexical (whole-word) processing abilities. Multivariate distance matrix regression provided converging evidence for regions of the IFOF having different connectivity patterns between the lTLE and rTLE groups. This research demonstrates language lateralization differences between lTLE and rTLE patient groups, and corresponding differences in the connectivity strength of the ILF, IFOF, and UF. This research provides a novel approach to measuring lateralization of language in general, and the fMRI and DTI findings were integral for guiding the neurosurgeons performing the TLE resections. This approach should inform future studies of language lateralization, and language reorganization in patients such as those with TLE.

Topic Areas: Disorders: Developmental, Reading

Poster Session D

Co-lateralization of linguistic and arithmetic processing to the left hemisphere

Poster D1 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session D.

Presenter Note: I will be happy to answer any questions you have and hear your feedback in my personal Zoom room: Yev Diachek's Personal Meeting Room Join Zoom Meeting https://vanderbilt.zoom.us/j/9816374435 Meeting ID: 981 637 4435

Evgeniia Diachek[1], Idan Blank[2], Evelina Fedorenko[3]; [1]Vanderbilt Univerisity, [2]University of California at Los Angeles, [3]Massachusetts Institute of Technology

The relationship between language and numerical cognition—especially exact arithmetic—has been long debated and remains controversial. On the one hand, humans are the only species that can manipulate large exact quantities, and words—a human invention—have been hypothesized to play a critical role in the acquisition of exact numerical comprehence (e.g., Dehaene et al., 1999). Furthermore, arithmetic calculations have been shown to interfere with syntactic processing (Fedorenko et al., 2007) and even to prime linguistic syntactic structures (Scheepers et al., 2012). On the other hand, linguistic and arithmetic cognitive processes are robustly neurally dissociable. fMRI studies have shown that language comprehension draws on the highly specialized fronto-temporal language network (e.g., Fedorenko et al., 2011; Monti et al., 2012), whereas arithmetic calculation is supported by the domain-general fronto-parietal multiple demand (MD) network (e.g., Fedorenko et al., 2013; Amalric et al., 2019). Furthermore, individuals with even severe aphasia exhibit preserved arithmetic abilities (Varley et al., 2005), and individuals with deficits in numerical cognition (acalculia) typically show intact language processing (e.g., Henschen, 1925; Ardilla & Roselli, 2002). However, in spite of recruiting non-overlapping brain areas, both language and arithmetic draw more heavily on the left hemisphere (LH), as evidenced by both stronger responses in the LH observed in neuroimaging studies, and a higher likelihood of linguistic / numerical deficits following LH damage. Could some of the findings that have been taken as evidence of language and arithmetic drawing on the same neural resources arise from the overloading of the LH? Here we used fMRI (n=68) to test the co-lateralization of language and arithmetic within the same study, and to probe their relationship using robust individual-subject analyses (Nieto-Castanon & Fedorenko, 2012). Replicating prior studies, we found that language and arithmetic i) draw on non-overlapping brain regions, and ii) are both robustly lateralized to the LH (in contrast to a control, spatial working memory task, which shows lateralization to the RH). (We ruled out the possibility that arithmetic lateralization within the MD network is simply due to the use of verbal representations by showing that three verbal executive-function tasks (digit span, Stroop, and a verbal version of the multi-source interference task; Fedorenko et al., 2011) do not lateralize to the LH.) Critically, we found that the degree of language and math lateralization are stable within individuals across runs, and that the degree of language lateralization within the language network is reliably correlated with the degree of arithmetic lateralization within the MD network, as evidenced in both the strength (effect sizes) and extent (volume regions) of activation. These results extend a prior report of a correlation between linguistic and arithmetic lateralization (Pinel & Dehaene, 2007) and suggest that arithmetic processing is deeply linked to linguistic processing, plausibly due to the use of language in the acquisition of math during development.

Topic Areas: Control, Selection, and Executive Processes, Meaning: Lexical Semantics

Distinct contributions of working memory and attentional control to sentence comprehension in noise in individuals with left hemisphere stroke

Poster D2 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session D.

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Sentence comprehension deficits are common in aphasia following a left hemisphere stroke. Previous work indicates that cognitive impairments (attentional control, working memory) may contribute to these sentence comprehension impairments. Yet, research linking cognition and sentence comprehension deficits post-stroke has primarily focused on sentences presented in optimal listening conditions (silence) despite everyday conversations often occurring in noisy environments. The present study explored the relationship between cognition and sentence comprehension in noise in 20 persons with chronic left hemisphere stroke and 11 matched-control participants. Sentence comprehension was measured with a sentence-picture matching task of canonical and non-canonical sentences presented in three background listening conditions: (1) multi-speakers, (2) broadband noise, and (3) silence. Mean reaction times were analyzed, and reaction time difference scores were computed to isolate the effects of informational masking (multi-speakers minus broadband) and energetic masking (broadband minus silence). Attentional control was measured using the Stroop task (incongruent RT–neutral RT) and working memory with the WAIS-IV's Working Memory Index. A 2x2x3 repeated measures ANOVA was computed for mean RT in each group, syntactic structure, and listening condition. As expected, the stroke survivors were slower than the control group in all conditions and both groups responded faster to canonical than non-canonical sentences. There was no significant main effect of listening condition. The two-way syntax x listening condition interaction was significant. Within canonical sentences: sentences in silence were significantly faster than sentences in multi-speakers; broadband noise did not differ from those in silence or multi-speakers. Within the non-canonical sentences, no significant differences between levels of masker were observed. However, exploratory analyses reveal that these effects differ by group. To test the hypothesis that cognitive ability is associated with sentence comprehension in noise in persons with stroke, multiple linear regression models were computed. The dependent variables were mean RT in each listening condition and RT difference scores representing informational and energetic masking. All models included attentional control and working memory as independent variables, and age and hearing ability (pure tone average, 500-400Hz) as covariates. The models predicting mean RT in silence and the effect of energetic masking (broadband noise RT–silence RT) were not significant. The models predicting mean RT in broadband noise and multi-speakers were both significant: better working memory abilities predicted faster mean RTs for sentences in both broadband noise (F(4,19)=3.89, p=.023, β=.88, p=.002) and in multi-speaker background listening conditions (F(4,19)=3.15, p=.046, β=-.85, p=.004); attentional control and the covariates were not significant in those models. However, the model of the effect of informational masking (multi-speaker RT-broadband noise RT) revealed that better attentional control predicted better sentence comprehension (F(4,19)=3.26, p=.041; β=.69, p=.003); working memory and the covariates were not significant. These findings reaffirm working memory's role in sentence comprehension generally, but also provide support of a specialized role in stroke survivors for attentional control to support sentence comprehension in multi-speaker listening environments.

Topic Areas: Control, Selection, and Executive Processes, Disorders: Acquired

Sex Differences in Lexical-Semantic Access During the Letter Fluency Task

Poster D3 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session D.

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Females have been shown to develop language skills earlier and have better performance than males on a number of language tasks. Although not usually acknowledged in published norms, this includes a slight advantage in the letter fluency task, with females generating more responses than males. There is a lack of information, however, to explain this difference. Whereas the number of responses is the typical rubric for this task, examining underlying linguistic qualities of the responses may be instructive. This may include linguistic factors such as age of acquisition (e.g. the age at which one acquires a term or concept), which has been speculated to be an organizing determinant of the lexical-semantic system. In the current study, we tested the following hypotheses: 1) females would generate more words than males on the letter fluency; 2) females would generate responses whose words would reflect an earlier age of acquisition; and 3) responses will correlate with left hemisphere cortical thickness measures more strongly in females than males. Fifty-four female and male control subjects matched on sample size, age, and education completed three trials of a letter fluency task. The number of words generated was tallied, and established norms for word frequency and age of acquisition were applied to each response. Subjects also underwent an MRI scan. Cortical thickness measures involved in language including the precentral and fusiform gyri were derived using a standard Freesurfer pipeline. Female and male groups were compared on the number of words, age of acquisition, and cortical thickness measures in separate ANCOVAs. Correspondances were drawn between task metrics and cortical thickness measures for each group using Spearman correlations. Female subjects generated more words than males (p = 0.002) when age and education were accounted for. Females also generated words from an earlier age of acquisition compared to males after controlling for the number of responses and word frequency (p = 0.001). Precentral gyrus cortical thickness was greater in females than males (p = 0.006). Response age of acquisition was correlated for both groups to left hemisphere neuroanatomical areas known to be involved in language. Specifically, female responses were associated positively with left precentral and postcentral gyrus, insula, pars opercularis, inferior temporal, and superior frontal thickness (p-values <0.05). Although it did not survive FDR correction, men's responses had a negative correlation to the fusiform gyrus (p = 0.01). For females, the greater number of responses during the letter fluency task and the age of acquisition of responses reflects developmental differences in language relative to males. Correlations with task performance and cortical thickness measures provides evidence of a specialized network within the left hemisphere for women. For males, correlations with the fusiform gyrus indicate a differential method of accessing the lexical-semantic system which may capitalize on a visual strategy.

Topic Areas: Control, Selection, and Executive Processes, Phonology and Phonological Working Memory

Environmental effects on white matter development and phonological skill among multilingual kindergarteners

Poster D4 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session D.

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Existing research has linked the development of language-relevant white matter tracts (such as AF, ILF, SLF) to phonological and sound processing skills in early readers (Broce et al., 2018; Saygin et al., 2013; Travis et al., 2017). Notably, most of this research has focused on monolinguals, whose phonological environment is much more restricted and uniform than that of multilingual children. Here, we ask whether the relationship between phonological skill and white matter organization in multilingual children differs based on the richness/diversity of their lived linguistic environment. We predicted a positive relationship between white matter structural organization and phonological awareness. We also predicted that this relationship would be modulated by the child's individual language exposure, which we quantified using a novel phonological diversity index. We tested a unique sample of L1-English kindergarteners that had been exposed to multiple languages during their preschool years (N = 105, mean age = 5.73 years, SD = 0.37; between 1 and 5 languages, median = 2, SD = 1.00). We calculated a novel measure of diversity of language exposure, being a time-weighted score of phonological diversity integrating information on the length of exposure to each language with a pairwise phonological inventory distance between the languages. The distances were derived from URIEL database using lang2vec software (Littell et al., 2017) which represents distinct phonological systems as information-rich vectors based on binary features derived from the PHOIBLE database (Moran, McCloy, & Wright, 2019). The summed distances (calculated as the arccosine of the dot product of the normalized vectors) between all language pairs for each child were weighted by the length of exposure to each language following Rao's (1982) quadratic entropy equation. We performed white matter tract segmentation using a novel convolutional-neural-network-based approach and probabilistic tractography with TractSeg (Wasserthal et al., 2018), based on multi-shell constrained spherical deconvolution (Tournier et al., 2019). Mean diffusivity, kurtosis, fractional anisotropy and peak length were measured for the left and right AF, SLF, and ILF. We ran multiple regression analyses on the WM indices, phonological skill scores and phonological diversity index, controlling for age, gender, SES, and non-verbal intelligence. For all WM indices but the peak length values, and across all investigated tracts, we found a significant interaction between children's phonological skill scores and phonological diversity index ($p<0.001$, FDR-corrected). Children exposed to less diverse phonological environments showed a positive relationship between white matter metrics and phonological skill (similar to previously reported data on monolingual populations). In contrast, greater phonological diversity in the child's language environment was associated with lower white matter diffusivity/kurtosis measures in the language tracts. Our findings show that Phonological Skill and Phonological Environmental Diversity interact to shape the indices of WM in the major language tracts.
Broce et al., 2020, Brain and Cognition. Littell et al., 2017, Proc. European Chapter of Association for Computational Linguistics. Moran et al., PHOIBLE Online. Saygin et al., 2013, Journal of Neuroscience. Tournier et al., 2019, NeuroImage. Travis et al., 2017, Brain Structure and Function. Wasserthal et al., 2018, Proc. Joint Annual Meeting ISMRM-ESMRMB.

Topic Areas: Development, Multilingualism

Developmental trajectories of magnocellular and parvocellular pathways and their contribution to reading

Poster D5 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session D.

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Visual information is mainly carried by two pathways with distinct histological and physiological properties. The dorsal magnocellular stream is insensitive to color, has higher contrast sensitivity, and responds to low spatial and high temporal frequencies. It is thus highly sensitive to motion, and involved in detecting spatial

relationships and rapid changes. In contrast, the ventral parvocellular stream is color-sensitive, has lower contrast sensitivity, and responds to high spatial and low temporal frequencies. It is thus responsible for visual resolution and chromatic processing. Research evidence in regard to the developmental trajectories of these main visual pathways is still sparse and the available findings are mixed. Since the magnocellular pathway appears to be involved in text perception and reading, unveiling age-related changes in these pathways and their associations with reading and visual discrimination is critical to further understand typical and atypical reading development. In fact, both the magnocellular and the parvocellular pathways have been found to be involved in dyslexia, but their specific roles and how they contribute to typical and atypical reading is still unclear. The present study was aimed at characterizing the developmental trajectories of the magnocellular and parvocellular pathways, and their contribution to normal reading. A total of 70 children (8-14 years) and 37 adults (18-35 years) carried out three tasks: 1) visual recognition, 2) lexical decision, and 3) visual discrimination. For the visual recognition task, participants made natural/artificial judgments on object images and words that were either (i) magno-biased: low luminance contrast and achromatic; (ii) parvo-biased: isoluminant (red-green) and chromatically defined; or (iii) neutral: not sensitive to low luminance contrasts and achromatic. To test participants' reading abilities we used a lexical decision task, where participants had to classify as words or non-words consonant strings, pseudowords and real words. Finally, we also tested visual discrimination by means of a letter-identification task with manipulation of the i) overlap-separation of the target letter with other distractors, and ii) the color differentiation of the target letter relative to distractors. Results revealed an Age X Visual Pathway interaction in the visual recognition task that was due to lower accuracy and longer response times to magnocellular versus parvocellular stimuli in children and early adolescents. These effects were not observed in adults. On the other hand, only adults exhibited positive correlations between i) the response latencies of magnocellular and parvocellular visual recognition and the response latencies to words and consonant strings in the lexical decision; and ii) the response latencies of parvocellular, but not magnocellular, visual recognition and the response latencies to pseudowords in the lexical decision task. Further, also only in adults, visual recognition of magnocellular stimuli was positively associated with visual discrimination abilities for the easier conditions for letter identification. In sum, our findings suggest that the magnocellular pathway has a more protracted maturation from childhood to adulthood compared to the parvocellular pathway. Importantly, performance associated with magnocellular and parvocellular visual recognition streams does not seem to explain part of the reading abilities and visual discrimination variance until adulthood.

Topic Areas: Development, Reading

A developmental investigation of the language-selective brain network

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Previous research has established that a set of frontal, temporal, and parietal areas: a) support lexico-semantic and syntactic processes in language comprehension and production (Fedorenko et al., 2020), b) are selective for language over diverse non-linguistic cognitive tasks, and c) are robustly separable from other brain networks (e.g., Fedorenko et al., 2011; Blank et al., 2014). However, the developmental trajectory of this language network remains poorly understood. Although a number of prior studies have examined language processing in children, most relied on traditional group-averaging analyses, which may complicate interpretation of both similarities and differences between the groups. Here, we investigated the language network in 38 children (mean age=8.96, SD=0.77) and 91 adults (mean age=27.96, SD=5.42) using individual-subjects analyses in fMRI. In a well-validated functional localizer task (Fedorenko et al., 2010; Scott et al., 2017), participants passively listened to clips of Alice in Wonderland, and two control conditions: acoustically degraded and therefore indecipherable versions of the passages, and passages in an unfamiliar language. For each participant, functional regions of interest (fROIs) were defined based on the intact>degraded contrast using a set of a priori masks derived from a large independent sample. Within each mask, we selected the top 10% of most responsive voxels based on half of the data, and then examined the responses of these individually-defined fROIs to the three conditions using the other half of the data. Based on preliminary analyses, three findings have emerged: 1) similar to adults, children demonstrated stronger responses to the comprehensible language condition than the control conditions in each language region, suggesting that at least by age 8, the topography of the language network looks similar to its adult state; 2) the response magnitude to comprehensible language was similar in adults and children in posterior temporal areas, but it was significantly reduced in children relative to adults in the frontal areas, in line with slower maturation of the frontal cortex (Fuster, 2002); and 3) as in adults, comprehensible language elicited deactivation in the regions of the domain-general multiple demand network (Duncan, 2013) that responds robustly to diverse cognitively demanding tasks and 'tracks' cognitive effort, suggesting that auditory language comprehension in one's native language does not draw on executive resources even in children (cf. L2 language processing; Pliatsikas and Luk, 2016). In summary, in line with prior work (e.g., Friederici et al., 2011), we show that the language network in children looks adult-like in topography (at least by age=8), although frontal language areas respond less strongly to linguistic input. Future work should try to relate the strength of frontal responses to linguistic ability and examine language processing in younger children. On the methodological side, this work establishes that functional localization is effective for identifying language-selective areas in children, and will likely confer the same benefits as it has in research on adult language processing (Nieto-Castanon & Fedorenko, 2012).

Topic Areas: Development, Meaning: Discourse and Pragmatics

What does GIMME tell us about brain literacy networks? Mapping neural connectivity patterns in linguistically diverse children

Poster D7 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session D.

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There are substantial individual differences in how children learn to read and form neural networks of literacy. Two important individual difference factors are literacy proficiency and language experiences. Beginning readers rely more on phonological skills to read, whereas more proficient readers tend to use more meaning-based skills, such as morphological awareness. Moreover, differences in language experiences are also thought to be a potential source in this variation. English as an alphabetic language prompts children to form stronger sound-to-print associations. Yet, children with Chinese exposure may form a stronger meaning-to-print association. Here we explore how literacy proficiency and bilingual experiences may influence children's individual variation in learning to read. Here, using the Group Iterative Multiple Model Estimation (GIMME) approach, we aim to identify the functional neural networks of children when they perform a morphological awareness task during functional Near-Infrared Spectroscopy (fNIRS) neuroimaging. Morphological awareness is the ability to manipulate the smallest units of meaning and supports recognition of word meanings. We hypothesized that children's bilingual experiences and their language proficiency underlie individual variation in the emerging neural organization for morphological awareness. Bilingual Chinese-English and monolingual English children (N = 130, MAge = 7.77) completed standard literacy measures and a lexical morphology task that asked children to listen to three words and identify two that matched in meaning (e.g., bedroom, classroom, mushroom). Across groups, the fNIRS task elicited robust activations in left IFG, left MTG, and bilateral STG. Using the GIMME, we further explored variations in children's emerging functional neural networks for morphological awareness by identifying person-specific, sub-group, and group level neural networks among seven predetermined brain regions of interests (ROIs). Group-level GIMME revealed common interconnections of channels within each ROI. GIMME identified two sub-groups, and each had connections in addition to the common within-region links. Sub-group 1 had four inter-region connections (between IFG, STG, and MTG), whereas sub-group 2 had only two inter-region connections (STG-IFG). The group that had more connections had better phonological awareness ability ($p = .025$) but was comparable on all other tasks as well as the bilingualism status to the other group. The findings are intriguing as they suggest a robust role of phonological processing in children's neural networks for segmenting words into lexical constituents, in both bilingual and monolingual children. The findings support literacy perspectives suggesting that children's joint morpho-phonological processes are universally at the core of learning to read across orthographies. Taken together, the findings shed light on mechanisms of individual variability in learning to read by highlighting the critical role of morpho-phonological processing in children's emerging neural architecture for literacy.

Topic Areas: Development, Multilingualism

Listen to your Mother: A randomized clinical trial of maternal speech exposure on structural brain connectivity in preterm newborns

Poster D8 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session D.

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Background: Behavioral research in infants has demonstrated the importance of speech input for language learning. Studies have yet to establish how speech exposure during infancy contributes to the maturation of brain structures relevant to speech. This study used a randomized controlled trial to determine if enhanced speech exposure changes structural brain connectivity in preterm (PT) newborns. Methods: Participants (N=44) were PT newborns (24-31 weeks gestational age (GA) at birth), recruited when they were medically stable. Exclusion criteria included complications of PT birth known to affect brain structure (e.g., cystic periventricular leukomalacia, hydrocephalous). Newborns were randomly assigned to treatment (T: n=21) or standard of care (C: n=23) groups. The treatment was enhanced maternal speech exposure, accomplished by playing audio recordings of each baby's own mother reading a children's book via an iPod placed in their crib/incubator for 2.67 hours/day (2x10mins/hour between 10pm-6am). Infants in the C group had the iPod set-up, but were not played recordings. Families and medical staff were blinded to treatment. High-angular resolution diffusion MRI scans were collected as part of routine MRI imaging at near term equivalent age. Treatment effects on structural connectivity were assessed using mean diffusivity (MD) as the pre-registered primary outcome metric (NCT02847689) from frontal and posterior regions of the corpus callosum (CC). Results: The T and C groups were matched on all medical, demographic, and experimental variables. Newborns in the T group had significantly lower MD in the superior frontal CC compared to the C group ($F(1,22)=6.054$, $p=0.02$) . The group difference remained after controlling for GA ($F(1,21)=6.09$, $p=0.02$). Group status (T vs C) contributed significant unique variance above GA, doubling the amount of variance accounted in the model (Total R2=37%). Conclusions: Findings demonstrate that increased exposure to maternal speech causes changes in structural brain connectivity at near term equivalent ages. Lower MD in the T group implies greater white matter maturation. These findings have important implications for understanding the neural bases of brain and of language development. The present findings also suggest that providing increased speech exposure as part of clinical care may be beneficial to pediatric populations that have limited exposure to maternal speech.

Topic Areas: Development, Language Therapy

Transcranial direct current stimulation with standard outpatient aphasia therapy: Receptiveness and efficacy

Poster D9 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session D.

Presenter Note: To request a copy of this poster or the published article, please email E. Susan Duncan at duncan1@lsu.edu.

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Introduction: As a safe, portable, and relatively inexpensive form of noninvasive brain stimulation that potentiates concurrent neural activity (Bikson and Rahman, 2013), transcranial direct current stimulation (tDCS) offers particular promise for augmenting effects of aphasia therapy. However, several methodological issues in existing studies may distance tDCS from potential clinical translation. For one, it remains unclear whether the general population of individuals with aphasia would be receptive to brain stimulation, as those volunteering for clinical trials might be more open to experimental treatments than those seeking standard speech-language therapy alone. Another issue is that studies pairing tDCS with aphasia therapy typically employ a more intensive schedule (five sessions weekly) than usual outpatient treatment (two sessions weekly). Therefore, in this study, we offered (and administered) tDCS to individuals seeking standard aphasia therapy at an outpatient clinic. Methods: We approached clients (n=10) planning to receive standard speech-language therapy for aphasia at a university clinic. Following a brief aphasia-friendly description of tDCS, we offered to provide stimulation during their therapy. With those who expressed interest and did not have contraindications, we conducted a double-blind, sham-controlled crossover study of tDCS paired with speech-language therapy provided twice weekly. Four participants with chronic aphasia completed two eight-week therapy phases (separated by a ten-week washout period) during which they received active or sham tDCS. The anode was placed over Broca's area (identified as the crossing point between T3-Fz and F7-Cz per the EEG 10-20 system) with the cathode on the contralateral forehead (Fp2). Stimulation (2 mA) was provided for the first 20 minutes of each one-hour session (30 seconds for sham). Therapy was provided by clinicians uninvolved in the study, with treatment goals and techniques selected on an individual basis given consideration of client needs and preferences. Before and after each phase, participants were video recorded telling the Cinderella narrative. Recordings were transcribed and analyzed to calculate correct information units (CIUs; Nicholas and Brookshire, 1993). Treatment, tDCS operation, and data analysis were all performed blind to tDCS condition. Results: Of the ten individuals approached, seven (70%) were interested in and eligible for tDCS and consented to participate in the study. Two individuals (20%) were interested in participating but ineligible due to medical exclusion criteria. One individual (10%) was not interested, expressing concern about potential safety issues. Of the seven individuals who participated, three were excluded due to therapy discontinuation (unrelated to research) or investigator error (technical issues and data loss). The four participants who completed both stimulation intervals opted to receive tDCS in nearly all (97.7%) therapy sessions. Statistical analysis indicated effective blinding (i.e., accuracy not significantly different than chance; $p = 0.69$). Cohen's d for CIU production corresponded to a large effect size ($d = 1.32$) favoring active over sham tDCS. The participant with the most severe deficits did not benefit from therapy in either condition. Conclusions: Findings suggest receptiveness and efficacy for tDCS provided in standard clinical practice. Further investigation is needed for replication and to determine individual characteristics predictive of treatment response.

Topic Areas: Disorders: Acquired, Language Therapy

Perfusion levels in the left hemisphere are associated with language outcomes in chronic post-stroke aphasia

Poster D10 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session D.

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Stroke typically alters blood flow to the brain resulting in tissue loss that is clearly visible on structural MRI scans. However, the disruption of cerebral blood flow (perfusion) can also be observed in surrounding tissue as well as distal areas where blood flow is indirectly altered (Boukrina et al., 2019; Robson et al., 2017). Functional compensation following stroke has been attributed to non-damaged tissue (Saur et al., 2006; Thompson et al., 2017). However, structurally preserved but suboptimally perfused regions may contribute less to recovery; thus, the relationship between perfusion and cognitive functioning needs to be systematically established, especially in the context of language. In the current study, we aimed to determine how perfusion in specific cortical areas and perilesional tissue would be related to language outcomes in chronic aphasia. We analyzed Pseudo-Continuous Arterial Spin Label Imaging in 31 chronic left hemisphere stroke patients (at least 3 months post-onset, age range 43 - 84) who showed clinical symptoms of language impairment as evaluated by the Western Aphasia Battery (WAB). The perfusion-weighted time series were used to obtain cerebral blood flow maps for each of the participants. We then used anatomically-defined ROIs based on the Harvard-Oxford atlas in FSL that covered different regions of the perisylvian cortex in the left hemisphere: inferior frontal gyrus (IFG), posterior temporal, anterior temporal, temporal pole, temporal-occipital region, inferior parietal, along with several control regions, that have not been implicated in language processing. We then parceled out the lesioned area from each atlas-based ROI in subject space and calculated mean perfusion values for each participant. We also looked at three bands of perilesional tissue: 0 – 5 mm around the lesion, 5 – 10 mm and 10 – 15 mm. Finally, partial correlations controlling for lesion volume and base-level perfusion of the occipital pole (another control area) were used to investigate the relationship between perfusion and language subtest scores on the WAB. We found that perfusion in the left temporal lobe (and most strongly in the posterior part of both superior and middle temporal gyri) was significantly related to all the subtest scores evaluated in the current study. In contrast, perfusion in the IFG or the inferior parietal region did not show such a relationship. Perfusion levels in language-unrelated (control) areas within the ipsilesional hemisphere also were not related to language outcomes. In the perilesional analysis, only perfusion in the band of 0 – 5 mm was related to fluency. However, the null results should be interpreted cautiously at this point and require further replication to eliminate the possibility of a type II error. Overall, the current results underscore the critical and general role that left hemisphere temporal regions play in various expressive and receptive language abilities. The findings highlight that slowed or reduced blood distribution can impact the functionality of regions beyond the lesion site and, in turn, have a direct impact on behavioral outcomes. Thus, hypoperfused neural tissue in critical language areas may not be fully able to support recovery, as previously suggested.

Topic Areas: Disorders: Acquired, Language Production

Adjective use by individuals with agrammatic primary progressive aphasia

Poster D11 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session D.

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Adjectives (e.g., hungry) are an important part of language, but have been almost entirely ignored in the study of individuals with impaired language. Adjectives are used in two different ways in English: attributively, to modify a noun (the hungry dog); or predicatively, after a verb (the dog is hungry). Attributive adjectives are posited to have a more complex grammatical structure than predicative adjectives, and may therefore be particularly prone to disruption in individuals with grammatical impairments (Meltzer-Asscher and Thompson, 2014). We investigated adjective use in individuals diagnosed with the agrammatic subtype of primary progressive aphasia (PPA-G; n=41; mean age: 65.7 years; mean time since disease onset: 4.1 years) and a comparable group of healthy control participants (n=24; mean age: 62.4 years). Participants were given a picture book showing the story of Cinderella, and were then asked to retell the story in their own words. Their narratives were recorded and transcribed and every adjective they produced was coded for whether it was used attributively or predicatively. For each participant, we calculated the rate of attributive adjectives per sentence and the rate of predicative adjectives per sentence. Compared to healthy controls, the PPA-G group had significantly fewer attributive adjectives per sentence (PPA-G: 0.29, Control: 0.44, p=.03), but did not produce significantly fewer predicative adjectives per sentence (PPA-G: 0.14, Control: 0.18, p=.42). In addition, we found a significant correlation in the PPA-G participants between impaired production of sentences with complex syntactic structure (subject cleft sentences like It was the boy that chased the girl; measured using the Northwestern Anagram Test – NAT; Thompson, Weintraub, & Mesulam, 2012) and the production of attributive (p=.02) but not predicative (p=.60) adjectives, where a greater syntactic impairment corresonded to fewer attributive adjectives. These results suggest that attributive adjectives present a particular challenge for individuals with agrammatic language production, and add a new dimension to the description of agrammatism.

Our results further suggest that attributive adjectives may be a fruitful target for improved treatment and recovery of agrammatic language.

Topic Areas: Disorders: Acquired, Syntax

Quantifying Flexibility in Thought: The Resiliency of Semantic Networks Differs Across the Lifespan

Poster D12 [Poster PDF] [Poster Tour] Visit me at [Gather.Town] in the Broca room during Poster Session D.

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Introduction: Previous studies have found that older adults show greater reserve of semantic knowledge, but that their retrieval abilities decline with age (Hoffman, 2018). Recent advances in quantitative methods based on network science have enabled investigating the effect of aging on semantic memory structure (Dubossarsky, et al., 2017; Wulff et al., 2019). However, it is yet to be determined how this aging effect on semantic memory structure relates to decline in flexibility of behavior in relation to aging. Recently, the application of percolation theory in conjunction with network science has been proposed as an objective measure to quantify flexible thinking. Percolation analysis provides a quantitative measure of the flexibility and robustness of a semantic network, by examining how a semantic memory network is resistant to "attacks", or breaking apart (Kenett et al., 2018). We incorporate percolation analyses to examine how semantic networks of younger and older adults breaks apart to investigate potential age-related differences in flexible thinking of older and younger individuals. Percolation analyses measure the robustness of complex networks under targeted or random attacks, specifically by analyzing the effect of removing nodes or links between nodes whose strength falls below an increasing threshold (Borge-Holthoefer, et al., 2011; Farkas, et al., 2007; Kenett et al., 2014, Kenett et al., 2018; Palla, et al., 2005). Methods: We applied this analysis to 3 independent sets of data (total N=78 younger, 78 older adults) from which we generated semantic networks based on verbal fluency performance. We then applied a percolation analysis on these semantic networks. Participants were healthy English monolingual adults (mean age(SD) younger groups: 24.6 (5.3), older groups: 67.18 (5.41)). We examined the percolation integral, which measures how fast the network breaks apart into separate modules. A network that breaks apart quickly (at lower thresholds) will have a smaller integral value and a steep percolation slope, while a network that breaks apart slowly will have a higher percolation integral, and therefore a flatter slope. Results: Across all 3 data sets, the percolation integrals of the younger adults were larger than older adults, indicating that older adults' semantic networks are less robust. In the first dataset, the average percolation integral of the younger adults ($M = 43.61$) was significantly larger than that of the older adults ($M = 41.82$, $t(998) = 27.5$, $p < .001$). In the second dataset, the average percolation integral of the younger adults ($M = 35.1$) was significantly larger than that of the older adults ($M = 33.95$, $t(998) = 18.70$, $p < .001$). In the third dataset, the average percolation integral of the younger adults ($M = 28.88$) was significantly larger than that of the older adults ($M = 28.29$, $t(998) = 9.07$, $p < .001$). Conclusion: Across 3 datasets, the semantic network of the older adults' broke down faster than that of the younger adults'. Our findings provide quantitative evidence for diminished flexibility in older adults', despite the stability of semantic memory across the lifespan. This may be one contributing factor to age-related differences in language production.

Topic Areas: Language Production, Meaning: Lexical Semantics

Improved speech after aphasia treatment is associated with increased microstructural integrity in the language-related brain cortex.

Poster D13 [Poster PDF] Visit me at [Gather.Town] in the Broca room during Poster Session D.

Janina Wilmskoetter[1], Allen Chang[1], Julius Fridriksson[2], Emilie McKinnon[1], Lorelei Phillip Johnson[2], Alexandra Basilakos[2], Jens Jensen[1], Chris Rorden[2], Leonardo Bonilha[1]; [1]Medical University of South Carolina, [2]University of South Carolina

Introduction: Recovery from aphasia in the chronic stroke remains unpredictable, and its mechanisms are largely unknown. In this study, we investigated the hypothesis that language recovery is associated with structural brain changes. More specifically, in a sample of individuals with chronic aphasia, we evaluated whether treatment-induced improvement in naming is associated with renormalization of tissue microstructure within the residual language cortex. Methods: Data analyzed in this study was obtained from a subset of participants who completed a Phase II clinical trial to evaluate the futility of transcranial direct current stimulation (tDCS) in aphasia treatment. All participants had a history of single-event left-hemisphere ischemic stroke that resulted in aphasia (Aphasia Quotient of the Western Aphasia Battery (Revised) (WAB-AQ) was < 93.8). The subset of participants whose data were analyzed here include 33 individuals (10 Females; mean age of 58 years, standard deviation of 12 years), all of whom were at least six months post-stroke, right-handed, native English speaking, and without a history of any other neurological disease affecting the brain. Participants completed a three-week-long treatment involving a computerized receptive naming test and were randomized to receive either concurrent anodal tDCS or sham tDCS. To evaluate the relationship between language treatment response and cortical changes, participants were assessed with the Philadelphia Naming Test and underwent diffusion MRI sequences optimized for the assessment of complex microstructure (diffusional kurtosis imaging) before and one week after treatment. We employed elastic net statistical models to identify optimal predictors for treatment-induced changes in naming from candidate predictors that included baseline mean kurtosis (MK) of 30 left and right hemisphere cortical regions, MK change from before to after treatment from those 30 regions, age, sex, education, time since the stroke, lesion volume, WAB-AQ, and baseline anomia severity (correct responses on the PNT at baseline). Results: For all 175 items in the PNT, participants produced on average 50.4 (28.8%) correct responses before and 53.4 (30.5%) correct responses after treatment. Out of the 33 participants, 20 made more correct naming responses from before to after treatment, 11 participants made fewer correct responses, and 2 showed no change in the number of correct responses. The elastic net model computed for the dependent variable change in correct naming had an R-square value of 0.616. The selected predictors in the model were: baseline mean kurtosis in the left postcentral gyrus, left supramarginal gyrus and left angular gyrus, change in mean kurtosis in the left posterior superior temporal gyrus, whether participants received concurrent A-tDCS, years of education, and baseline anomia severity. Conclusions: We observed that improved naming accuracy (Philadelphia Naming Test) was statistically associated with increased post-treatment microstructural integrity in the left posterior superior temporal gyrus. This longitudinal relationship between brain tissue integrity and language improvement was not observed in other non-language related brain regions. Our findings provide evidence that structural brain changes in preserved left hemisphere regions are associated with treatment-induced language recovery in aphasia and are part of the mechanisms supporting language and brain injury recovery.

Topic Areas: Language Production, Disorders: Acquired

Distributed Frontal Cortex Activity Encodes Task-specific Word Retrieval

Poster D14 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session D.

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Speech production critically depends on frontal cortex activity to retrieve, plan, and execute speech utterances, but the timing and extent of cortical activation across different task demands, modalities, and the nature of the neural representations remain unknown. To investigate this, we employed a battery of five functional language tasks which prompt the subject to produce the same word through varying word retrieval routes: word reading, picture naming, auditory naming, auditory word repetition, and auditory sentence completion. We obtained direct cortical ECoG recordings in a cohort of 27 neurosurgical patients undergoing treatment for refractory epilepsy. Neuronal activity from both regular and high-density arrays was collected and epoched locked to stimulus or speech onset. We focused on high gamma (70 ~ 150 Hz) spectral responses shown to correlate with the spiking rate of underlying neuronal populations. We employed analyses based on specific regions of interest, unsupervised clustering of the data as well as Representational Similarity Analysis in order to investigate which areas are recruited and when in time stimulus identity is encoded. Based on anatomy, robust activity was evident in STG locked to perception for the three auditory tasks as well as pre- and post- central gyri activation locked to production. We found a pre-articulatory response profile in the posterior IFG (pars opercularis), with significant activity prior to speech onset for all five production tasks. Portions of the anterior IFG (including pars triangularis) showed early activity locked to stimulus onset which was selective to one task or a subset of tasks. A similar profile of task-selective pre-articulatory responses was seen in the posterior MFG adjacent to precentral gyrus locked to both stimulus and speech onset. These data suggest two speech production components in IFG and MFG, a motor-related component shared across tasks, and a task-selective component reflecting task demands and stimulus perception. While IFG and MFG activity was significant prior to speech it varied greatly across tasks. In order to test if a more distributed representation, rather than specific anatomical regions, encode retrieval we applied non-negative matrix factorization, an unsupervised clustering technique. This technique revealed a pre-articulatory cluster distributed across frontal cortex. Unlike IFG and MFG alone, the distributed activity of the frontal cluster showed significant activity prior to speech similarly across all five tasks. We employed an RSA analysis in order to probe the nature of this distributed neural activity over time. The dissimilarity matrix of the frontal cluster was most correlated ($p<0.05$, permutation test) with word identity models prior to speech onset and with semantic models (word embedding vectors) locked to and during speech. These models outperformed correlations with word frequency, number of syllables, and phonotactic models. Our results suggest that frontal cortex represents stimulus identity during retrieval in a distributed manner across frontal regions prior to and throughout speech production.

Topic Areas: Language Production, Perception: Speech Perception and Audiovisual Integration

Effects of tDCS over the Left Angular Gyrus on Verbal Episodic Memory in Amnestic MCI and Logopenic Variant Primary Progressive Aphasia

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Introduction: The neural substrate of verbal episodic memory (vEM)(and subsequent semantic integration) has been shown to be the left angular gyrus (L_AG). Verbal episodic memory comprises the processes of verbal learning and retention. Recent studies suggest that verbal learning and retention are impaired in individuals with amnestic mild cognitive impairment (aMCI), while only retention is impaired in individuals with logopenic variant of primary progressive aphasia (lvPPA). In the present study, we asked whether transcranial direct current stimulation (tDCS) over the L_AG in conjunction with targeted language intervention on vEM will improve verbal learning and retention in aMCI and lvPPA. Methods: In this double-blinded study, participants were randomly assigned to tDCS or sham condition in Period 1. During tDCS condition, participants received tDCS over the L_AG for 20 minutes coupled with language intervention; sham involved only language intervention. Periods were separated by 2 months. Language intervention comprised a word list learning intervention (WordLLI) modeled after Rey Auditory Verbal Learning Test (RAVLT) where participants learned a list of 12 words, 1 list with semantically related words (e.g., sports) and 1 list with unrelated words. Evaluations before and immediately after intervention included the trained lists and 2 matched untrained lists. Primary outcomes were the changes in the sums of words correctly recalled immediately after the first 5 trials (verbal learning measure) and their delayed recall after 20 min (retention measure). Structural T1 MRI scans were obtained at baseline and volumetric measurements were calculated via ROI analyses using MRIcloud. Results: Verbal learning significantly improved for the patient with aMCI in semantically related word lists in tDCS more than sham condition (chi-square(1) = 7.9, p = .005), while it numerically improved for the patient with lvPPA.

The patient with aMCI also generalized verbal learning improvements to untrained word lists. Retention improved only for the patient with lvPPA in both semantically related and unrelated word lists in tDCS condition only (performance was maintained at a higher level in semantically related lists with tDCS yet decreased significantly with sham: chi-square(1) = 5, p = .025, and improved significantly in semantically unrelated lists with tDCS only: chi-square(1) = 5.7, p = .017). The patient with lvPPA also generalized retention improvements to untrained word lists. Discussion: The present study provides initial evidence of tDCS-related improvement in verbal learning in aMCI and retention in lvPPA. Improved verbal learning of semantically related words, even in the untrained list, in the patient with aMCI shows that tDCS over the L_AG may modulate verbal learning, one of the components of verbal episodic memory, thus mitigating a primary deficit in amnestic neurodegenerative disorders. Improved retention and generalization in the untrained list in the patient with lvPPA shows that tDCS over the L_AG may also modulate retention of verbal information, the second component of verbal episodic memory, thus mitigating a major deficit in lvPPA, a neurodegenerative language disorder. Improvements in semantically related lists, in particular, in both patients confirm the principal role of the L_AG in semantic processing and, specifically, in integration of semantic information.

Topic Areas: Language Therapy, Disorders: Acquired

The Cat in the Cingulate: Source-domain differentiation of implicit metric and phrase processing in children's poetry

Poster D16 [Poster PDF] [Poster Tour] Visit me at Gather.Town in the Broca room during Poster Session D.

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INTRODUCTION: Phrase boundaries in language and music elicit a late positive deflection in event-related potential (ERP) waveforms (closure positive shift; CPS), generated in cingulate and medial temporal cortices (Knösche et al., 2005). In contrast, metric stress elicits a frontocentral late metric negativity (LMN; e.g., Fitzroy et al., 2015), the generators of which are unknown. To determine the generators of the LMN and assess its separability from the CPS, we investigated source-domain ERP correlates of implicit phrase boundary and metric strength processing during the perception of aprosodic synthesizations of The Cat in the Hat (CITH; Seuss, 1957), a poetic children's book containing strong, clear phrasal and metric structure. METHODS: Twenty-seven adults listened to two CITH synthesizations (canonically and randomly ordered) while 64-channel electroencephalogram (EEG) was recorded. Syllables were presented isochronously (425 ms inter-onset intervals), with flat intensity and pitch contours. CITH syllables form six-beat metric groups, with beat 1 having highest strength, beat 4 having intermediate strength, and beats 2-3-5-6 having low strength. Phrase boundaries are most likely on beat 4 (69%), second most likely on beat 1 (17%), and uniformly unlikely on beats 2-3-5-6 (~3.5%). ERPs were averaged by synthesization (canonical, random) and beat, then source-localized using sLORETA with unconstrained dipole orientations. Whole-brain cluster analyses revealed clear effects of beat in cingulate and temporal cortices for the canonical synthesization. Source-domain activations within anatomical regions of interest (ROIs) were extracted from the vertically-oriented dipole along the cingulate cortex, and from the horizontally-oriented dipole within and near the Sylvian fissure. Sylvian ROIs were subtracted across hemisphere to capture apparent asymmetries. Within-ROI source activations were measured 330-475 ms following syllable n for LMN effects and syllable n+1 for CPS effects. Source activations were analyzed using mixed-effects models for cingulate and Sylvian regions with fixed effects synthesization and beat (separately contrasting 1-2-4-5 against the mean of 3 and 6), and participant as a random effect; cingulate models also included linearly-coded anteriority and hemisphere as fixed effects. RESULTS: A CPS was evident 455-600 ms after beats 1 and 4 offset (i.e., 330-475 ms after beats 2 and 5 onset) in cingulate cortex. The beat 4 CPS was evident over the entire cingulate; the beat 1 CPS was smaller and restricted to anterior cingulate. An LMN was evident 330-475 ms after beats 1 and 4 onset in regions near the Sylvian fissure, and largest within it. The beat 1 LMN was larger than the beat 4 LMN within the Sylvian fissure. The CPS was not evident in Sylvian ROIs, and the LMN was not evident in cingulate ROIs. The CPS and LMN effects were also observed at the scalp with typical topography. CONCLUSIONS: The CPS and LMN responses are differentiable indices of phrase and meter processing, respectively, reflecting differentiability of these cognitive mechanisms during poetic speech processing. The CPS is partially generated by cingulate cortex, whereas the LMN is partially generated by temporal cortex within the Sylvian fissure. CPS/LMN generators are more active for higher likelihood/strength of eliciting stimuli, suggesting a graded response within these regions.

Topic Areas: Prosody, Speech Perception

Individual differences in categorical perception of intonation contrasts predict reading comprehension skills: A behavioral and mismatch negativity (MMN) study.

Poster D17 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session D.

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Over the past 15 years, converging evidence strongly suggests that sensitivity to prosodic cues contributes to reading acquisition during early childhood. The present study used a combination of event-related potentials (ERPs) and standardized behavioral measures to explore the time-dynamic processes of attending to prosodic cues in adult readers as well as the contribution of prosody sensitivity to individual differences in adult reading comprehension skills. In a passive oddball paradigm, mismatch negativity (MMN) responses to within- or between-category deviants with a phonemic (/p/ to /b/) or prosodic (statement to question) change were recorded in 23 native English speakers. To account for perceptual variability between the participants, stimuli were tailored to their individual point of subjective equality (PSE). To that end, participants first performed two-alternative forced choice (2AFC) tasks focusing on either the phonemic or prosodic aspect of stimuli varying on a 21-step pitch contour by 21-step voice-onset-time (VOT) continuum. Within-category and between-category deviants were located at -15% and +15% from PSE, respectively. Participants were also administered standardized behavioral measures of non-verbal IQ, vocabulary knowledge and silent reading comprehension skills. Significant centro-frontal MMNs were found for all four types of deviant stimuli. MMNs were larger for between-category than within-category deviants, both for phonemic and prosodic contrasts. Within- and between-category phonemic deviants also elicited early positive components. In addition, a statistically significant relationship was found between prosody categorization performance and reading comprehension scores, even after controlling for non-verbal IQ, phonemic awareness, and vocabulary. The present findings show that variability in reading comprehension skills relates to how categorically listeners perceive intonation contrasts, and more generally suggests that the relationship between prosody sensitivity and reading skills continue in adulthood.

Topic Areas: Prosody, Reading

Grammatical number in French and Chinese brains

Poster D18 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session D.

Donald Dunagan[1], Shulin Zhang[1], Jixing Li[2], Christophe Pallier[3], John Whitman[4], John Hale[1]; [1]University of Georgia, [2]New York University Abu Dhabi, [3]INSERM-CEA, [4]Cornell University

A requirement for natural language understanding, common to all languages, is the ability to understand how many of what or whom. While much work has been done to document the neural correlates of number comprehension and quantity comparison [1, 2, 3, 4], we investigate grammatical number from a cross-linguistic perspective with the goal of identifying cortical regions involved in distinguishing plural from singular nouns. We analyze parallel Chinese and French data, selecting these two languages because of the differences in their semantics [5]. Because Chinese lacks nominal pluralization, bare nouns have a number interpretation which is general and includes the plural. In contrast, in French, count nouns are explicitly marked for grammatical number via a determiner that has a different form in plural as opposed to singular. We use two fMRI datasets, each around 100 minutes in length, in which 30 French and 35 Chinese speakers listen to an audiobook of a children's story translated into their native language. We align the audiobook texts and identify parallel observations of interest where French nouns are indexed by a common, definite article (le, la, l', les) and the Chinese nouns are not marked for number, either morphologically or with a number and classifier construction. These criteria maximize the typological distinction between the two languages and result in 282 parallel observations: 261 singular and 27 plural in the Chinese and 257 singular and 25 plural in the French. The Chinese observations, while not overtly marked, nonetheless convey grammatical number to the listener (kappa = 0.96 between two annotators). In the singular-plural opposition, at least in French, singular is taken to be the default form with plural as the non-default [6]. Predicated on the assumption that plural nouns are more marked than singular nouns, we subtract singular from plural activation in each language's GLM analysis. We observe several common regions of increased activation: the left pars orbitalis, the left angular gyrus, and the left parahippocampal gyrus. We also observe regions of increased activation in the French that are not present in the Chinese: left, lateral middle temporal gyrus, left pars triangularis, left dorsomedial prefrontal cortex, right pars orbitalis, and right medial prefrontal cortex. In contrasting neural activation between singular and plural nouns, we identify a number of cortical regions which have previously been implicated in semantic processing [7]. While one outcome of comparing languages with starkly different number semantics would be that the processing takes place in different regions, we find overlap between the Chinese and French results, suggesting that they share systems for making sense of number in natural language. Indeed, all of the regions identified in the Chinese results appear in the French results. We attribute the additional regions in the French results to the greater perceptual salience of the overt French marking.

Topic Areas: Meaning: Discourse and Pragmatics, Meaning: Lexical Semantics

Time frequency analysis of imageability and performance level

Poster D19 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session D.

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Imageability is a measure of language defined as the extent to which a word evokes a mental image, unique from concreteness which is defined by the extent a word can be experienced by the senses (Richardson, 1975). While completing a remember/know Task involving recalling words rated for their individual levels of imagery, participants showed enhanced memory for words rated as highly imageable compared to less imageable, demonstrating the Imagery Effect (O'Neil, 2005). Indeed, there is a fair amount of research corroborating these findings. Still any possible modulation of brain activity caused by imageability leading to its behavioral advantages is unknown. The present study examined the effect of imageability on changes in neural oscillations and associated lexical decisions using time frequency analysis. Participants included 26 right-handed monolingual English speakers ages 18-35 . Participants were free from ADHD, interfering psychological conditions, trauma, or serious head injury. Hearing was screened upon arrival to ensure there was no deficit. Participants used a two-button response, one button for no and one for yes, with the role of left or right hand varied across participants. EEG data were recorded using a 64-channel BrainVision actiCHampsystem. The auditory lexical decision task consisted of three sets of stimuli, 75 high imageable words, 75 low imageable words, and 150 non-words, created by changing the ending to the real words so determination of lexicality would require participants to process the entire word. Word groups were matched on word frequency and phonotactic probability. Participants were instructed to respond 'yes' for words or 'no' for non-words. EEG data recorded during the lexical decision task, were segmented into non-overlapping short (1200ms) and long (5000ms) epochs around stimuli with a 200ms prestimulus interval. Epochs were average-referenced and baseline corrected to the prestimulus interval. Reaction time was faster for words than for non-words. Accuracy was higher for words than for non-words, but varied greatly across participants, with accuracies ranging from 40-95%. As a result, we split participants into two groups, above (high performers) and below (low performers) 80% accuracy, to control for individuals who may not have properly understood the task. Our preliminary time frequency analysis looked at beta frequency(20-30Hz), known to reflect motor imagery (Weiss & Mueller, 2012), and found that there were significant differences in bilateral and wide-spread beta engagement across high, low, and non-words between 1000ms and 1600ms, but only for the (high performers). Thus, our results for the high performing group showed distinctive time frequency patterns primarily in the high imageable words, while the low imageable and non-words appeared more similar. The low group data looked the same across the three conditions, appearing to use the same mental strategy regardless of the words imageability. This suggests that imageability of target words differentially impacts neural oscillations in the beta frequency as well as decisions about lexicality of target words.

Topic Areas: Meaning: Lexical Semantics, Methods

Temporoparietal Specialization for Event Knowledge Demonstrated by Multivoxel Pattern Classification and Representational Similarity Analysis

Poster D20 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session D.

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Neurobiological studies of concept representation have focused mainly on object types, yet knowledge about types of events is an equally important component of the conceptual store. Compared to objects, events are defined more by spatial and temporal phenomena, roles and relationships linking participants, social phenomena, and causal relations. Several univariate contrast studies have suggested a role for posterior temporal and inferior parietal cortex in event concept processing. Here we use representational similarity analysis (RSA) on fMRI data evoked by event and object concepts, together with an embodied conceptual model composed of 65 experiential attributes, to compare event and object representations. This experiential model was shown previously to outperform other semantic models in RSA over a predefined general semantic network. Here we use searchlight RSA to discover local differences between event and object representation. In a complementary analysis, a support vector machine (SVM) classifier was trained to predict from neural activity patterns the membership of individual concepts in subcategories of events and objects, with classifier accuracy compared between objects and events using a searchlight approach. Methods: 27 right-handed English speakers were shown 320 English words consisting of 40 items in each of 4 event categories (negative, social, verbal, nonverbal sound) and 4 object categories (animal, food, tool, vehicle) using a fast event-related design during 3T fMRI. Each stimulus was presented 6 times across 3 sessions on separate days. Participants were asked to rate the familiarity of each word on a 1 to 3 scale. MRI data were preprocessed with the Human Connectome Project pipeline. Functional data were processed with AFNI under a general linear model that included each of the words as 320 regressors of interest. Beta coefficient maps for each word were mapped to a surface template. For RSA, concept dissimilarity matrices (DSM) were built separately for objects and events based on 65-dimensional experiential vectors, and compared with neural DSMs on 10-mm radius surface patches at each vertex. For SVM classification, the neural patterns from each patch were used to train and test classification over subcategories of events or objects, with 10-fold cross validation. The Pearson correlation (RSA) or accuracy score (SVM) at each vertex location was then Fisher z transformed, and a group level, paired t-test of these values was used to directly compare events and objects. Thresholded ($p < .001$) t maps were corrected for multiple comparisons via permutation testing. Results: RSA showed stronger representation of information for event concepts compared to object concepts in a left temporoparietal region extending from posterior superior temporal sulcus into angular gyrus, and in the left inferior frontal gyrus (IFG). A similar pattern was observed in the classifier analysis, with additional involvement of the left supramarginal gyrus and superior frontal gyrus. No areas showed stronger representation or classification of object compared to event concepts. Discussion: These convergent results provide strong evidence for a specialization of left posterior temporal and inferior parietal cortex in representation of event knowledge. The left IFG also showed stronger representation of events than objects.

Topic Areas: Meaning: Lexical Semantics, Meaning: Combinatorial Semantics

Investigating the spatiotemporal dynamics of speech production in children

Poster D21 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session D.

Presenter Note: This work was supported by NSF Grant BCS-1923144. Please contact me at mh5752@nyu.edu with any questions or comments! You can also find me on Twitter: @HauptmanMiriam I look forward to hearing from you.

Miriam Hauptman[1,2], Ellie Abrams[1], Sarah Phillips[1], Alicia Parrish[1], Ria Geguera[1], Liina Pylkkänen[1,2]; [1]New York University, [2]New York University Abu Dhabi Research Institute

[INTRODUCTION] The spatiotemporal dynamics of language production remain under-characterized compared to comprehension, especially in children. This study uses MEG to investigate children's neural activity as they produce simple two-word phrases. We build on prior MEG work implicating the role of the vmPFC and LATL during this type of basic composition in adults (Blanco-Elorrieta et al., 2018; Blanco-Elorrieta & Pylkkänen, 2016; Pylkkänen et al., 2014). Although MEG has been used previously to study language production in children, nearly all prior work has focused on atypical populations (Buard et al., 2013; Sowman et al., 2014), limiting our understanding of language production in the typically developing brain. The present study addresses this critical gap in the literature. Data collection was paused due to COVID-19, so our findings are preliminary in nature. [METHOD] 10 children (M = 8.7 years, range = 7-10) completed a blocked picture-naming task while magnetoencephalography (MEG) was recorded. In "phrase" blocks, participants produced the color and name of a simple object displayed in color (e.g., "blue house"), while "object" blocks involved producing only the object's name (e.g., "house"). This paradigm was designed to target processing related to composition, using single word production as a baseline. Data were epoched both forwards from picture onset and backwards from speech onset. Non-parametric cluster-based permutation tests were conducted in 11 bilateral ROIs identified in past work investigating constituent structure (Pallier et al., 2011) and combinatory linguistic processing (e.g., Pylkkänen et al., 2014). [RESULTS] Phrase productions began significantly later than object productions (M = 1107 ms v. M = 987 ms). Consistent with prior work on the production of adjective-noun phrases, increased activity for phrases over objects was observed in the vmPFC and middle temporal lobe 500 to 300 ms before speech onset. Critically, these effects were observed only in the right hemisphere, and no other effects from the backwards averaged dataset were observed earlier than 300 ms before the onset of articulation. Forwards averaged data revealed increased activity for objects over phrases in the right LATL and right temporal pole 0 to 200 ms after picture onset. [CONCLUSION] The right-lateralization of our results is surprising given recent evidence for early left-lateralization of language regions in children (Enge et al., 2020; Weiss-Croft & Baldeweg, 2015). Notably, the same group of participants also demonstrated a right-lateralized profile when completing a comprehension task (Phillips et al., abstract submitted to SNL 2020). Further work is needed to help clarify our findings, especially considering the small size of the current dataset. Until MEG data collection resumes, a lateralization analysis (e.g., Sowman et al., 2014) could provide important insight into the role of the right hemisphere during language production in children. In addition, we plan to compare the current results with those of 13 adult participants who completed the same production task. Finally, stratifying child participants by age group (target range: 6-12 years old) once more data is collected would allow for a systematic investigation of language production throughout development.

Topic Areas: Development, Language Production

Electroencephalographic Neurofeedback in Treatment of Speech and Language Deficits in Aphasia: A Methods Overview and Preliminary Case Results

Poster D22 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session D.

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Recent work on mechanisms of recovery of language function following adult brain injury (e.g. stroke, TBI) has focused heavily on the relevant brain networks for language. However, relatively few direct methods exist for strengthening connections between the nodes of these networks. Electroencephalographic (EEG) neurofeedback (NF) is currently a topic of growing interest, in that it has significant potential both as a clinical and experimental tool for network modulation. By feeding back real-time information on electrical activity across brain sites, participants are able to change those patterns of activity, and to affect the strength of connectivity between brain regions. Though NF has been successfully used to treat symptoms of multiple disorders (e.g. ADHD, dyslexia, traumatic brain injury, stroke), the utility of this tool to address language deficits directly has not yet been systematically explored. To achieve meaningful clinical impact in the realm of speech and language therapy, it is necessary to design and support language-specific, evidence-based approaches. We will discuss several strategies for development of these standard protocols, including current methods used in standard NF treatment, and novel correlations between specific symptoms and resting-state EEG patterns. Additionally, as with many neuromodulation techniques, in order to improve behavioral language performance, it may be most effective to combine neurofeedback with standard behavioral treatment of speech language deficits. Ideally, this should be done alongside sensitive within-session measures of the relevant impairments, so that behavioral improvements which accompany neurofeedback-related gains can be clearly linked together in time. To this end, we employed individually tailored neurofeedback protocols in concert with speech therapy in several individuals, to address patient-specific brain and behavioral deficits in an integrated fashion. We will show results from these case studies, and discuss implications of our findings for future work. Many factors need to be considered in this approach, but it has strong potential to be a powerful tool in the remediation of speech-language deficits following a brain injury.

Topic Areas: Disorders: Acquired, Methods

Musical rhythm and language traits share genetic architecture

Poster D23 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session D.

Presenter Note: Contact me at reyna.gordon@vanderbilt.edu My Zoom room for the week of the conference is: https://vanderbilt.zoom.us/my/reynagordonvanderbilt?pwd=RTgvTHRMN29HUGJUMHh5dUtHR2lYdz09

Reyna Gordon[1], Else Eising[2], Maria Niarchou[1], the 23andMe Research Team[3], the GenLang QTL-GWAS Working Group[4], Lea Davis[1], Nancy Cox[1], Simon Fisher[2]; [1]Vanderbilt University Medical Center, [2]Max Planck Institute for Psycholinguistics, Nijmegen, [3]23andMe, Inc., [4]GenLang Consortium

Individual differences in musical rhythm ability are related to phonological awareness, reading skill, spoken grammar, prosodic awareness, and second language acquisition across individuals with a wide range of language skills. These phenotypic associations also extend to speech-language disorders such as dyslexia, developmental language disorder, and stuttering, as prior research indicates that individuals with these disorders perform more weakly on musical rhythm tasks. We hypothesized that shared genetic architecture may account for phenotypic associations between musical rhythm ability and language traits. To examine this hypothesis, we used summary statistics from a large-scale GWAS on a musical rhythm phenotype (self-reported beat-synchronization) from a new study conducted with personal genetics company 23andMe, Inc. in 606,825 individuals (Niarchou et al., 2019), and summary statistics from GWAS meta-analyses on five quantitative language traits conducted in the GenLang consortium in 11,176 to 19,946 individuals of European ancestry from 9 to 14 cohorts. LD-score regression genetic correlations were calculated between musical rhythm and five language-related phenotypes: non-word repetition, phoneme awareness, spelling, word reading, and non-word reading. All five language-related phenotypes showed significant positive genetic correlation with musical rhythm, with the highest genetic correlations with phoneme awareness (rg = 0.30, se = 0.06, p=2.06x10-7) and nonword repetition (rg = 0.41, se = 0.09, p=9.2x10-6). These findings are, to our knowledge, the first results to show genetic pleiotropy between rhythm and language-related phenotypes. Moreover, these results support one of the primary predictions of the Atypical Rhythm Risk Hypothesis (Ladanyi et al., 2020) which posits that individuals with atypical rhythm ability are at higher risk for developmental speech/language disorders, and that shared genetic architecture may account for these phenotypic associations within both typical and atypical development. Ongoing work will extend the scope of inquiry to test if polygenic risk scores for rhythm can predict individual differences in spoken grammar ability and other spoken language traits.

Topic Areas: Language Genetics, Development

Monitoring changes in frontal lobe hemodynamic response following working memory training in a young adult with Developmental Language Disorder: A fNIRS and HD-tDCS feasibility study

Poster D31 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session D.

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Background Deficits in working memory, attentional control and inhibition are characteristic of cognitive processing impairments in young adults with developmental language disorder (DLD). Recent neuroimaging studies show both abnormal and compensatory brain responses during verbal working memory in young adults with DLD (Berglund-Barraza, et al., 2019). Even though behavioral working memory training paradigms have had mixed results in addressing the deficits in individuals with DLD, High Definition transcortical Direct Current Stimulation (HD-tDCS) has been shown to enhance working memory and aspects of cognitive control in neurotypical populations. The objective of this study was to determine whether fNIRS can be used to track changes in the hemodynamic response in frontal networks in a single subject following combined HD tDCS-phonological working memory training. Methods Functional near-infrared spectroscopy (fNIRS) is a non-invasive, low-cost neuroimaging modality that measures the relative changes of oxygenated hemoglobin (HbO2) and deoxygenated hemoglobin (Hb) based on near-infrared light absorption (650-900nm). This technology allows researchers to extract functional brain activity information with high temporal resolution and low sensitivity to movement artifacts (Ferrari & Quaresima, 2012). In this study, fNIRS was used to record prefrontal cortex activity during a 2-back auditory working memory task in two adult female subjects with DLD both prior to and post one session of a phonological working memory task paired with anodal HD tDCS (1.0 mA tDCS; 20 minutes) to the pre-supplementary motor area (preSMA). Standardized z-scores of behavioral measures (accuracy and reaction time) and de/oxygenated hemoglobin were compared to that of a normative sample of 21 age-matched female normal language controls (ages 18 to 25). Results Standardized z-scores of oxygenated and deoxygenated hemoglobin showed that prior to HD-tDCS, the channel-wise hemodynamic response in the frontal lobe for the subjects with DLD was markedly outside normal limits. Following training, the subjects' hemodynamic response moved within normal limits for established ROIs. Behavioral standardized z-scores (accuracy and reaction time) showed that while the subjects were within normal limits prior to HD-tDCS training, their ability to maintain task stimuli in memory and inhibit conflicting information improved, and reaction time decreased for both high- and low-frequency words after treatment. Conclusion These findings highlight the feasibility of fNIRS to detect individual differences in single subjects with DLD, as well as within subject changes in brain activity immediately following working memory training.

Topic Areas: Methods, Phonology and Phonological Working Memory

The Use of Language Proficiency Assessments in Neurobiological Studies of L2, Bilingualism, and Multilingualism: A Systematized Review

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There is increasing interest in exploring the neurobiological effects of language proficiency in second language, bilingual, and multilingual speakers. Prominent studies have sought to investigate the role of proficiency as it relates to the determination of the functional neural systems that underlie human language, as well as the neural expression of extra-linguistic cognitive behaviors such as executive function. In these efforts, researchers may rely on language proficiency assessments to define participant groups. However, the construct of language proficiency itself is often poorly defined, leading to the potential for variability in the characterization of its neural impact. This systematized review investigates the types of language proficiency assessments utilized in functional neuroimaging studies of L2, bilingual, and multilingual speakers to characterize the ways in which language proficiency is conceptualized and applied in experimental research and identify opportunities for improvement of research practice. A survey comprising 57 studies was collected via the PUBMED database. Selected studies met the following eligibility criteria: 1) involved healthy adult subjects; 2) investigated issue(s) related to L2, bilingualism, or multilingualism and proficiency as a construct; 3) utilized at least one of the following functional neuroimaging methods: fMRI, EEG, MEG; 4) were published between the years 2010 and 2018; 5) were published in a peer-reviewed journal. We sought to address the following questions: 1) what proficiency assessments are being used in this research, 2) whether types of assessments used vary between functional imaging modalities, and 3) how researchers utilize proficiency assessments. Findings indicate a great deal of variability in research practice. For example, a wide variety of proficiency assessments ranging from Self Assessment (e.g., self-reporting of language history or ability) to Indirect Assessment (e.g., prior test scores) to formal Standardized Assessments (University of Cambridge Quick Placement Test, Versant English Test, etc.) were utilized by researchers, with no one assessment clearly favored over others. The number of proficiency assessments reported in each study also varied between one and seven, with a mean of 2.37 per study. Findings suggest slight differences as a function of imaging modality. For example, MRI studies tended to utilize standardized tests most often (46.88% Standardized, 28.13% Self, 25% Indirect), while EEG (40.68% Self, 35.59% Indirect, 23.73% Standardized) and MEG (50% Self, 25% Indirect, 25% Standardized) studies showed more of a preference for Self Assessments. Additional analysis explored the use of proficiency assessments as a function of cognitive task (e.g. comprehension, production), though no strong evidence of a connection between these factors was found. Several observations based on the corpus studies were also noted, namely: an inconsistency in categorization of participants as L2, bilingual, and multilingual and variable usage of language background information. Taken together, our findings suggest that more consistent definitions and methodological standards related to language proficiency should be sought in order to avoid variable conclusions in research. These data also draw attention to the need for better accuracy and consistency of language proficiency assessments, as well as increased conscientiousness in experimental design.

Topic Areas: Methods, Multilingualism

Individual-subject functional localization does not benefit ERP analyses

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The analysis of electrophysiological (EEG/ERP) data has been central to the study of the neurobiology of language. Luck and Gaspelin (2018) recently highlighted that, due to the richness of the EEG signal and a large number of preprocessing/analysis choices, certain standard analytic approaches may be susceptible to false positives. They proposed several remedies including functional localization—a powerful approach from functional neuroimaging (fMRI) where experimental effects are analyzed only within functional regions of interest that are identified, in each individual, by an independent ‘localizer’ task established a priori to tap the cognitive process of interest (Saxe et al., 2006). This approach confers benefits in sensitivity and functional resolution (Nieto-Castañon & Fedorenko, 2012) and, aside from fMRI, has been successfully applied to magnetoencephalography (MEG) (Liu et al., 2001), electrocorticography (ECoG) (Cogan et al., 2016), and functional near-infrared spectroscopy (fNIRS) (Powell et al., 2017). Here, we evaluated the utility of functional localization for the analysis of ERP data in language research. We re-analyzed an existing dataset (Ryskin et al., 2020) which probed two classic ERP signatures of language processing: the N400 component (a stronger negative deflection for semantically unpredictable words, 300-500ms after critical word onset) and the P600 component (a stronger positive deflection for words with morpho-syntactic errors, 600-800ms after word onset). We compared N400 and P600 effect sizes obtained from a traditional analysis (with the same 8 channels of interest (COIs) used for every participant and selected based on prior literature; Kutas & Federmeier, 2011) against two variants of individual-participant functional localization. In both variants, COIs were defined in each individual based on the largest effect size in half of the data (selecting top 8 channels), and the effects were then examined in the other half of the data; in one variant, COI selection was restricted to the traditional set of centro-posterior channels, and in the other, COIs were selected from among all channels. Neither variant yielded larger effect sizes compared to the traditional approach for either component. Functional localization is beneficial when signals are spatially stable within an individual over time but variable across individuals. Do ERP signals have these properties? The N400 effect, but not the P600 effect, showed a moderate degree of spatial stability within individuals, assessed by correlating the effect magnitude across channels for odd- vs. even-numbered trials (N400: mean Pearson's $r = 0.36$, $p < 0.001$; P600: $r=0.12$, $p=0.10$). However, the spatial distribution did not vary across participants: the effect magnitudes on odd trials were similarly correlated to the magnitudes on even trials of another (randomly-selected) participant (N400: $r = 0.34$; P600: $r=0.13$). In summary, despite the greater statistical power that functional localization affords in other modalities (e.g., fMRI, MEG, ECoG, fNIRS), it does not appear to benefit analyses of ERP data, at least for the N400 and P600 components, which are frequently investigated in language research. Future work will test the generalizability of these findings to other components and datasets.

Topic Areas: Methods, Meaning: Lexical Semantics

The intensity and connectivity of spontaneous brain activity relate to aging and language

Poster D34 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session D.

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Typically, neuroimaging studies either look at functional activation in response to an explicit task, or functional connectivity (i.e., interregional integration of neural networks) during resting-state. Among aging studies, older adults often elicit increased bilateral functional activation, increased activation in prefrontal regions, and reduced within-network connectivity during rest. However, few studies have looked at the intensity of brain activity (i.e., BOLD amplitude) or its relationship with age, behavior, and language. The current study investigated both the functional connectivity and the intensity (i.e., the amplitude of lower-frequency fluctuation, ALFF) of spontaneous brain activity during rest and their relationship with age and language. A life-span sample of individuals was tested (N=154, 20-78 years, mean = 46.9 years). Participants completed a battery of neuropsychological tests to assess basic cognitive functions. Exploratory factor analysis categorized different cognitive functions. Here we focus on the language factor which loaded significantly on all language-related tasks (i.e., verbal fluency, comparative reading, author recognition test, and the WAIS vocabulary). To measure spontaneous brain activity, functional resting-state images were collected while participants were instructed to relax in the scanner with their eyes open and to look at a fixation cross for about 6 minutes. Preprocessing and first-level analyses were conducted using the CONN toolbox (Whitfield-Gabrieli and Nieto-Castanon, 2012). We focused on an extend language network (Ferstl et al., 2008) and also included a visual network as a control network (Power et al., 2011; Damoiseaux et al 2006). For each network, 6-mm radius sphere ROIs were created (13 for the language network, 10 for the visual network). The mean ALFF and total degree (i.e., number of positive connections stronger than $r=0.2$) were calculated for each network. Then, linear regressions were conducted on both measurements for the language network while including age, language factor score, and their interaction as predictors. To investigate the specificity of the ALFF results in the language network, additional regressions were conducted on the relationship between the working memory factor and ALFF in the language network, and the language factor scores on ALFF in the control network. In the language network, older age was associated with higher ALFF but lower degree, suggesting that older adults engaged

language regions more than younger adults at rest, but not in a coordinated manner. Additionally, there was a main effect of language in which hyper activity (i.e., higher ALFF) was associated with worse performance on language measures. Our specificity analyses indicated that neither the relationship between the working memory factor score and the ALFF in the language network, nor the relationship between the language factor score and the ALFF in the visual network were significant, suggesting that the results were specific to the language network. In general, these results suggested that older adults may show more intense, but less coordinated brain activity in the language network during resting-state than younger adults. Moreover, such increases in brain activity during rest in the language network reflect lower language ability.

Topic Areas: Methods, Language Production

Bilingual advantage in the subcomponents of attention: A resting state functional connectivity study

Poster D35 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session D.

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Introduction: Evidence exists in favour of bilingual advantage in cognitive functions (Bialystok et al., 2012; Costa et al., 2008), more so, in ageing individuals (Berroir et al.,2017; Luk et al., 2011; Dash et al 2019). In healthy ageing, bilingualism provides resilience against the usual wear and tear of the neural and the cognitive systems. Thus, bilingualism can be considered as a proxy of reserve that supports cognitive function, despite brain decline. However, different facets of bilingualism need to be studied. A common practice in bilingual research is to compare dichotomous groups (high vs. low proficient; balanced vs. unbalanced; early vs. late) instead of continuous. In the present study, we overcome these limitations by analyzing the individual and joint contribution of age and measures of bilingualism – measured as continuous variables – on the resting-state functional connectivity (rsFC) of the brain networks related to subcomponents of attention – alerting, orienting and executive control. Methods: 52 right-handed young adults (Mean age = 66.2 years, 36 F) were included in the study. All participants were French speakers who spoke English as second language (L2). Measures of bilingualism and cognitive reserve were collected. The rcFC between individuals varying in age and measures of bilingualism were compared to explore the changes in functional connectivity. Data were preprocessed and analyzed using the CONN toolbox with SPM12. 20 seed regions related to the subcomponents of attention were selected for the rsFC analysis. Results: Our results indicate that brain-behavioural relationship was present for only alerting and orienting networks. Also, various measures of bilingualism – defined as a continuous variable – impacts brain plasticity by modulating the rsFC, only for the alerting and orienting seed regions. The results suggest that an increase in the ability to take advantage of alerting and orienting cues was related to stronger rsFC for the alerting (BA 22) and orienting (BA 2 & 6) seed regions with default mode network (DMN) regions. Furthermore, with increasing L2 exposure and task proficiency, there were stronger rsFC for orienting (BA2) and alerting (IFG; BA22) seed regions, with various regions in the brain. Also, with increasing L2 AOA, there was a weaker rsFC for alerting (IFG) and orienting (BA6 & BA37) seed regions with other brain areas. This pattern of results held after controlling for other proxies of the cognitive reserve – education and occupation. All reported clusters survived the threshold of $p < 0.05$ using a false-discovery rate correction. Conclusion: Our findings highlight how the brain's intrinsic functional patterns for the subcomponents of attention are influenced by the measures of bilingualism. Our results indicate that bilingual experience when other proxies of the cognitive reserve are controlled for modulates the functional connectivity within the alerting and orienting network only. These findings shed new light on the importance of modelling bilingualism as a continuous variable rather than dichotomous. In addition, the current result emphasizes the role of bilingualism in the early attentional component – alerting & orienting – rather than executive control that is previously reported in the literature.

Topic Areas: Multilingualism, Control, Selection, and Executive Processes

Bilingual lexical selection without lexical competition: ERP evidence from bimodal bilinguals and picture-word interference

Poster D36 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session D.

Presenter Note: These results were just published: https://doi.org/10.1080/23273798.2020.1821905 Emmorey, K., Mott, M., Meade, G., Holcomb, P.J., Midgely, K.J. (2020). Lexical selection in bimodal bilinguals: ERP evidence from picture-word interference. Language, Cognition and Neuroscience.

Karen Emmorey[1], Megan Mott[1], Gabriela Meade[1], Phillip Holcomb[1], Katherine Midgley[1]; [1]San Diego State University

Introduction: A central issue in bilingual language production concerns how bilinguals manage to select words in a target language while ignoring words in another language. The picture-word interference (PWI) paradigm has been used to provide evidence for cross-language activation in bilingual language production and to investigate the role of competition in lexical selection. We used event-related potentials (ERPs) and the PWI paradigm to investigate whether lexical selection in deaf and hearing ASL-English bilinguals occurs via lexical competition or whether the response exclusion hypothesis (REH) for PWI effects is supported. The REH predicts that semantic interference should not occur for bimodal bilinguals because sign and word responses do not compete within an output buffer. Methods: While undergoing EEG recording, 36 bimodal bilinguals (18 deaf; 18 hearing) named pictures in ASL, preceded by either a translation equivalent, semantically-related, or unrelated English written word. The translation and semantic sets each contained 50 pictures, presented twice (once with a related prime and once with an unrelated prime). ASL response times (RTs) were recorded via a key release. Results: The same pattern of behavioral and ERP results was observed for the deaf and hearing bilinguals. Both groups showed facilitation effects in both the translation and the semantically-related conditions: reduced RTs and N400 amplitudes for related compared to unrelated prime conditions. These results are predicted by the REH and cannot be easily explained by models of word production that assume lexical selection by competition. We also observed an unexpected focal left anterior positivity (at the FC5 electrode) that was stronger in the translation condition. To our knowledge, this focal positivity effect has not been reported in previous spoken word production studies. Exploratory analyses suggested that this positivity may be related to articulatory or phonological priming of the ASL sign response. Conclusion: Bimodal bilinguals offer a unique avenue to explore the predictions of the REH versus lexical competition accounts of the PWI paradigm because their two languages involve distinct articulatory output buffers. Overall, our results supported the REH and are more consistent with models of bilingual language production that assume lexical selection occurs without competition between languages. Our data also suggested the existence of a new component, focused around electrode FC5, which may reflect articulatory priming for sign language production.

Topic Areas: Multilingualism, Language Production

Addressing the discrepancy between online and offline measures of word segmentation in L2: ERP and accuracy measures

Poster D37 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session D.

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To interpret an utterance, listeners need to isolate lexical items from one another based on acoustic cues present in the signal. Studies have demonstrated that speakers of different languages rely on different strategies for word segmentation. For instance, in English, listeners reportedly rely on lexical stress to locate word onsets, whereas in French, listeners rely on phrase final lengthening and F0 rise to locate word offsets.

Nonetheless, questions remain concerning L2 learners' ability to adapt their segmentation strategies to the L2. Although studies relying on offline judgments have suggested that listeners continue to use their L1's segmentation strategy in L2, recent experiments relying on online measures have shown that high-proficiency L2 listeners can learn to use L2-specific segmentation strategies. Given the inconsistent results as a function of the paradigm used, it is important to investigate L2 segmentation processes using methods allowing both online and offline measures. The present study combines ERPs with offline behavioural measures to determine if non-native listeners demonstrate sensitivity to segmentation cues in the signal and decision strategies comparable to native listeners. We hypothesize that native-like online processing of segmentation cues might not be sufficient to ensure a final native-like segmentation decision. To test this hypothesis, we developed an EEG task involving a cross-modal (audiovisual) priming paradigm and tested 57 English-French bilingual listeners (24 English-L1/French-L2 and 23 French-L1/English-L2). Audio stimuli included 80 sentence pairs (40/language) produced by a native speaker, built around syllable strings interpretable as either two words (… two cans …) or one bisyllabic word (… toucans …). Visual stimuli included pictures representing the first syllable alone (two), the bisyllabic word (toucans), or an unrelated word. Participants determined as quickly as possible if the picture was related to the initial portion of the heard utterance. Picture presentation was time-locked to the onset of the second syllable of the string, and each picture was presented once with each sentence of a pair. EEG signals were pre-processed and artefact-free ERP waveforms were time-locked to the onset of picture presentation. Mean amplitudes were extracted from two 100ms time windows centered around the typical N2 and N4 components (180-280 ms and 350-450 ms after picture onset). Linear mixed effects models of response accuracy and ERP amplitudes (N2 and N4 to correct responses) revealed different results. The models on N2 and N4 amplitudes yielded significant effects of sentence (toucan or two cans) and picture conditions, but no significant effect (or interaction) of participants' L1, suggesting that native and non-native listeners relied on the same language-appropriate early processes. In contrast, significant effects of L1 were found for behavioral (offline) accuracy scores in both languages, with L2 listeners significantly less accurate than L1 listeners. Taken together, these results show that even if L1 and L2 participants relied on the same early processes as indexed by comparable N2 and N4 amplitudes, they nonetheless ended up making different final segmentation decisions. We also consider the impact of individual differences in language experience (language dominance, age of acquisition) on both the ERPs and behavioral performance.

Topic Areas: Multilingualism, Speech Perception

Functional Differences for Native Language Processing in Multilingual Language Users

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Presenter Note: For additional information, question and comments, please contact us at lmidrigan@ucdavis.edu

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While burgeoning efforts are beginning to entertain models of language processing in bilingual speakers, far less is known about brain organization in highly multilingual individuals. The present study investigates functional brain differences between 15 monolingual English speakers and 15 individuals that demonstrate fluency in four or more languages (i.e. English, Romanian, Russian and a fourth language that differs from participant to participant. We obtained three fMRI measures of linguistic processing and one acoustic control condition. We characterize BOLD activation during the processing of subject's L1 (e.g. Romanian), early learned L2 (Russian) and a later learned L3 (English) and an acoustic non-speech control. A multi-band two-fold slice acceleration scheme was used. GE-EPI (voxel resolution 3.5 × 3.5 × 3.5 mm3; FOV = 224mm; TE = 25 ms; flip angle = 90 deg.; bandwidth = 2232 Hz/Px; TA = 0.97 s; TR = 1 s; no in plane acceleration; 34 slices). Functional data was pre-processed using both FSL (i.e. for brain extraction of anatomical images) and SPM12 for further preprocessing and statistical analysis. In this paper we present preliminary evidence from an ROI analyses of language regions

STG, SMG, AG, as well as lIFG (BA44, BA45) in these populations. Preliminary evidence suggests similar activation for native language processing (i.e. Romanian for the multilingual group and English for the monolingual group) in the bilateral STG, SMG and AG, largely consistent with dual-stream language processing (Hickok and Poeppel, 2007; Saur et al., 2008; Friederici and Gierhan, 2013, etc.). However unexpectedly, we observed significantly different activation between the groups for native language processing in the lIFG. In addition, preliminary results suggest stronger activation in the bilateral STG and BA44, for the processing of the early, less proficient L2, compared to the more proficient L3. We discuss these results in relation to theories of language proficiency (Abutalebi and Green, 2007) and the cortical-striatal, and thalamic processes, and frontal-basal ganglia loop involved in language control (Perani & Abutalebi, 2005; Pilatsikas et al., 2014b; Del Maschio and Abutalebi, 2019, etc.).

Topic Areas: Multilingualism, Speech Perception

General organizing principles governing the amount of neuroanatomical overlap between languages in bilinguals

Poster D39 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session D.

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What are the principles that determine whether or not the same brain area subserves two different languages? There is a vast literature that has identified multiple important factors affecting the extent to which languages rely on the same neural populations in the specific brain region (Sulpizio et al. 2020). The factors include, e.g., the age of acquisition of the second language (L2), proficiency level of the first language (L1) and L2, the amount of exposure to each language, the manner of L2 acquisition (formal vs. informal), the linguistic similarity between L1 and L2, and the modality of acquisition of L1 and L2 (oral versus signed) (Hirosh & Degani 2018; Rahmani et al.2017; Emmorey et al. 2016; Liu & Cao 2016; Hull & Vaid 2007; Perani et al. 1998). We will refer to these factors as language modifiers (LMs). These LMs have been generally studied one or – less frequently – two at a time. What is lacking is a set of global principles that explains how the many factors relate to the extent to which languages overlap neuroanatomically in bilinguals. We are offering a small set of such principles that together accounts for the numerous sources of data that have been examined individually but not collectively. We have categorized LMs as primary and secondary. The primary LMs subdivide into acquisition modifiers (the age of L1 acquisition, the level of proficiency in L1 and L2, the amount of exposure to each language, and the manner of language acquisition), and linguistic modifiers (the linguistic distance between L1 and L2, and the modality of L1 and L2). The primary LMs can explain independent regions of language specialization versus neuroanatomical overlap (e.g., a late versus early age of L2 acquisition). The secondary LMs subdivide into internal (individual factors including, for instance, motivation and metalinguistic awareness) and external (the type of language switching). The internal modifiers may indirectly modulate the degree of neuroanatomical overlap between languages through affecting selected primary LMs (e.g., proficiency). The external modifier does not seem to impact the neuroanatomical representation of L1 and L2. The principles we propose are: (1) the principle of acquisition similarity between L1 and L2, (2) the principle of linguistic similarity between L1 and L2, (3) the principle of internal modifiers, and (4) the principle of the effect of LMs on cognitive control. The level of prediction offered by the principles is essential in the neurosurgical setting, where knowledge about the representation of each language will guide the application of invasive procedures (e.g., electrode implantation to localize functional language sites) and direct brain surgery (Fernández-Coello et al., 2017; Ojemann & Whitaker, 1978). Referencing the broad characteristics of language organization in bilinguals as presented in the set of principles can also provide a roadmap for future clinical and basic science research.

Topic Areas: Multilingualism, Language Production

Perceptual asymmetries and auditory processing of Estonian quantities

Poster D40 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session D.

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Similarly to visual perception, auditory perception also has a clearly described "pop-out" effect, where an element with some extra feature is easier to detect among elements without the extra feature. This phenomen is better known as auditory perceptual asymmetry. We investigated such asymmetry between shorter or longer duration, and level or falling pitch of linguistic stimuli that carry a meaning in one language (Estonian), but not in another (Russian). This lexical difference between the groups – the linguistic stimuli having a meaning for Estonian native speakers but not for the Russian native speakers – gives us an opportunity to see if the effect might also be dependent on the language background and long-term memory traces created by it, or it could be more universal. For the mismatch negativity (MMN) experiment, we created four different types of stimuli by modifying the duration of the first vowel [ɑ] (170, 290 ms) and pitch contour (level vs falling pitch) of the stimuli words ('SATA', 'SAKI'). The stimuli were synthesized from Estonian words ('SATA', 'SAKI') and follow the Estonian language three-way quantity system, which incorporates the tonal features (falling pitch contour) together with the temporal patterns. This made the meaning of the word dependent on the combination of both features and allows us to compare the relative contribution of duration and pitch contour in discrimination of language stimuli in the brain on the MMN generation. Jaramillo, Paavilainen and Näätänen (2000) have previously shown that deviants with decreased duration might lessen the amplitude of MMN response, although it is highly dependent of specific language structure and common linguistic patterns in it. Considering the results of Joutsiniemi et al. (1998), the shortening effect might also be influenced by the percent of which the deviant duration has been decreased compared to the standard. The participants of the experiment were 12 Estonian native speakers and 12 Russian native speakers with little or no experience in Estonian and living in Estonia short-term (age 18-27 years). Additional information about language skills, time spent in Estonian language environment and musicality was gathered through online questionnaire to control the influence of confounding factors. The language groups differed in perception of the linguistic stimuli, confirming that the meaning of the word interferes with the early automatic processing of phonological features, proving the effect of the language background. The analysis of the reversed design results showed that the deviant with longer duration among shorter standards elicited a MMN response with earlier latency and bigger amplitude than the short deviant among long standards while changes in pitch contour (falling vs level pitch) did not produce similar differences. The experiment confirmed previous results (Jaramillo et al., 2000) as additional proof of auditory perceptional asymmetry. The study was supported by the Norwegian-Estonian Research Cooperation Programme (EMP180), Estonian Ministry of Education and Research (SF0180029s08 and IUT02-13), Primus grant (#3-8.2/60) from the European Social Fund, the Estonian Research Council grant (PRG770), and the Doctoral School of Behavioural, Social and Health Sciences created under the auspices of European Social Fund.

Topic Areas: Perception: Auditory, Speech Perception

Lexical morphology and reading development in children with typical development and dyslexia

Poster D41 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session D.

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Children's reading success has been linked to their developing competence in lexical morphology. It is easier to read a long, polysyllabic word if one can also recognize its morphemic structure; consider unstoppable, which can be broken down into un+stop+able, and vegetable, which cannot be broken down into smaller meaningful units. Nevertheless, the role of morphological awareness in reading deficits or dyslexia remains elusive. Dyslexia

is typically characterized as a deficit in phonological awareness, yet little is known about the role of morphological awareness , or the ability to recognize and manipulate the smallest units of meaning in language, in the disorder. Theoretical perspectives on dyslexia offer two possible mechanisms. One view is that dyslexia is the result of a phonological deficit, and so morphology and related lexical processes may offer a compensatory mechanism for impaired readers. Alternatively, word segmentation deficits in dyslexia may extend to include both phonological and morphological segmentation, and thus both processes would be impaired. To address this conundrum, we investigated the brain bases of phonological and morphological processing in children with typical development and dyslexia (N = 40, ages 7-12). Participants completed fNIRS neuroimaging measures of morphological and phonological awareness as well as standardized measures of language and literacy. During the phonological awareness task, typically developing children exhibited stronger activation in the left IFG and posterior temporal STG than children with dyslexia, regions typically associated with sound processing. During the morphological awareness task, however, typically developing children exhibited stronger activation in the left ventral IFG and MTG than children with dyslexia, regions typically associated with semantics or lexical processes. Therefore, our findings reveal hypoactivity in children with dyslexia during both phonological and morphological processing, in brain regions specific to phonological versus lexical processes, respectively. These results suggest that reading impairments associated with dyslexia reflect a deficit in the ability to segment words into both units of sound and units of meaning, which will help to inform both theory and instruction for children with reading impairments.

Topic Areas: Reading, Morphology

Why does the tracking of rhythm influence reading? Linking eye movements and chunking in text recitation

Poster D42 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session D.

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Numerous studies have reported correlations between children and adolescents' reading skills and their performance on tasks of motor-sensory synchronisation, such as taping to heard rhythms (David et al., 2007; Dellatolas et al., 2009; Douglas & Willatts, 1994; Holliman et al., 2010a; Rautenberg, 2015; Tierney & Kraus, 2013). It has also been established that dyslexia, a reading disorder, relates to deficits of rhythm synchronization (Atterbury, 1983, 1985; McGivern et al., 1991; Thomson et al., 2006; Thomson & Goswami, 2008; Wolff, 2002), and recent studies involving electro- and magneto-encephalography (EEG/MEG) suggest that dyslexia associates with atypical neural oscillations in the delta range (1-3 Hz; Molinaro et al., 2016; Power et al., 2013; Soltesz et al., 2013). But how do atypical delta waves and deficits on motor-sensory synchronization link to reading? One popular theory suggests that atypical neural oscillations may impact phonological awareness or the tracking of letter-like elements of speech which can, in turn, support phoneme-grapheme associations in reading (Goswami, 2011; 2017). However, the frequency of phonemes in speech exceeds that of delta oscillations, and the theory does not directly explain the link between reading and deficits on rhythm detection and motor-sensory synchronization. We propose another account with reference to recent findings that show a synchronization of delta waves with marks of perceptual chunking in speech (Boucher et al., 2019). Perceptual chunking relates to a buffering of motor-sensory sequences. Its relevance to reading can be seen in common tasks of list recitation of verbal items where rhythmic chunking arises spontaneously. Similarly, in reciting a text aloud to someone, individuals scan a portion of text before looking up and uttering sequences, usually in coherent rhythm blocks. By reference to such behaviors, one can surmise that the time taken to scan and convert visual signs into sequences of articulated sounds would be influenced by the buffering of sequences in chunks. We examined this effect using eye-tracking techniques in an experiment involving oral text reading by 43 expert readers. The text material (sentences) was elaborated to create time-varying rhythm chunks in reading and determine their effects on eye motions. The main results showed that the text material successfully created a chunking in recitations and that these blocks significantly correlated with probabilistic counts of word

fixations (with no significant effect on other eye-tracking measures). Secondary results on experimental conditions revealed that congruent and non-congruent rhythms heard just before text recitation had no significant impact on chunking in recitations or probabilistic fixations, suggesting that effects of chunking were directly linked to the text material and were not entrained by asynchronous rhythms. The results support the view that text recitation inherently involves a buffering of sequential information in characteristic rhythm chunks which can influence reading processes as indirectly reflected by probabilistic counts of fixation. The findings may serve to explain the observed benefits of exercising rhythm synchronisation in reading deficits. We will also outline the limitations of probabilistic word fixation measures in understanding processes of text-to-speech conversion and provide suggestions for future research.

Topic Areas: Reading, Speech Motor Control

Examining Orthographic Neighborhood Size Effect in Chinese Character Recognition Applying NIRS

Poster D43 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session D.

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The effect of orthographic neighborhood size in visual word recognition of alphabetic writing systems has been investigated extensively to establish cognitive models of mental lexicon; however, experimental stimuli selected in most of these studies failed to carefully control for the phonological neighborhood size, a linguistic variable that may covariate with orthographic neighborhood size in alphabetic writing systems. In Chinese writing system, it is not difficult to independently manipulate the orthographic neighborhood size while controlling for the phonological neighborhood size, making it possible to differentiate the influences of orthographic representations from those of phonological representations. In the present study, we examined the effect of orthographic neighborhood size in Chinese character recognition applying near-infrared spectroscopy (NIRS), an optical imaging technique measuring the blood flow changes in the brain. Twenty college students with normal IQ and Chinese reading abilities participated in the present study. Chinese stimuli in two experimental conditions (i.e., high vs. low orthographic neighborhood size) were controlled for word frequency, strokes, regularity, consistency, and homophone neighborhood size. A lexical decision task was applied, in which participants were to decide whether the character presented on the screen was a legal Chinese character as quickly and as accurately as possible. During the task, their neural activities were monitored using NRIS, which measured the changes in the concentration of oxy-hemoglobin and deoxy-hemoglobin in the brain regions of interest by shining near-infrared light (650-950nm) into the scalp and applying its absorbing and scattering characteristics. Brain areas of language network including bilateral inferior frontal cortex, bilateral superior/middle temporal areas, and bilateral temporal-occipital areas were examined. The results revealed that orthographic neighborhood size effect was mainly associated with middle temporal gyrus (BA21), middle frontal gyrus (BA9), and angular gyrus (BA39), indicating that Chinese orthographic neighborhood size effect may relate to the conversions among orthographic, phonological, and semantic representations. The activation of BA9 in the present manipulation may also highlight the syllabic processing and/or writing-related processes in Chinese character recognition.

Topic Areas: Reading, Meaning: Lexical Semantics

Barriers to communication: Effect of visibility on communication modality and efficiency

Poster D44 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session D.

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INTRODUCTION: The study of language has often privileged the verbal modality and face-to-face interaction. However, real life communication is multi-modal and frequently occurs in situations where visibility is restricted (e.g., talking on the phone). We examine how the speech and gesture of people with amnesia and healthy comparison participants vary as a function of visibility in a collaborative barrier task. Barrier tasks have long been used in the clinical treatment of aphasia and in the experimental study of language and common ground. These have employed both shortened barriers that allow communication partners to see each other and complete barriers that eliminate all visual cues. Building on prior work using barrier tasks in people with amnesia to understand the memory representations that underlie communication, we examine the effect reduced visibility has on communication modality and efficiency and the memory systems that support flexible communication. METHOD: Three people with bilateral hippocampal damage and amnesia and nine healthy comparison participants participated. Participants (the director) described how to build Lego models to a research assistant (the builder) in two conditions: In the short barrier phase, participants sat across from a builder separated by a short barrier that allowed them to see the builder's face but prevented viewing the Lego pieces or building progress. They explained to the builder how to make two models (a house and a dog). Both partners could ask questions and talk as much as needed but could not show Lego pieces above the barrier. In the tall barrier phase, directors described two more models (a deer and a dinosaur) with no visual access to the builder. RESULTS: Main effects of group revealed that pairs with amnesic directors required significantly more words (β=834.17, t(24)=3.30, p=.003), had longer build times (β=441.94, t(19)=3.14, p=.005), and had lower accuracy (β=-0.44, t(29)=-2.14, p=.04) than pairs with healthy adults. There was no main effect of barrier height on word count, (β=223.13, t(4)=1.22, p=.29), build time (β=120.17, t(34)=1.57, p=.13), or accuracy (β=0.13, t(43)=0.62, p=.54). Barrier*group interactions for word count (β=-762.90, t(32)=-2.41, p=.02) and build time (β=-358.50, t(34)=-2.34, p=.03) revealed that while pairs with healthy directors required more words and time on average with the tall barrier, pairs with amnesic directors required more words and time with the short barrier. The gesture rate analysis revealed a significant main effect of barrier height (β=-0.03, t(4)=-3.87, p=.02). Both people with amnesia and healthy adults gestured more in the short than tall barrier condition. There was no main effect or group (β=0.02, t(13)=1.11, p=.29) or interaction effect (β=0.00, t(32)=0.05, p=.96). DISCUSSION: While barrier height did not significantly affect overall word count, build time, or accuracy, it robustly affected gesture use in both groups, thus increasing our understanding of the memory systems that support dynamic multi-modal communication. Here, the hippocampus was not necessary for successful adaptation in gesture, suggesting that gesture may invoke the nondeclarative memory system. Thus, manipulating visibility has important consequences on communication modality with implications for the use of barriers in research and clinical practice in neurogenic communication disorders.

Topic Areas: Signed Language and Gesture, Disorders: Acquired

Association Between Frontal Aslant Tract Structure and Phonetic Misarticulation in 4- to 7-year-old Children

Poster D45 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session D.

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Speech articulation is supported by a number of perisylvian cortical and subcortical brain regions, and this network is structurally connected by several long association fiber pathways. One of these, the frontal aslant tract (FAT), connects the pre-supplementary motor area (pre-SMA) and SMA and the inferior frontal gyrus pars opercularis (IFGOp). Models of FAT function have implicated the left FAT in processes related to speech production (e.g., verbal fluency and speech initiation; Catani et al, 2013; Mandelli et al, 2016), but its importance for articulation has been questioned (Chernoff et al, 2019). Some work has examined the FAT in very young children (ages 5-8-years), and has uncovered significant associations with fluency (Broce et al, 2015; Chenausky et al, 2017) and stuttering (Misaghi et al, 2018), but it remains to be seen whether the microstructure of the FAT is involved specifically in speech articulation in early development. In the current study, we examined the FAT of 196 4- to 7-year-old children (M= 5.64 years) using High Angular Resolution Diffusion Imaging (HARDI). The bilateral FAT was manually tracked in all subjects. Phonetic articulation was tested using the syllable repetition task (SRT; Shriberg et al., 2009), which requires the child to repeat 18 two- to four-syllable nonsense words. Our analysis showed that (controlling for whole brain anisotropy and demographic variables) higher quantitative anisotropy (QA) in the left FAT, but not the right, was strongly associated with higher SRT scores ($ß = 0.63$, $p < 0.01$). Further, greater left laterality of the FAT was related to higher SRT scores ($ß = 0.18$, $p < 0.05$). These results suggest that the left FAT is associated with articulation development, and it may be an important pathway to investigate for young children with expressive language impairments.

Topic Areas: Speech Motor Control, Language Production

Impairment of Speech Auditory Feedback Error Detection and Motor Correction in Post- Stroke Aphasia

Poster D46 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session D.

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Introduction: Aphasia is a common consequence of left-hemisphere stroke and is an acquired communication disorder characterized by deficits in comprehension and production of speech and language. While ample research has been conducted to examine the language deficits, recovery, and treatment in aphasia (Brady et al., 2016; Ellis & Urban, 2016), research on the basic underlying mechanisms of speech production in this population is less prevalent. The present study sought to elucidate the relationship between damage to left-hemisphere brain networks and deficits in sensorimotor processing of speech in persons with aphasia (PWAs), specifically how this damage impairs the ability to overtly detect and correct for errors in speech auditory feedback. Methods: The altered auditory feedback (AAF) paradigm was used to externally induce speech errors by pitch-shifting the online auditory feedback in 34 PWAs (13 female; age range 38.4 – 80.0 years; mean age 61.2 years; mean time post-stroke: 5.45 years) and 25 neurologically intact control speakers (17 female; age range 47.5 – 86.7; mean age 62.6 years) undergoing two randomized experimental tasks: 1) vocalization of a steady speech vowel sound /a/, and 2) passive listening to the playback of the same self-produced vocalizations. Randomized control trials were interleaved in between vocalization and listening tasks where no pitch-shift stimuli were delivered. Following each trial, subjects pressed a button to indicate whether they detected a pitch-shift (i.e., error) in their speech auditory feedback. Speech error detection and error rejection accuracy rates were calculated, as were vocal error correction responses (i.e. speech compensation magnitudes). Results and Conclusions: Error detection and rejection accuracy analyses revealed a main effect of pitch-shift ($F(1, 57) = 6.094$, $p < .05$) whereby the accuracy rate of speech error detection during pitch-shifted trials was significantly lower than error rejection during no pitch-shift in both groups. In addition, there was a main effect of group ($F(1, 57) = 13.936$, $p < .001$) in which PWAs showed significantly lower rates of error detection and rejection accuracy compared with controls. No main effect of task (i.e. vocalization vs. listening; $F(1, 57) = .885$, $p > .3$) or interactions were indicated. Results of analysis of vocal error correction responses revealed a main effect of group ($F(1,57) = 4.32$, $p < 0.05$), indicating diminished magnitude of speech compensation responses in PWAs vs. controls in a time window at 150-200 ms after the onset of pitch-shift stimuli. No main effect of pitch-shift stimulus direction (up-shift or down-shift) and no interactions were indicated. Additionally, we found that lower speech error detection accuracy during listening in PWAs was significantly correlated ($r=0.40$, $p < 0.05$) with their impaired vocal error correction responses. These findings provide evidence that post-stroke damage to left-hemisphere brain networks impairs sensorimotor mechanisms of speech auditory feedback processing in aphasia.

Topic Areas: Speech Motor Control, Disorders: Acquired

The contribution of structural brain aging to speech perception in various levels of intelligibility

Poster D47 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session D.

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Older adults often experience difficulties following conversations, especially in challenging listening environments. Though these difficulties are commonplace in older adults, their etiology and underlying mechanisms remain elusive. The objective of this study was to investigate the contribution of structural brain aging to speech perception decline in older adults while manipulating talker variability and background noise. Our hypotheses were that 1) age-related speech perception decline would be worse in the presence background noise and high talker variability, and 2) in the most difficult listening environments, performance decline would be mediated by structural decline within auditory and speech processing areas. Method. 15 young (29.3 ± 10.2 years), and 17 older (71.7 ± 5.8 years) healthy right-handed adults were recruited. An auditory syllable discrimination task was used. Syllables were presented in silence (low noise) or in a pink noise presented in a signal-to-noise ratio of -5 dB (high noise). Within a pair, syllables were spoken by the same male talker (low talker variability), or by two different male talkers (high talker variability). Pure-tone audiometry was performed and an auditory attention test was administered. Linear mixed model (LMM) analyses were conducted to evaluate the effects of age group, noise and talker variability on performance, measured as sensitivity (d') and reaction time (RT). Structural MR images were acquired with a T1-weighted MPRAGE sequence (1 mm3). Cortical regions showing age differences were first identified. Next, simple mediation analyses were used to examine if cortical thickness within each of these areas mediates the relationship between age and speech perception performance (d', RT). In all LMM and mediation analyses, hearing and auditory attention were included as covariates. Results. The LMM analyses revealed that high Noise and high Talker variability conditions were associated with lower d' ($p < .05$), independently of age. High noise was also associated with longer RT ($p < .05$) for both groups, and an interaction between Group and Noise revealed a greater Group difference in d' in the low noise condition. Mediation analyses revealed that Group indirectly influenced d' in the low noise condition through its effect on cortical thickness in the bilateral STC, the bilateral IFG/dAI, and the bilateral SFG. Specifically, older adults had lower cortical thickness within these areas, and lower cortical thickness was related to lower d'. In the High variability condition, an indirect effect was also found in the left STC, left IFG/AI and right SFG. Discussion. This is one of the first studies to evaluate the relationship between structural brain aging and speech perception decline in aging when intelligibility is reduced by talker variability or background noise. Here we showed that background noise had a more detrimental impact on performance in young and older adults than did talker variability, and that speech perception difficulties were related to cortical structure within auditory, speech processing and executive control areas, suggesting global rather than focal cerebral disruptions. A better comprehension of the mechanisms involved in age-related speech perception decline is key to guide the development of mitigation strategies to reduce these difficulties.

Topic Areas: Speech Perception, Perception: Auditory

Asymmetric processing of between-category and within-category vowel contrasts in English and French listeners as reflected by the mismatch negativity and theta band oscillations

Poster D48 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session D.

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Behavioral studies examining vowel perception in infancy indicate that, for many vowel contrasts, the ease of discrimination changes depending on the order of stimulus presentation, regardless of the language from which the contrast is drawn and the ambient language that infants have experienced. For instance, infants perform better at discriminating a change from a relatively less peripheral to a relatively more peripheral vowel within the F1 -F 2 acoustic space, regardless of the language from which the contrast is drawn. By adulthood, linguistic experience has altered vowel perception; analogous asymmetries are observed for non-native contrasts but are mitigated for native contrasts. Recent behavioral work also shows that vowel perception asymmetries derive from phonetic encoding strategies, rather than general auditory processes. Although these directional effects are well documented behaviorally, the brain mechanisms underlying them are poorly understood. In the present study we begin to address this gap. Using event-related brain potentials (ERPs), we measured pre-attentive neural processing involved in vowel discrimination as reflected by the mismatch negativity (MMN) in monolingual Canadian English and Canadian French listeners in response to various pairings of four synthetic vowels (English /u/, French /u/, French /y/, and a control /y/) presented in a classic oddball paradigm. From the French listeners' perspective the vowels spanned two different phonetic categories (/y/ vs. /u/); from the English listeners perspective, they fell within the same category (/u/). Stimulus presentation was organized such that each vowel was presented as standard and as deviant in different blocks. The vowels were presented with a long (1,600-ms) inter-stimulus interval to restrict access to short-term memory traces and tap into a "phonetic mode" of processing. MMN analyses revealed weak asymmetry effects regardless of the (i) vowel contrast, (ii) language group, and (iii) MMN time window. We also conducted time-frequency analyses of the standard epochs for each vowel. In contrast to the MMN analysis, time-frequency analysis revealed significant differences in brain oscillations in the theta band (4–8 Hz), which have been linked to attention and processing efficiency. Collectively, these findings suggest that early-latency (pre-attentive) mismatch responses may not be a strong neurophysiological correlate of asymmetric behavioral vowel discrimination. Rather, asymmetries may reflect differences in neural processing efficiency for vowels with certain inherent acoustic-phonetic properties, as revealed by theta oscillatory activity.

Topic Areas: Speech Perception, Perception: Auditory

Syntactic vs. lexical prediction in posterior temporal lobe

Poster D49 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session D.

Presenter Note: This study is described in greater detail in Chapter 5 of the first author's dissertation, available here: https://drum.lib.umd.edu/handle/1903/26392.

Phoebe Gaston[1], Ellen Lau[1]; [1]University of Maryland

INTRODUCTION: Many theories of sentence comprehension have suggested that syntactic analysis of the input is accomplished predictively. A recent MEG study comparing structured sentences with unstructured lists (Matchin et al., 2019) has reported a neural effect in posterior temporal lobe (PTL) that the authors ascribe to syntactic prediction. However, because the structured sentences also have greater lexical predictability, this effect could have instead indexed the generation of lexical predictions. Here, we report a new MEG study aimed at determining whether syntactic prediction effects are observed in the absence of lexical predictability. METHODS: In a block design, we visually presented pairs of lexically unpredictable noun phrases as the subject and object of a sentence ("the verbose wizards trampled the opulent baths"), as a coordinated phrase ("the verbose wizards and the opulent baths") or as a list ("the verbose wizards the opulent baths"). The stimulus type was indicated to participants at the beginning of each block. Single-word memory probes were presented at the end of each block. This design allows comparison of the response to identical initial noun phrases when participants expects upcoming sentence-level structure, coordination, or no structure. We recorded neural data with MEG (N = 32). Participants also completed a short localizer task in which natural sentences, scrambled sentences, and lists of nonwords were presented in random order. We analyzed the averaged response in an ROI based on the Matchin et al. (2019) syntactic prediction effect in PTL, during the reported time window following both the adjective and the noun in the first noun phrase. We also evaluated ROIs created from the localizer's sentence/scrambled and sentence/nonword contrasts (in superior temporal gyrus, transverse temporal sulcus, and posterior superior temporal sulcus) with temporal cluster tests. Finally, we conducted more exploratory spatiotemporal cluster tests over the left temporal lobe and inferior frontal gyrus (IFG), for both the first noun phrase and the remainder of the trial. RESULTS: We found no 'predictive' response differences at the first noun phrase, in any analysis. We also found no differences in the response to the second noun phrase. However, we observed many significant differences in the response to the verb or the coordinator relative to the list condition's blank screen: an M130 response to both words in ventral temporal areas; apparent M170 and M350 responses to the verb along lateral superior, middle, and inferior temporal clusters; responses to the verb and the coordinator with opposite polarities in anterior ventral areas in the M350 time window; a response to the verb in IFG in the M350 time window; and graded effects of the verb and coordinator in a sustained response in anterior temporal lobe. CONCLUSION: We fail to observe a syntactic prediction effect in the absence of lexical predictability. The only potential effects of syntactic structure in our dataset are in response to the verb, consistent with bottom-up rather than top-down parsing accounts. This suggests the possibility that syntactic and lexical prediction processes are interrelated, such that syntactic prediction becomes contingent on the presence of semantic coherence.

Topic Areas: Syntax, Reading

Neurolinguistic Correlates of Syntactic Unification: Do EEG Oscillations Reflect Syntactic Operations or General Cognitive Processes?

Poster D50 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session D.

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Purpose: Linguistic theory asserts that language is hierarchically constructed such that individual words, morphemes or phrases are combined to form larger units (i.e., constituents). This combinatory process is often referred to as 'unification.' In this study, we used event-related spectral perturbations (ERSPs) from EEG measurements to investigate hypothesized neurological indices of syntactic unification. Design: 24 participants read word pairs that formed grammatical constituents (e.g., a determiner+nonsense noun, the moop) and pairs that did not (e.g., a nonsense noun+determiner, moop the). These constructions were chosen because they contain little semantic information, allowing us to isolate syntactic processes while also balancing lexical information across conditions. As some have suggested that statistical properties of word sequences may permit unification in the absence of grammatical information, we also tested if frequently occurring word sequences would elicit similar responses as unifiable word pairs, even if they did not form traditional grammatical constituents. To do this, we trained participants on nonsense word pairs (e.g. doal hink) and subsequently recorded EEG while participants read these pairs as well as the words in an untrained, reversed order (e.g., hink doal). We then compared ERSPs from each condition in the alpha (8-13Hz), beta (14-25Hz), and delta (1-4Hz) frequency bands, since each of these have been suggested to index unification by previous work. Results: Alpha band activity was similar across all conditions. As alpha oscillations are sensitive to task-specific cognitive demands, we suspect that this lack of differences resulted from differences in methodology between our study and others that did observe alpha band effects when studying unification. In the beta band, non-unifiable sentences showed greater desynchronization after each sentence than all other sentence types. This was similar to previous work that observed beta desynchronization when participants encountered grammatical errors. Though our non-unifiable sentences did not include a grammatical violation, they did resemble incomplete English imperative constructions (e.g. kick the ball -> moop the ___ ***). By parsing non-unifiable sentences this way, participants may have anticipated another item to follow the determiner. When no item appeared, normal sentence processing was likely disrupted. This is also the case when encountering a grammatical violation, resulting in a similar beta band effect. All conditions showed delta band synchronization following the final word of each sentence. Synchrony was sustained for different periods of time for each

condition, increasing linearly with the amount of processable syntactic information present. Trained and untrained sentences contained only serial order information and exhibited delta synchrony for the shortest amount of time before returning to baseline. Non-unifiable sentences elicited longer synchronization and though incomplete, resembled a known syntactic pattern. Unifiable sentences that formed complete constituents and elicited synchronization for the longest period of time. This suggests that delta synchronization can be sensitive to multitude of syntactic operations, such retrieval of stored syntactic patterns as well as unification. Conclusions: Delta oscillations appear to be sensitive to syntactic information, while alpha and beta oscillations more likely index more general cognitive-linguistic processes.

Topic Areas: Syntax, Meaning: Combinatorial Semantics

Sustained left anterior negativity is not an index of working memory load

Poster D51 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session D.

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Introduction: In many languages, sentences with filler-gap dependency are more difficult to process than those without filler-gap dependency as reflected by ERPs, such as sustained left anterior negativity (SLAN). Previous studies have proposed different mechanisms as to how a filler is associated with a gap. According to the Reactivation Hypothesis, the parser encodes information of a filler into the working memory upon encountering it. After detecting a gap location, the parser reactivates the filler information and forms a filler-gap dependency. Other studies have proposed the Active Maintenance Hypothesis that the parser keeps a filler active after encountering a filler until a gap. The latter hypothesis has been supposed by the observation that the SLAN is elicited between the filler and the gap. The SLAN has been interpreted as an index of working memory load. However, previous studies have not presented any context for sentences with filler-gap dependency even though syntactically complex sentences require certain pragmatic conditions to be met. Thus, it is possible that the SLAN reflects a pragmatically infelicitous use of sentences with filler-gap dependency. Methods: The present study tested this hypothesis in Japanese by conducting an ERP experiment that manipulated syntactic complexity: syntactically simple subject-object-verb (SOV) Ms.Aoki-SUBJ Ms.Kitamura-only-OBJ greeted. 'Ms.Aoki only greeted Ms.Kitamura' vs. complex object-subject-verb (OSV) Ms.Kitamura-only-OBJ Ms.Aoki-SUBJ greeted. A discourse factor was also manipulated by presenting a supportive or non-supportive context prior to the target sentences. In Japanese, SOV can be used in a wider range of contexts whereas OSV requires O to be discourse-given. Thus, the supportive context (Ms.Kitamura and Ms.Yamada were in the meeting room) renders OSV felicitous, whereas the non-supportive context (Ms.Aoki and Ms.Yamada were in the meeting room) does not. In literature of Japanese syntax, it has been argued that the O of OSV can be interpreted in either a surface position or its original position. Since the present study was interested in filler-gap dependency formation, the O was presented with a particle "only," which forces the parser to obligatorily reconstruct a filler into the gap position (Kataoka, 2010). Eighteen native speakers of Japanese participated in this experiment (nine females, mean age = 21.4). Results: The result showed a SLAN in OSV relative to SOV in the non-supportive context, in consistent with the results of previous studies. However, no SLAN was not observed in OSV when the supportive context was provided. Conclusion: The results show that obligatory reconstruction does not always elicit a SLAN. This suggest that the processing difficulty of filler-gap dependency is largely due to a pragmatic factor, not a syntactic one. In other words, the SLAN is a cognitive process not specifically recruited for keeping a filler active. Therefore, we argue against the Active Maintenance Hypothesis. The present findings advance not only the understanding of the functional role of SLAN, but also an understanding of the way the parser forms a long-distance dependency with the memory system.

Topic Areas: Syntax, Reading

Methods for Investigating Continuous Speech Production and Perception with EEG

Poster D52 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session D.

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EEG is well-suited for studying the rapid temporal changes in speech production. However, speech production is under-studied using EEG because electromyographic (EMG) artifact contaminates the EEG signal. Here we investigated differences in neural responses during speech production and perception of continuous sentences. We used canonical correlation analysis (CCA) to remove EMG artifacts from a dual perception-production experiment. Event-related potential (ERP) analysis demonstrated removal of EMG and preservation of auditory responses in post-CCA data. Furthermore, multivariate temporal receptive field (mTRF) analysis demonstrated suppression of auditory responses to phonological features in continuous speech production compared to perception while controlling for extraneous EMG artifact. We recorded 64-channel scalp EEG, vertical EOG, and jaw EMG from the orbicularis oris, masseter, or submentalis in 13 participants. The task was a dual perception-production paradigm where participants overtly read and listened to playback of English sentences from the MOCHA-TIMIT corpus off an iPad. A broadband click sound indicated the start of each trial. Stimulus playback made the acoustic-phonetic content identical across conditions. Manually corrected timings from forced alignment were generated for sentence, word and phonemes during speech production. These identical timings were then used for the speech perception portion of trials. We isolated EOG and EMG artifact using independent component analysis (ICA) and CCA, respectively. We then calculated phonological tuning and the effect of perception versus production using mTRF analysis including regressors for phonological features, perception/production condition, and recorded EMG activity. A ±300ms delay window was used, including negative data to account for pre-articulatory neural activity. Models were fit using ridge regression and trained using cross-validation. Data were split sentence-by-sentence to avoid overfitting by including the same sentence in both training and test sets. We then compared the model weights for perception versus production. ERPs epoched to EMG activity from facial musculature electrodes confirmed EMG was removed from the EEG. Qualitative inspection of ERP waveforms alongside quantitative statistics demonstrated that click ERPs were preserved in post-CCA data; however, a reduction in EEG amplitude across all timepoints was observed due to uniform application of correction algorithms across the dataset. Paired t-tests were run per channel for the perception and production weights generated by the STRF model, and significant differences in the EEG response between conditions were observed, with larger perception weights in central and parietal electrodes. mTRF weights were higher in the production condition only in frontal and temporal electrodes; however, this cannot be explained only by EMG, as EMG was regressed from the model. EMG artifact remains an obstacle to analysis of EEG data due to the lack of ground truth in the signal. However, we demonstrate the feasibility of studying continuous speech production without EMG artifact rendering the data too noisy. Our mTRF analysis suggests that responses to self-produced speech are suppressed during continuous speech production. This provides an opportunity for improving speech encoding/decoding models using EEG, which could be applied to medical and consumer speech BCI. The use of overt articulation in EEG studies also allows for study of motor speech disorders in naturalistic contexts.

Topic Areas: Language Production, Speech Perception

Electrophysiological Markers of Native and Nonnative Speech Contrasts Relate to Phonological Processing in School-Aged Children

Poster D53 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session D.

Vanessa Harwood[1], Alisa Baron[1], Peter Kowalchuk[1]; [1]University of Rhode Island

Phonological processing is an important early predictor of reading skill (Torgesen et al. 1999). Further, a long line of research demonstrates that event-related potentials (ERPs) as measures of phonemic discrimination

within young children predict language and literacy skills later in development (Kuhl & Rivera-Gaxiola, 2008; Naatanen, 2003). While, both the P300 and MMN ERP components have been linked to phonological processing in infants and adults, fewer studies have explored how these components relate to individual differences in phonological processing skills among school-aged children. We are interested in investigating the speech processing mechanisms associated with native and non-native speech sound contrasts in monolingual first and second-grade students using ERP. We hope to determine how the neural signatures associated with phonemic discrimination and processing (measured with the P300 component) relate to clinically useful measures of phonological working memory in young students. Methods: Thirty-three monolingual first and second-grade students (age range 6-8) completed standardized measures of phonological processing. ERPs were recorded in response to an active auditory oddball paradigm of native English contrasts (/ta/, /pa/) and non-native Spanish contrasts (/t̪a/, /d̪a/) in which participants were asked to press a button for the deviant token. Results: Preliminary English ERP results are based on a subsample of 20 children. ERP amplitude for the English contrast is correlated with Nonword Repetition performance (r=.60, p=0.006) and the Phonological Working Memory Composite of the CTOPP-2, (r=0.54, p=0.01). A trend is present within the data in which the ERP amplitude difference between the standard and deviant contrasts (i.e., deviant amplitude - standard amplitude) for native contrasts predicts the Phonological Working Memory Index, of the CTOPP-2, (R2 =.11, F (1,19) =3.45, p=0.08). Preliminary Spanish ERP results are based on a sub-sample of 10 children. No significant correlations or predictions were present among Spanish P300 ERP data. Discussion: Preliminary results suggest an association between P300 response to native English contrasts and behavioral measures of phonological working memory used in the diagnosis of language and literacy impairments in early school-aged children. The data will be further processed for the entire sample to more thoroughly explore how the neural signature of phonemic processing of native and nonnative contrasts relates to clinical measures of speech and language in school-aged children. This will be completed by the time this poster is presented.

Topic Areas: Speech Perception, Phonology and Phonological Working Memory

Audiovisual conflict triggers an inhibitory control system to facilitate speech recognition in noise

Poster D54 [Poster PDF] Visit me at [Gather.Town] in the Wernicke room during Poster Session D.

Presenter Note: Questions? Contact teubner@auburn.edu. Follow the Auburn Language, Attention, and Memory lab at https://www.facebook.com/auburnlamlab or https://twitter.com/AuburnLamLab.

Susan Teubner-Rhodes[1], Kenneth I. Jr. Vaden[2]; [1]Auburn University, [2]Medical University of South Carolina

Older adults, even those with normal hearing, struggle to understand speech in background noise [1-4]. Understanding how factors beyond the peripheral auditory system affect speech recognition in older adults can contribute to developing novel treatments. Inhibitory control refers to the ability to suppress irrelevant information and is hypothesized to facilitate selective attention to a target word and suppression of phonologically similar items during listening [5-6]. The present research aims to characterize moment-to-moment effects of inhibitory control during spoken word recognition in noise. During the performance of classic executive function tasks, competing information appears to engage inhibitory control, implemented by the cingulo-opercular network, and improve performance on subsequent trials [7-8]. Here, we extend this work by manipulating audiovisual conflict during a speech-recognition-in-noise fMRI experiment. Preliminary results show that audiovisual conflict engages cingulo-opercular regions and improves subsequent word recognition. We plan to recruit 48 healthy native-English speaking adults aged 50-89 years. Research volunteers are screened for moderate-to-severe hearing loss, contraindications to MRI scanning, neuropsychological disorders, psychoactive drug use, and cognitive impairment. Participants report demographic information and perform cognitive tasks to assess inhibitory control, vocabulary, and verbal working memory. Finally, they complete an audiovisual speech recognition in noise fMRI paradigm. Images are acquired on a 3T Siemens Prisma using a sparse-scanning echo-planar imaging sequence with 4-fold multi-band acceleration (2.5 mm3, 56 slices, TR = 8600 ms, TE = 40 ms). Participants hear 150 monosyllabic words (60 match, 60 nonmatch, 30 filler) presented at

+4 dB SNR in continuous multitalker babble during the quiet interval between MRI volume acquisitions. Their task is to repeat the word that they heard. Stimulus conflict is manipulated on a trial-by-trial basis by presenting matching pictures (e.g., bridge) or nonmatching pictures of phonological neighbors (e.g., brick) with the spoken word (e.g., "bridge"). Preliminary results from seven participants (Age: $M = 72 \pm 11$ years) show nonmatch words elicited significant activity in the dorsal anterior cingulate cortex and left inferior frontal gyrus compared to match words in each subject (voxel: $p < .01$, cluster: p-FWE < .05), consistent with neuroimaging results obtained with classic executive tasks. A verbal conflict adaptation effect was also observed: word recognition on nonmatch trials significantly improved following audiovisual conflict (Difference: $M = 0.14 \pm 0.13$; $t(6) = 2.45$, $p = .03$). These preliminary results support the prediction that engaging an inhibitory control system via stimulus conflict can benefit subsequent recognition of speech in background noise. [1] Bilodeau-Mercure M, Lortie CL, Sato M, Guitton MJ, Tremblay P. Brain Struct Funct 2015;220(2):979-97. [2] Divenyi PL, Stark PB, Haupt KM. J Acoust Soc Am 2005;118(2):1089-100. [3] Dubno JR, Dirks DD, Morgan DE. J Acoust Soc Am 1984;76(1):87-96. [4] Plomp R, Mimpen AM. J Acoust Soc Am 1979;66(5): 1333-42. [5] Sommers MS, Danielson SM. Psychol Aging 1999;14(3):458-72. [6] Taler V, Aaron GP, Steinmetz LG, Pisoni DB. J Gerontol: Psychol Sci 2010;65B(5):551-60. [7] Botvinick MM, Cohen JD, Carter CS. Trends Cogn Sci 2004;8(12):539-46. [8] Kerns JG, Cohen JD, MacDonald AW, Cho RY, Stenger VA, Carter CS. Science 2004;303:1023-6.

Topic Areas: Speech Perception, Control, Selection, and Executive Processes

Poster Session E

Are two lexica better than one? Testing computational hypotheses with deep convolutional models

Poster E1 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session E.

Enes Avcu[1,2], Olivia Newman[1], Alison Xin[3], David Gow[1,2,4,5]; [1]Massachusetts General Hospital, [2]Harvard Medical School, [3]Harvard College, [4]Athinoula A. Martinos Center for Biomedical Imaging, [5]Salem State University

Introduction: Gow's 2012 dual lexicon model suggests that the primary purpose of words is to mediate the mappings between acoustic-phonetic input and other forms of linguistic representation. Motivated by evidence from functional imaging, aphasia, and behavioral results, the model argues for the existence of two parallel wordform stores. In the dorsal processing stream the supramarginal gyrus and inferior parietal lobe mediate the mapping between sound and word-level articulatory representation. In the ventral processing stream the posterior middle temporal gyrus mediates the mapping between sound and semantic/syntactic representation. We hypothesize that this separation arose because of fundamental differences in the computational requirements of these mappings. The mapping between sound and articulation, though complex, is largely systematic and temporally continuous. In contrast, the mapping between sound and syntactic/semantic information, though partially systematic at the level of productive morphology, is largely arbitrary and dependent on identifying larger temporal units. Methods: To test this hypothesis we created two deep convolutional neural networks and trained them independently on the same set of auditory word tokens taken from the Spoken Wikipedia Corpus. A dorsal lexicon model was trained to identify individual spoken words, while a ventral lexicon model was trained to map them onto overlapping sets of collocates as a surrogate measure of semantic content. All words had unique output representations in each network informed by overlap at the level of phoneme sequences and collocate sets in the two respective models. After training both models to asymptote we tested them in two ways. To determine whether the features extracted from the models and the penultimate level constituted lexical representations we used machine classification to see whether they could be used to discriminate all individual words. Next, we extracted patterns of network activation from the penultimate level of each network and tested how well the features extracted from the dorsal network supported the ventral classification task and vice versa. Results: Both models were independently able to discriminate individual words with high accuracy. In contrast transfer testing showed that featural representations extracted from the dorsal network did not support strong classification in the ventral task. Moreover, simultaneous training of both tasks in a single network produced weaker overall performance. Conclusion or Summary: These results suggest that the development of parallel lexica in the dorsal and ventral pathways arose from computational pressures for optimizing the primary mapping functions that support lexically organized processes in the dorsal and ventral processing streams. These results are discussed in the context of similar results in the general auditory and visual systems examining the role of computational pressures in the development of localized functional specialization.

Topic Areas: Computational Approaches, Meaning: Lexical Semantics

Behavioral and connectometric evidence that conceptual representations contribute to verb-retrieval impairments

Poster E2 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session E.

Haley C. Dresang[1,2,3], Tessa Warren[1,4], William Hula[2,1], Fang-Cheng Yeh[5], Michael Walsh Dickey[1,2,3]; [1]University of Pittsburgh, [2]VA Pittsburgh Healthcare System, [3]Center for the Neural Basis of Cognition, [4]Learning Research & Development Center, [5]University of Pittsburgh Medical Center

There is controversy regarding whether, and if so how, lexical, conceptual, and motor systems contribute to language processing in general (e.g., Barsalou, 2008) and verb retrieval in particular. This study presents novel neuropsychological evidence that conceptual and motor representations may play a causal role in verb retrieval, by examining behavioral and neurological (white-matter) predictors of aphasic verb-retrieval impairments. Such impairments are common in aphasia (Mätzig et al., 2009), but it remains unclear whether lexical or conceptual-motor deficits underlie them (Dresang et al., 2019; Kemmerer et al., 2012). 17 adults with chronic (>6 months post-onset) aphasia due to a single left-hemisphere stroke and 15 age-matched controls completed a validated action-processing battery to characterize conceptual versus lexical action-processing impairments (Fiez & Tranel, 1997). Conceptual action-processing was assessed with two picture-based tasks (comparison: "Which is unrelated?"; attribute judgment: e.g., "Which would take the longest?"). Lexical action-processing was assessed with the same tasks, but verbs were judged rather than pictures. Scores were empirical-logit and z-score transformed, and separate composite z-scores for conceptual and lexical ability were calculated per participant. Verb retrieval was assessed using a 100-item action-picture naming task. In addition, diffusion spectrum imaging and connectometry analyses were employed to identify specific white matter tracts associated with degree of verb-retrieval impairment. First, Bayesian multilevel logistic regression models examined the extent to which fixed effects for conceptual and lexical composite z-scores, aphasia severity, and their interactions predicted aphasic verb-retrieval performance. Random intercepts were included for subjects and items. Results revealed positive interactions between aphasia severity and both conceptual and lexical z-scores, such that milder aphasia amplified the effect of conceptual (β=1.05, EE=0.82, 95% HDI=[-0.52, 2.76]) and lexical abilities (β=0.42, EE=0.52, 95% HDI=[-0.69, 1.49]) on verb retrieval. Furthermore, there was a negative interaction between conceptual and lexical z-scores, indicating that higher conceptual action-processing reduced the effect of lexical impairment on verb retrieval, and vice-versa (β=-1.15, EE=0.68, 95% HDI=[-2.53, 0.15]). Second, connectometry analyses examined white-matter correlates of participants' verb-retrieval performance. These analyses identified portions of tracts implicated in classic dual-stream language models (e.g., Saur et al., 2008): left inferior fronto-occipital fasciculus, inferior longitudinal fasciculus, and arcuate fasciculus (FDR<0.001). However, most tracts associated with verb retrieval were projection pathways that connect frontal and parietal cortices to subcortical motor regions: left corticothalamic pathway, frontopontine and parietopontine tracts, corticostriatal pathway, and corticospinal tract (FDR<0.001). These results show that action-related lexical- and conceptual-processing deficits both contributed to participants' verb-retrieval impairments. The neuroimaging results provide converging evidence for the contribution of action representations, highlighting the involvement of cortico-subcortical projection pathways implicated in motor functions but not included in dual-stream language models (Saur et al., 2008). Together, these findings provide novel evidence for grounded-cognition accounts, which emphasize the role of conceptual and motor representations in language performance (Barsalou, 2008). Furthermore, the behavioral interaction findings indicate that strong conceptual processing can offset the influence of language-processing impairments on verb retrieval, consistent with aphasia treatments that leverage conceptual knowledge to improve language production, including verb retrieval (Edmonds, 2016).

Topic Areas: Disorders: Acquired, Language Production

Neural correlates of spoken language comprehension in chronic stroke aphasia

Poster E3 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session E.

Niki Drossinos Sancho[1], Ajay D. Halai[2], Lauren Cloutman[1], Anna M. Woollams[1]; [1]University of Manchester, [2]MRC Cognition and Brain Sciences Unit, University of Cambridge

Aphasia affects approximately 30% of subacute stroke survivors, persisting chronically in around 20% (Engelter et al., 2006). It has recently been shown that aphasic patients' naming abilities can continue to improve many years after stroke, with these effects reflected in neural changes in brain structure. This contradicts the standard model of post-stroke aphasic recovery, which postulates that patients' linguistic abilities stabilise after approximately one year (i.e. in the chronic phase). Here we considered the potential for recovery and decline, and their neural correlates, in another linguistic dimension, spoken sentence comprehension. 34 chronic aphasic patients were assessed twice on the Spoken Sentence Comprehension subtest of the Comprehensive Aphasia Test over a time interval of at least one year (Mean change in % correct over one year = -1.967, SD = 5.03, range = -17.23 to +6.71). Detailed T1 images were acquired at the time of their first assessment. Subsequently, normalised change per year in sentence comprehension scores were entered in voxel-based correlational methodology (VBCM) analyses of tissue abnormality probability maps (Seghier et al., 2008) to associate behavioural change with neural structures. In line with the previous exploratory work, a modest amount of linguistic change, both positive and negative, occurred between assessments. Furthermore, whole brain analyses using a threshold of $p < 0.005$ voxel-level, $p \leq 0.05$ FWE corrected cluster-level revealed two clusters associated with change over time. There was a negative association between the probability of tissue abnormality and behavioural change in both areas. The larger cluster was centred in the left superior temporal cortex (STC) and extended into the planum temporale and the insula. The other cluster was located in the right anterior temporal lobe (ATL) and the insula, and it included portions of the uncinate fasciculus white matter tract. Our results are consistent with the work on the left STC's role in sentence comprehension in healthy adults (Scott, 2019). Moreover, the right ATL has previously been implicated in speech recovery in aphasia in the earlier stages post stroke (Saur et al., 2010), and has recently been shown to underpin naming improvements in chronic aphasia (Hope et al., 2017). Overall our results indicate that there is evolution of linguistic symptoms amongst those with chronic stroke aphasia, and that key areas of the neural language network are systematically related to this change. References: Engelter, S. T., Gostynski, M., Papa, S., Frei, M., Born, C., Ajdacic-Gross, V., Gutzwiller, F. & Lyrer, P. A. (2006). Stroke, 37(6), 1379-1384; Seghier, M. L., Ramlackhansingh, A., Crinion, J., Leff, A. P. & Price, C. J. (2008). Neuroimage, 41(4), 1253-1266; Scott, S. K. (2019). Science, 366(6461), 58-61; Saur, D., Ronneberger, O., Kummerer, D., Mader, I., Weiller, C. & Kloppel, S. (2010). Brain, 133, 1252-1264; Hope, T. M. H., Leff, A. P., Prejawa, S., Bruce, R., Haigh, Z., Lim, L., Ramsden, S., Oberhuber, M., Ludersdorfer, P., Crinion, J., Seghier, M. L. & Price, C. J. (2017). Brain, 140(6), 1718-1728.

Topic Areas: Disorders: Acquired, Speech Perception

Impaired phonemic discrimination in logopenic variant primary progressive aphasia

Poster E4 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session E.

Jeremy Johnson[1], Jessica Jiang[2], Elia Benhamou[3], Mai-Carmen Requena-Komuro[4], Harri Sivasathiaseelan[5], Charles Marshall[6], Anna Volkmer[7], Jonathan Rohrer[8], Jason Warren[9], Chris Hardy[10]; [1]University College London, [2]Queen Mary University

Background: Whilst current diagnostic criteria for primary progressive aphasia syndromes (PPA) emphasise impaired language output and linguistic processing, deficits of auditory analysis are increasingly recognised in PPA syndromes. We assessed phonemic discrimination and its neuroanatomical correlates in patients representing all major PPA variants, compared with typical Alzheimer's disease (tAD) and healthy age-matched individuals. Methods: 81 patients with PPA or typical Alzheimer's disease, and 73 controls performed a phonemic minimal pair discrimination task. Neuroanatomical associations of phonemic discrimination performance across the PPA cohort were assessed using voxel-based morphometry. Results: Patients with logopoenic variant primary progressive aphasia (lvPPA) as a group performed significantly worse than both the healthy control group and other PPA variants, after adjusting for auditory verbal working memory. Patients with typical Alzheimer's disease showed a similar pattern of performance to the lvPPA group. Voxel-based morphometry revealed a significant association of regional grey matter in left angular gyrus with phonemic discrimination performance. Conclusions: Impaired phonemic discrimination is a component of lvPPA and may help differentiate this syndrome from other forms of PPA. These findings speak to the emerging theme of auditory perceptual dysfunction in the progressive aphasias, with implications both for refining diagnostic criteria and developing new clinical biomarkers.

Topic Areas: Disorders: Acquired, Phonology and Phonological Working Memory

Is the emergence of speech errors in chronic post-stroke aphasia a result of ongoing compensatory brain plasticity mechanisms?

Poster E5 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session E.

Diana Lopez-Barroso[1,2,3], María José Torres-Prioris[1,2,3], Núria Roé-Vellvé[4,5], Jose Paredes-Pacheco[4,6], Guadalupe Dávila[1,2,3], Marcelo Berthier[1,2]; [1]Cognitive Neurology and Aphasia Unit, University of Malaga, Malaga, Spain, [2]Instituto de Investigacion Biomedica de Malaga - IBIMA, Malaga, Spain, [3]Department of Psychobiology and Methodology of Behavioural Sciences, Faculty of Psychology and Speech Therapy, University of Malaga, Malaga, Spain, [4]Molecular Imaging Unit, Centro de Investigaciones Medico-Sanitarias, General Foundation of the University of Malaga, Malaga, Spain, [5]Biomedical Research Networking Center in Bioengineering, Biomaterials and Nanomedicine (CIBER-BBN), Barcelona, Spain, [6]Molecular Imaging and Medical Physics Group, Department of Psychiatry, Radiology and Public Health, University of Compostela, Galicia, Spain

Traditional descriptions of aphasia have ascribed language disturbances to tissue damage, mostly in the left perisylvian cortex. This seems the simplest explanation for the impairments that imply impoverishment of the previous language abilities, for instance reduced auditory comprehension or anomia. However, symptoms expressed as repetitive verbal behaviors such as echolalia, paraphasias, perseverations, and so forth, cannot emanate from fully dysfunctional areas affected by irreversible tissue damage. We propose that in aphasia, repetitive verbal behaviors may be compensatory behaviors emerging from ongoing plastic changes occurring in the preserved tissue. Among these behaviors, conduite d'approche (CdA) and mitigated echolalia (ME) are among the more frequent verbal symptoms associated to aphasia. CdA is the repetitive and self-initiated approximation to a target word during spontaneous speech or naming tasks (e.g., target word: elephant; Patient response: eli… elipha… eliphan… iliphan… ephe… a… eli… aliphant…ile… elephant!). ME refers to the echoing of a just heard word/sentence introducing a subtle change (e.g., the examiner asks: are you a doctor?; patient response: Are you a doctor?.. I' m not a doctor!). At brain level, language deficits usually result from lesions affecting the perisylvian cortex and the underlying white matter pathways linking frontal, parietal and temporal cortices, namely the dorsal and the ventral streams. Damage to the main dorsal pathway, the arcuate fasciculus, is related to, for instance, deficits in verbal repetition and fluency, while lesions affecting the ventral pathway are mostly related to comprehension deficits. Thus, based on previous studies we propose that ME may emerge from spared dorsal stream when the ventral system is compromised, while CdA may result as an attemp of the ventral stream to compensate dorsal damage. Therefore, in this study, we analysed three cases of aphasia whose profiles were characterized by the presence of CdA, ME or both as clinical examples of the proposed idea of compensatory behaviors. Analyses based on structural MRI and PET data were performed in order to explore plastic compensation underlying the studied behaviors. In patient 1, speech was predominantly characterized by instances of CdA, patient 2 presented predominantly ME instances, and patient 3 had both CdA and ME. Results showed that patient 1 had a disconnection pattern that greatly overlapped with the dorsal language pathway, while patient 2´s lesion location bisected the ventral pathway discontinuing the projection of fibers that run through it. Patient 3 presented a disconnection pattern in-between the two previous ones. Our results suggest that CdA is related to lesions affecting in greater extent the left dorsal language pathway, while ME may emerge preferentially after damage to the left ventral one. These findings suggest that symptoms as CdA and ME, that frequently appear in the chronic stage of aphasia may represent the behavioral expression of plastic changes occurring within the preserved language network in an attempt to compensate the linguistic functions associated to the damaged pathway. The present work value lies in the fact that it offers an alternative vision of two frequent symptoms and shed light on the aphasia recovery process.

Topic Areas: Disorders: Acquired, Language Production

Comparing aphasia profiles caused by left-hemisphere glioma surgery versus stroke

Poster E6 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session E.

Andrey Zyryanov[1], Ekaterina Stupina[1], Valeriya Zelenkova[2], Elizaveta Gordeyeva[1], Evdokiia Novozhilova[1], Olga Buivolova[1], Olga Soloukhina[1], Maria Ivanova[3], Ekaterina Iskra[1,4], Natalya Gronskaya[5], Dmitry Kopachev[6], Andrey Zuev[7], Nikita Pedyash[7], Igor Medyanik[8], Konstantin Yashin[8], Andrey Sitnikov[9], Olga Dragoy[1]; [1]Center for Language and Brain, National Research University Higher School of Economics, Moscow, Russia, [2]Graduate program in Cognitive Science, University of Trento, Italy, [3]Department of Psychology, University of California, Berkeley, USA, [4]Center for Speech Pathology and Neurorehabilitation, Moscow, Russia, [5]National Research University Higher School of Economics, Nizhny Novgorod, Russia, [6]Department of Neurosurgery, Neurology Research Center, Moscow, Russia, [7]Department of Neurosurgery, National Medical and Surgical Center Named after N. I. Pirogov, Moscow, Russia, [8]Department of Neurosurgery, Privolzhsky Research Medical University, Nizhny Novgorod, Russia, [9]Department of Neurosurgery, Federal Centre of Treatment and Rehabilitation of the Ministry of Healthcare of the Russian Federation, Moscow, Russia

Converging neuropsychological and neuroimaging evidence suggests that gliomas in the language-dominant hemisphere cause a reorganization of the language network before surgery. This raises a possibility that surgical lesions may cause atypical profiles of aphasia compared to those caused by stroke, where lesions disrupt a typically organized language network. We performed k-means clustering to identify and compare profiles of aphasia after left-hemisphere glioma surgery (75 patients) and left-hemisphere stroke (76 patients). Language assessment was performed using the Russian Aphasia Test (Ivanova et al., 2016) which taps into language production (naming, picture-based sentence and discourse production), comprehension (non-word discrimination, lexical decision, auditory word- and sentence-to-picture matching, discourse comprehension), and repetition (non-word, word and sentence repetition). We used the data collected at the acute period after glioma surgery, or at the subacute or chronic stage after stroke. When possible, we filled missing scores with those measuring the same linguistic level and modality, or zeros, if a patient had global aphasia. Otherwise, patients with missing scores were excluded. The resulting samples included 62 patients with gliomas (age, years: mean 36.3, range 17–63; high-grade gliomas: 25; low-grade gliomas: 37; surgery-to-test interval, days: mean 5; range 1–32), and 59 patients with stroke (age, years: mean 56.6, range 25–80; stroke-to-test interval, months: mean 25.6; range 1–168); all were right-handed. Using the gap statistic, we determined the optimal number of clusters to be K=2 for patients with gliomas and K=3 for patients with stroke. Finally, we performed k-means clustering in each patient group (random seeds; 100 iterations). We have not performed inferential statistics for cluster comparison since we plan to extend the samples. In patients with gliomas (G), scores were higher in cluster G1 (53 patients; average RAT score 90.7%, range of subtest means 84.2–97.7%) versus G2 (9 patients; average RAT score 30.2%, range of subtest means 3.4–65.0%). In patients with stroke (S), scores were higher in cluster S1 (33 patients; average RAT score 86.0%, range of subtest means 68.0–98.1%) versus S2 (17 patients;

average RAT score 61.1%, range of subtest means 21.6–95.3%), and in cluster S2 versus S3 (9 patients; average RAT score 27.9%, range of subtest means 0.0–79.2%). These patterns were consistent across all subtests. Thus, in both patient groups, the clusters were delineated based on overall aphasia severity. However, cluster S2 showed a dissociation between word (WR: mean 69.7%, SD 17.3%) and non-word repetition (NWR: mean 33.3%, SD 20.7%). This dissociation was not evident in any other clusters (G1: WR 97.7%, SD 6.5%, NWR 92.3%, SD 11.4%; G2: WR 16.3%, SD 30.8%, NWR 11.3%, SD 22.2%; S1: WR 97.5%, SD 4.7%, NWR 85.9%, SD 13.4%; S3: WR 10.6%, SD 20.5%, NWR 6.3%, SD 15.3%). Therefore, patients with aphasia after stroke may demonstrate a selective phonological or sensorimotor integration deficit, which is less distinguishable from concurrent symptoms after left-hemisphere glioma surgery. These preliminary findings add to the growing evidence that profiles of aphasia after glioma surgery differ from those caused by a left-hemisphere stroke (Brownsett et al., 2019).

Topic Areas: Disorders: Acquired, Language Production

Atypical processing of phonotactic probability and syllable stress in dyslexic adults: an MMN study.

Poster E7 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session E.

Presenter Note: Welcome, and thank you for stopping by my poster! If you don't catch me in Gather.Town, please contact me via email a.emmendorfer@maastrichtuniversity.nl or Twitter @AlexEmmendorfer for any questions or more information about my project. I look forward to hearing from you! -Alex

Alexandra K Emmendorfer[1], Bernadette M Jansma[1], Sonja A Kotz[1], Milene Bonte[1]; [1]Maastricht University

During language development, we acquire sensitivity to regularities in the phonotactic and temporal structure of the speech signal. Sensitivity to these regularities is crucial in early word learning (e.g. Thiessen & Saffran, 2003, Dev Psychol), and may further contribute to the development of reading skills. While the relationship between phonological and reading skills is well-studied, recent developments suggest that sensitivity to the rhythmic structure of speech may also play a critical role in successful reading development (e.g. Goswami, 2011, TICS). This study examines how sensitivity to regularities in both phonological and temporal structure of speech contribute to acquisition of reading skills. We tested adults with and without dyslexia in a passive multi-feature oddball paradigm. We manipulated phonological and temporal predictability in Dutch pseudowords varying in phonotactic probability (formal deviant) and syllable stress (temporal deviant). In separate conditions, each stimulus was presented as formal deviant, temporal deviant, or standard. This allows comparing of identical stimuli across conditions, to examine the effect of these more abstract features beyond acoustic differences. We predicted the MMN would be modulated by both phonotactic probability and syllable stress in typical readers, with more predictable features (high phonotactic probability/first syllable stress) eliciting a larger or earlier MMN response, indicating facilitated change detection. This modulation is expected to be absent in dyslexic individuals (Bonte et al., 2007, Neuropsychologia; Noordenbos et al., 2013, NeuroReports). Finally, we expect the sensitivity of the MMN to correlate with measures of phonological and reading abilities. In typical readers (n = 24), we observe a sensitivity of MMN latency to variations in phonotactic probability, with high probability deviants eliciting an earlier mismatch response compared to low probability, in line with previous accounts of facilitated change detection for more predictable items. In contrast, preliminary findings in dyslexics (n = 15) show a trend towards MMN amplitude modulation rather than MMN latency. Here, deviants with low phonotactic probability elicit a larger MMN compared to high probability deviants. MMN response to temporal deviants does not show a statistically robust modulation by syllable stress in typical readers, however dyslexics show an effect of syllable stress in MMN peak latency, with first syllable stress deviants (i.e. more typical stress pattern in Dutch) eliciting an earlier MMN compared to second syllable stress deviants. This pattern suggests that speech perception in dyslexics is more disrupted by irregularities in the speech signal, requiring more processing time to evaluate less common stress patterns. Further, the observed MMN modulations appear to correlate with measures of phonological and readings skills, with higher skill levels showing a stronger MMN sensitivity. This is in line with the hypothesis that sensitivity to these regularities in the speech signal is relevant for successful development of spoken and written language skills. Our findings add to the accumulating evidence showing atypical processing of rhythmic speech structure in dyslexic individuals. The observed relationship between reading abilities and MMN modulation further suggests that acquiring sensitivity to regularities in speech may contribute to successful reading development.

Topic Areas: Disorders: Developmental, Speech Perception

Microstructural differences in dorsal and cerebellar tracts of adults with developmental stuttering

Poster E8 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session E.

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Persistent developmental stuttering (PDS) affects the fluent production of speech in about 1% of the adult population. Increasing evidence points to deficits in sensorimotor integration as key in the etiology of PDS. Indeed, a recent study in people who stutter (PWS) demonstrated subtle deficits in a nonspeech auditory-motor synchronization task (Sares et al., 2019). Data from functional imaging indicate atypical patterns of activation in motor, auditory, and cerebellar cortices of PWS (Etchell et al.,2018; Neef et al., 2015). Diffusion imaging studies point to abnormalities in dorsal, but not ventral, white matter pathways (Kronfeld-Duenias et al., 2016), as well as in cerebellar white matter pathways (Connally et al., 2014). However, there are inconsistencies in reports of the location and direction of white matter differences associated with PDS. Here, we studied microstructural white matter differences between PWS and control speakers using two complementary approaches: First, we assessed previously reported group differences in white matter diffusivity between PWS and controls. Then, we further evaluated the relationship between white matter diffusivity and sensorimotor synchronization in each group. Diffusion MRI and manual synchronization to a metronome were measured in 28 adult participants (13 PWS, 15 controls). Imaging data were acquired on a 3T Siemens scanner, using diffusion weighted, single-shot EPI sequence (b=1000; 60 diffusion directions; voxel size: 2x2x2mm). Deterministic tractography was used to identify the prominent dorsal- and ventral-stream language pathways: the arcuate and frontal aslant tract (FAT) dorsally, and the inferior fronto-occipital fasciculus (IFOF) ventrally. The three cerebellar peduncles were further segmented in each individual. Fractional anisotropy (FA) and mean diffusivity (MD) were extracted from each tract and compared between the groups using the Wilcoxon signed-rank test. Spearman correlations were calculated between mean asynchrony and diffusion measures along the tracts. The results replicate previously reported group differences in dorsal, but not ventral, language tracts. Specifically, PWS had significantly lower FA in the left arcuate, and significantly higher MD in the bilateral FAT compared to controls, but no significant group difference was detected in the IFOF (FDR controlled at q=0.05). Additionally, we found significant differences in microstructural properties of the cerebellar pathways, specifically, the middle cerebellar peduncle. Moreover, the left superior and inferior cerebellar peduncles (SCP and ICP, respectively) showed different patterns of association with mean asynchrony, such that MD within both tracts was significantly correlated with mean asynchrony only in PWS, not in fluent speakers. The difference in correlation coefficients was significant (SCP: Fisher's Z= 1.19, p=.02; ICP: Fisher's Z= -2.03, p=.02). In summary, we have replicated previously-reported microstructural differences in dorsal and cerebellar tracts of PWS compared with controls. We further found that cerebellar tracts correlate with timing behavior. Our results support the view that PDS involves modifications in dorsal tracts and that timing deficits in PWS are associated with cerebellar tracts. Evaluating structural differences in the context of sensitive behavioral measures that go beyond stuttering provide a powerful tool for discovering additional functional differences in the underlying connectivity within these groups.

Topic Areas: Disorders: Developmental, Speech Motor Control

Planning production across morphological contexts, semantic content and syntactic categories

Poster E9 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session E.

Presenter Note: This work was supported by NYU Abu Dhabi Grant G1001. Please contact me at mh5752@nyu.edu with any questions or comments! You can also find me on Twitter: @HauptmanMiriam I look forward to hearing from you.

Miriam Hauptman[1,2], Esti Blanco-Elorrieta[1,2], Liina Pylkkänen[1,2]; [1]New York University, [2]New York University Abu Dhabi Research Institute

A central goal of the study of the neurobiology of language is to delineate linguistic processing stages in time and space. Lexical, morphological, and phonological processing are viewed as separate processing levels in most models, yet neural characterizations of these levels remain under-specified, especially with regard to production. A limited number of studies using invasive intracranial electrophysiology recordings have suggested spatial and temporal selectivity for morphological processing during production (Sahin et al., 2009; Lee et al., 2018). In an attempt to extend this work to a non-invasive method, we used a tightly controlled set of stimuli and a simple production task to probe the neural correlates of inflectional morphological processing during production in healthy participants while magnetoencephalography (MEG) was recorded. Specifically, we investigated whether neural activity corresponding to morphological processing could be explained in terms of syntactic category, phonological differences, and/or aspects of word meaning. To accomplish this, we elicited productions of words orthogonalized both by semantic content ("abstract", "non-manipulable", "manipulable") and syntactic category (noun, verb, category-ambiguous) in their inflected and uninflected forms. The task was a phrase completion task in which verbs and nouns were inflected in a given context (e.g., He DREAMS). Each trial started with a visual display of the target word ("dream"), followed by an auditory presentation of the syntactic context ("He"), after which the subject inflected the target word accordingly ("DREAMS"). Critically, trials were counterbalanced such that they required phonological modification in all directions (+s, -s, or no change). Data analysis was performed using non-parametric permutation tests and spatiotemporal searchlight representational similarity analysis (ssRSA; Kriegeskorte, Mur & Bandettini, 2008; Su, Fonteneau, Marslen-Wilson & Kriegeskorte, 2012). Both analyses were performed across the left hemisphere. Results (n = 24) revealed three clear effects. First, we observed both 1) increased activity for inflection independent of phonology, syntactic category, and semantic content corresponding to a cluster extending from approximately 335 to 410 ms after the presentation of the auditory prompt, and 2) increased activity for inflection specific to phonological modifications corresponding to a cluster from 165 to 245 ms. Both effects emerged in frontal and frontotemporal regions. Second, we found increased activation for verbs over nouns throughout the left hemisphere (Shapiro, Moo & Caramazza, 2006; Bedny et al., 2008), after controlling for semantic content and inflectional status. Importantly, category-ambiguous roots elicited the same increase when produced as verbs, suggesting that this increase stems from the syntactic process involved in producing a verb. Additionally, ssRSA revealed finer-grained, distributed neural representations of inflectional, semantic, and syntactic properties over time and space. In conclusion, we find evidence of abstract grammatical inflection during production, common to verbs and nouns, suggesting the existence of a category-independent, unified inflectional system. This system appears insensitive to the phonological realization of inflection (i.e., whether or not pronouncing an "s" is involved). Further, our work suggests that previously reported increases for verbs may emerge as a result of engaging with them in a particular syntactic context, and not due to intrinsic properties of the verb roots.

Topic Areas: Morphology, Language Production

Automatic morpheme identification in reading development: MEG evidence from Fast Periodic Visual Stimulation

Poster E10 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session E.

Presenter Note: For questions, meet me during Poster Session E (Board 10) or contact me at vpescuma@sissa.it.

Valentina N. Pescuma[1,2], Maria Ktori[1], Elisabeth Beyersmann[2], Paul Sowman[2], Anne Castles[2], Davide Crepaldi[1]; [1]International School for Advanced Studies (SISSA), Trieste, Italy, [2]Macquarie University, Sydney, Australia

Morphemes are the smallest linguistic units that carry meaning (e.g., a complex word such as artist is composed of a stem, art-, and a suffix, -ist). Behavioural evidence suggests that morphological structure is accessed when processing complex words (Amenta & Crepaldi, 2012) and that reading development benefits from the morphological structure of words, especially from the presence of stems (e.g., Grainger & Beyersmann, 2017). Relying on previous EEG evidence for selective word representations in the brain (e.g., Lochy, Van Belle & Rossion, 2015), the aim of this study was to investigate selective neural responses to morphemes embedded in pseudowords, in both adults and children. Using Fast Periodic Visual Stimulation (FPVS) with an oddball paradigm (base frequency: 6 Hz, oddball frequency: 1.2 Hz) and MEG recording, we presented skilled adult readers (N=28, native English speakers) with pseudoword combinations of 12 stems (e.g., soft), 12 suffixes (e.g., ity), 12 non-stems (e.g., trum) and 12 non-suffixes (e.g., ust). The participants were administered four experimental conditions: Condition 1 with stem+suffix oddballs (e.g., softity) and nonstem+suffix base stimuli (e.g., trumess); Condition 2 with stem+nonsuffix oddballs (e.g., softert) and nonstem+nonsuffix base stimuli (e.g., trumust); Condition 3 with stem+suffix oddballs (e.g., softity) and stem+nonsuffix base stimuli (e.g., stopust); Condition 4 with nonstem+suffix oddballs (e.g., terpity) and nonstem+nonsuffix base stimuli (e.g., trumust). In order to investigate the developmental trajectory of morphological sensitivity, we asked whether a discrimination response to morphemes would emerge in developing readers as well. Fifth and sixth graders (N=17, native English speakers) were therefore presented with a simplified version of the same paradigm, using pseudoword combinations of 6 stems, 6 suffixes, 6 nonstems and 6 nonsuffixes, and only two of the four experimental conditions administered to adults (Conditions 1 and 3). All participants engaged with the unrelated task of monitoring the colour change of the fixation cross. Preliminary sensor-level analysis revealed, both in developing and skilled readers, a successful discrimination response at the oddball frequency (1.2 Hz) and its harmonics (2.4, 3.6, 4.8 Hz), in left occipito-temporal regions of interest, for the two experimental conditions in which the oddball stimuli were fully decomposable into stems and suffixes (e.g., softity). These results provide evidence for automatic morpheme identification, even at relatively early stages of reading development, and are in line with all major accounts of morphological decomposition. Critically, these initial findings also suggest that morpheme identification can be modulated by the context in which the morphemes appear. Additional ongoing analyses aim at providing more refined spatial and source-level information, in order to shed light on the neural underpinnings of morpheme identification in visual word processing.

Topic Areas: Morphology, Reading

Variability in the Adolescent Brain: the influence of age and sex on behavioural and ERP correlates of referential word production

Poster E11 [Poster PDF] Visit me at [Gather.Town] in the Broca room during Poster Session E.

Tanja Atanasova[1], Marina Laganaro[1]; [1]Faculty of Psychology and Educational Sciences, University of Geneva

To date, neurolinguistic studies largely focus on language development in childhood, or on language changes related to ageing, whereas the transition period from childhood to adulthood received far less attention. It is also common practice to neglect adolescents' distinct status in linguistic evaluation in neuropsychology, as in many oral and written language assessment tests, the 16-year-olds undergo the same task as fully-grown adults and their performances are compared to the latter. This is at odds with the knowledge that adolescence reflects a key period in cognitive, social and cortical maturation variability. A vivid illustration is the lexical-semantic network, which grows throughout one's entire life, with approximately 40,000 new words learnt from the first decade to adolescence. Lexical selection also becomes progressively more efficient in this time-period, with production latencies progressively shortening. In fact, variations in the mental processes involved in word production and their time-course are likely to accompany the observed behavioural changes. Previous EEG/ERP studies have shown that younger adolescents (14-16 y.o.) displayed distinct behavioural and electrophysiological patterns in picture naming relative to older adolescents (17-18 y.o.) and to adults, with the recruitment of different neural networks in the P100 and the N2/N170 time windows (Atanasova et al., submitted) although with huge interindividual variability. Here, we aim to shed light on the factors underlying behavioural and electrophysiological development in referential word production among adolescents. In particular, our goal is to improve the understanding of the inter-individual variability observed in previous data. To this purpose, we tried to pinpoint two possible predictors underpinning the variability in maturation in adolescents: age and sex. 60 participants (28 females), aged 13 to 18-year-old performed a picture-naming experiment under high-density EEG/ERP recording. Behavioural results suggest that both accuracy and latency are already adult-like among younger girls (13-16-year-olds), while the male counterpart is less precise and slower. We performed microstate analysis on the ERP signal, which allowed us to simultaneously track functional and time-course changes in the development of the word encoding processes. The group analyses indicated minor topographic differences between younger female adolescents and older adolescents (both male and female), while young male adolescents display a different pattern, which was closer to the children-like activation in the time-window pattern of activation described in the literature following the P100 component. To conclude, our results show mostly adult-like patterns in picture naming in the group of older adolescents, and of female younger adolescents, with immature behavioural, and neurophysiological in the 13-16-years-old boys. The time-window of variable/immature ERP patterns in the latter group has been associated to conceptual-to-lexical processes. The stabilization of production latencies and precision in girls, and the electrophysiological data illustrate that the speeding up of word production in picture naming is developing precociously among females compared to males. This should be taken into consideration when studying this population or when standardising assessment tools.

Topic Areas: Language Production, Development

Do alpha and beta oscillations dissociate in context-driven spoken-word production?

Poster E12 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session E.

Yang Cao[1], Phillip Alday[2], Vitória Piai[1,3]; [1]Radboud University, Donders Institute for Brain Cognition and Behaviour, Donders Centre for Cognition, [2]Max Planck Institute for Psycholinguistics, [3]Radboudumc, Donders Centre for Medical Neuroscience

Alpha- and beta-band oscillatory power decreases have been consistently found in spoken-word production, and localized to left lateral-temporal and lateral-frontal lobes (e.g., Piai et al., 2015; Roos & Piai, 2020). These oscillations have been linked to both motor preparation and conceptual and lexical retrieval processes (Piai et al., 2015). However, the observed power decreases have a broad frequency range comprising two “classic” (sensorimotor) bands, alpha and beta. It remains unclear whether alpha- and beta-band power decreases support a single operation or contribute independently when a spoken word is planned. Using magnetoencephalography, we probed whether the alpha and beta bands are distinct from an anatomical perspective. Participants named or judged pictures after reading a sentence that was either constraining or nonconstraining towards the final word, presented as a picture (Piai et al., 2015). To better isolate the alpha and beta bands for each individual, alpha and beta spectral distributions on the sensors were defined using an irregular-resampling auto-spectral analysis (IRASA, Wen & Liu, 2015). IRASA allows distinguishing rhythmic activity from the concurrent power-spectral 1/f modulation, which creates spurious correlations across frequency bins. The peaks of alpha and beta were defined on a participant basis using the 1/f modulation-free power spectrum averaged over the sensors that yielded large context effects on the group level. Then, we used beamforming to localize the alpha- and beta-band oscillations respectively in the pre-picture interval based on the individualized peaks of alpha and beta on a participant-by-participant basis instead of using canonical frequency bands. For both the naming and judgment tasks, the alpha and beta power decreases overlapped in the left posterior temporal lobe extending into the left inferior parietal cortex, associated with conceptual and lexical processes. To compare the spatial distribution of alpha and beta power for each task, we used the earth mover’s distance, which is a measure of the distance between two probability distributions over a region

(Rubner et al., 2000). For both tasks, the power distributions of alpha and beta at the source level in the left temporal and inferior parietal cortex did not differ, as shown by a significantly small earth mover's distance. By contrast, for the left frontal region, the power distributions differed significantly between alpha and beta for the naming task. These results are consistent with previous findings that alpha-beta oscillations in the left frontal cortex for context-driven word production are less consistent (Roos & Piai, 2020) and less critical (Piai et al., 2017) than in the left temporal and inferior parietal cortex. Our results suggest that for lexical-conceptual retrieval, alpha and beta oscillations do not dissociate and, thus, are distinct from the classical sensorimotor alpha and beta oscillations.

Topic Areas: Language Production, Meaning: Lexical Semantics

Dual-tasking with simple linguistic tasks: Cascaded, extended and delayed cognitive processes

Poster E14 [Poster PDF] [Poster Tour] Visit me at [Gather.Town] in the Broca room during Poster Session E.

Presenter Note: If you have any questions or comments, and can't find me at the conference/on Gather.Town, I am more than happy to be contacted by email at amie.fairs@univ-amu.fr. Thanks!

Amie Fairs[1,2], Phillip Alday[2], Antje S. Meyer[2,3], Alexis Hervais-Adelman[4]; [1]Aix-Marseille Universite, [2]Max Planck Institute for Psycholinguistics, [3]Donders Institute for Brain, Cognition and Behaviour, Radboud University, [4]University of Zurich

Theories of dual-tasking posit that central cognitive operations are either 1) unable to be carried out concurrently during dual-tasking, or 2) share capacity, leading to extended processing in both tasks. However, in a dual-tasking MEG experiment with two non-linguistic tasks (Marti, King & Dehaene, 2015) neither of these theoretical predictions were supported. Marti et al. (2015) found overlap in task 1 and task 2 processes during dual-tasking (evidence against theory 1), but no extension in processing time (evidence against theory 2). We applied a similar methodology to the dual-tasking of two linguistic tasks, to discern whether linguistic tasks would show a similar dual-tasking pattern, and to add to the new literature on the coordination of language production and comprehension. In an MEG study, 30 participants carried out the dual-task of syllable identification (task 1) and picture naming (task 2). In the critical condition, participants carried out both tasks simultaneously. In two other 'isolated' conditions participants carried out the dual-task, but a non-response stimulus was displayed for one of the tasks (e.g., concurrently with a syllable (task 1), a scrambled image requiring no response was presented (task 2)). MEG recordings were analysed using decoding analyses generalised across time (GAT), which is a decoding technique that allows parsing of a timeseries of neural activation data into patterns which reflect distinct cognitive states. This is achieved by training classifiers to discriminate between conditions. We trained our classifiers on data from the isolated task 1 and task 2 conditions, which allowed us to determine the sequence of cognitive processes in both syllable identification and picture naming throughout a trial. These classifiers were then tested on the simultaneous condition, to determine whether and how the cognitive processes of syllable identification and picture naming were affected during simultaneous task performance. We found that syllable identification (task 1) was largely unaffected by dual-tasking, showing a similar sequence of cognitive processes when carried out in isolation versus simultaneously. In contrast, picture naming (task 2) was substantially affected by the dual-task context. Processes up to 500ms proceeded similarly in the isolated and simultaneous conditions. However, during the dual-task, processes beginning after 600ms were delayed by 50-100ms in comparison to when carried out in isolation. These delayed processes were also extended in duration by 500ms, from 400-500ms when carried out in isolation to 1000ms during the dual-task. Remarkably, the magnitude of the extension of cognitive processes was consistent with the response latency difference between naming in isolation and during the dual-task (459ms), suggesting a causal relationship between the extension in cognitive processing and naming speed. These results do not follow either of the theoretical predictions, nor are in line with the results of Marti et al. (2015). Instead, our results suggest that task coordination is strongly dynamic, with the coordination pattern

potentially affected by the specific dual-task context. Moreover, these results give insight into how language production and comprehension processes may be coordinated.

Topic Areas: Language Production, Methods

fMRI evidence for shared lemma representations in speech production and comprehension

Poster E15 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session E.

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On a prominent account, lemma representations map the meaning of words to their sounds and vice-versa, and are shared across production and comprehension (Levelt et al., 1999). A meta-analysis of word production studies suggests that lemmas are localised in the middle of the left middle temporal gyrus (left mMTG) (Indefrey, 2011; Indefrey & Levelt, 2000, 2004). This account is supported by other evidence from production and comprehension studies in healthy subjects and patients (Dronkers et al., 2004; Piai et al., 2014; Roelofs, 2014; Schwartz et al., 2009). An alternative account, from a series of reviews based on comprehension data, suggests that sound to meaning mapping during word comprehension is carried out bilaterally in the posterior middle temporal and posterior inferior temporal cortex (bilateral pITG & pMTG)(Hickok & Poeppel, 2000, 2004, 2007). These claims have been challenging to test empirically due to the abstract nature of lemma representations. The sole purpose of a lemma is to link together various types of representations associated with a word (conceptual, syntactic, and phonological representations). Thus, any single task on word comprehension or production would always involve another type of representation making it hard to attribute observed effects specifically to lemmas. To circumvent this problem, we conducted an fMRI study, using four tasks that targeted different modalities (production and comprehension) and different levels of representation (semantic and syntactic) to which the lemma connects. We analysed activities common to all four tasks to determine if the left mMTG or bilateral pITG and pMTG are activated across all the four tasks regardless of modality or level of representation. We used behavioural and fMRI data from 32 healthy native speakers of Dutch. Each participant performed all the four tasks. For production, participants named pictures without determiner (bare picture naming) and with determiner (gender-marked picture naming). For comprehension, participants judged whether the spoken words denoted something man-made or natural (semantic classification -conceptual level) and whether the words were associated with the Dutch determiners “de” or “het” (gender classification – syntactic level). Participants were scanned with a Siemens 3T scanner with a multi-band multi-echo EPI sequence (TR-1.5 seconds). Contrast images of each task against the implicit baseline for each participant were compared across participants. The activation maps of all the four tasks were subjected to a conjunction analysis to identify brain regions that were activated reliably across all the four tasks. We specifically looked within two regions of interests (ROIs), namely the left mMTG and bilateral pITG and pMTG combined to see whether one or the other model was more likely. In our analysis, significant clusters were found in the left mMTG and in the pITG and pMTG, albeit only in the left hemisphere, suggesting a role of both these ROIs in lemma access and, thus, that the two models are not mutually exclusive. Our results support the claim that lemma representations underlie both production and comprehension and reveals the likelihood of a wider, more distributed neural basis of the lemma than has been suggested so far.

Topic Areas: Language Production, Speech Perception

Production-comprehension asymmetries for constituent structure building in the language network

Poster E16 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session E.

Presenter Note: Thank you for visiting my poster! I'm looking forward to discussing this study during the poster session on Friday, if you can't make it please reach me at laura.giglio@mpi.nl or DM me on twitter (lau_giglio)

Laura Giglio[1], Markus Ostarek[1], Peter Hagoort[1,2], Kirsten Weber[1]; [1]Max Planck Institute for Psycholinguistics, [2]Donders Institute for Brain, Cognition and Behaviour

The neurobiology of sentence production has been largely understudied compared to the neurobiology of sentence comprehension, due to difficulties with experimental control and motion-related artifacts in neuroimaging. A recent meta-analysis of syntactic processes in production and comprehension found that only the left inferior frontal gyrus (LIFG) was reliably active in production studies, but a larger network including the left temporal lobe was engaged in comprehension (Indefrey, 2018). This discrepancy in the sentence production and comprehension networks is incompatible with previous evidence for shared resources in production and comprehension (Segaert et al., 2012). To add to the current understanding of the brain organization of language production, we studied the neural response to constituents of increasing size in production, and investigated the differences between the production and comprehension of these stimuli. Participants (n = 40) had to produce or listen to sentences in a gradient of constituent structures based on a visual prompt in an fMRI study. The stimuli (in Dutch) could be: noun phrase list (“to think”, “to jump”, “the boy”, “the girl”), coordinated sentences (“the boy jumps”, “the girl runs”), or embedded sentences (“the boy thinks that the girl jumps”). Therefore, the conditions had very similar numbers of words but involved constituents of increasing size. We found that larger constituent sizes engaged the LIFG and LMTG extending to inferior parietal areas in both production and comprehension, confirming that the neural resources for syntactic encoding and decoding are largely overlapping. We also found an interaction between modality and constituent size, with the LIFG and the left posterior MTG being more sensitive to constituent size in production than comprehension. An ROI analysis in predefined regions (LIFG and LMTG) confirmed that the LIFG is more sensitive to constituent size in production than comprehension, and additionally showed that the LMTG was more active in comprehension than production, and overall more active than the LIFG. Therefore, these results robustly show that the LMTG is critical for sentence processing also in production. In addition, syntactic encoding and parsing engage largely overlapping areas, providing further evidence for production and comprehension processes relying on shared resources. The asymmetries in the response in each modality reveal the distinct requirements of production and comprehension.

Topic Areas: Language Production, Syntax

Distributed and overlapping neural mechanisms for lexical access and syntactic encoding during language production

Poster E17 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session E.

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A set of interconnected left frontal and temporal brain regions has long been known to support language comprehension and production. However, because of relatively fewer investigations of language production, the precise contributions of this ‘language network’ to production remain debated. In particular, it is not known whether production-related computations depend on particular regions within the network, whether production mechanisms are selective for production over comprehension, or whether different aspects of production depend on the same or distinct mechanisms. Here, across four fMRI experiments, we comprehensively characterize the role of the language regions in language production. In the critical word-production and sentence-production conditions—designed to mimic encoding of conceptual representations into linguistic utterances—participants named pictures of objects (targeting lexical access) and described pictures of events (targeting syntactic encoding) either by speaking out loud or typing on a keyboard. In two control conditions, they repeated sequences of nonwords, also by speaking or typing (targeting low-level production demands), and made semantic judgments on event pictures (targeting visual semantic processing). Finally, they silently read lists of words and sentences (targeting lexical and syntactic comprehension, respectively). Several results emerged robustly across experiments. First, in line with prior reports, production tasks elicit strong responses in both frontal and temporal regions. The control conditions rule out the possibility that these responses are due to low-level production demands or visual semantic processing. Second, all the regions respond to both lexical access and syntactic encoding, with stronger responses to syntactic encoding (in spite of the fact that the word production condition is more difficult, as evidenced by stronger responses in the domain-general Multiple Demand network, which 'tracks' cognitive effort). This pattern implies a strong integration between lexical and syntactic processes—in line with current linguistic theorizing—and mirrors the picture that has emerged in language comprehension, where the same brain regions support word-level and syntactic comprehension, and understanding sentences elicits stronger responses than understanding lists of unconnected words. Third, responses to lexical and syntactic production appear to be robust to output modality (speaking vs. typing). This is the first demonstration of output-modality independence in high-level production. Finally, some have previously hypothesized the existence of production-selective mechanisms given that syntactic encoding is a critical part of sentence production, in contrast to comprehension, which is possible even when syntactic cues are degraded or absent. However, we find no evidence of brain regions that support syntactic encoding in production but not comprehension, either within the fronto-temporal language network, or in the rest of the brain. Instead, many language regions respond overall more strongly to the word and sentence production conditions compared to the content-matched word and sentence comprehension conditions, which suggests that production is associated with a greater cost for the language network than comprehension. Together, these results align with the idea that language comprehension and production draw on the same set of linguistic knowledge representations, and with the analysis-by-synthesis view of sentence comprehension whereby the mechanisms of production are used during comprehension to enable predictive processing.

Topic Areas: Language Production, Syntax

Functional neuroanatomy of context-driven word retrieval: across-session consistency in fMRI

Poster E18 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session E.

Presenter Note: Please stop by at my virtual poster board during poster session E on Friday, and/or watch my presenter video. I am looking forward to feedback and discussions regarding my study! Otherwise you can reach me via n.roos@donders.ru.nl Hope to see you at the conference, Natascha

Natascha Marie Roos[1], Atsuko Takashima[1], Vitória Piai[1,2]; [1]Radboud University, Donders Institute for Brain Cognition and Behaviour, Nijmegen, [2]Radboud University Medical Center, Donders Centre for Medical Neuroscience, Department of Medical Psychology, Nijmegen

Functional magnetic resonance imaging (fMRI) is suitable for mapping the functional neuroanatomy of cognitive processes. However, mapping brain areas for specific tasks with fMRI does not necessarily guarantee validity, as activity profiles can vary across multiple measurements. Another difficulty is to capture temporally dynamic modulations of brain activity, which could result in unreliable or poor mapping results. To study word retrieval in a way that more closely resembles natural language use, we employed context-driven picture naming, providing an either constrained or unconstrained setting for naming. The picture depicted the final word of a sentence, retrievable either through sentence context (constrained sentences) or only after picture appearance (unconstrained sentences). We tested the suitability of fMRI for language mapping of context-driven word retrieval and whether it captures a build-up of sentence context during language processing, as well as its consistency across sessions. Fifteen healthy speakers performed the task, reading incomplete sentences (word-by-word) and subsequently naming the picture depicting the final word. This procedure was repeated in an equivalent second session two to four weeks later. Picture naming times showed a strong context effect, confirming that constrained sentences prime the final word. Tapping into word retrieval per condition, the fMRI analysis focused on BOLD contrasts during three different points in the sentence: first word, pre-picture interval, picture appearance. We assumed that the final word of constrained sentences would be retrieved at the pre-picture interval, while this could only happen after picture appearance for unconstrained sentences. Averaged over sessions, the contrasts at sentence beginning were similar across conditions, but revealed differences between constrained and unconstrained sentences at the pre-picture interval as well as at picture appearance. Before picture appearance, the contrasts revealed BOLD increases for constrained over unconstrained sentences in classical left-hemisphere language areas as well as other areas in both hemispheres. After picture appearance, we observed a similar profile of BOLD increases for unconstrained over constrained sentences. This indicates that sentence processing is condition-specific and differences only unfold with the build-up of sentence context over the course of the sentence. Thus, the BOLD increases are likely to reflect processes of word retrieval per condition, as they only occur when the final word is known. Although the activity profiles of word retrieval per condition are similar, they do not completely converge. In terms of across-session consistency, the contrasts per time point yielded highly similar results per session, when averaged across conditions. Nevertheless, the different BOLD contrasts per session were not as similar, and session consistency was decreased when not averaging over conditions. To conclude, the context build-up over the sentence was captured as activity increase in language-related areas before picture onset in constrained sentences. The consistency of the mapping was high, but only when averaged across conditions, suggesting that more power is needed for detecting reliable activation patterns. Thus, the suitability of fMRI for mapping rapid and subtle context-driven retrieval processes may be limited, which is especially relevant for clinical purposes.

Topic Areas: Language Production, Methods

UNDER-STANDING: combinatorial processing in German

Poster E19 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session E.

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Derivational morphology is associated with the creation and representation of new words in the language, where the meaning of these new words is not always predictable from the combination of meanings of their constituents (slow+ly vs wit+ness). This has prompted a long-standing debate on whether the processing and representation of derivationally complex words reflects their underlying morphological structure. Within the spoken domain, converging neuroimaging evidence across different languages (English, Polish, Italian) has suggested that spoken derived words are processed and represented as full forms, primarily engaging the bilateral fronto-temporal network associated with the demands of perceptual and semantic interpretation of whole words (Bozic et al, 2013a,b; Carota et al, 2016). In addition, there is evidence that these representations might still retain markings of their underlying morphological structure, especially for semantically transparent forms (cf Clahsen et al, 2003). Against this backdrop of cross-linguistic data, here we studied German, a language whose marked combinatorial structure provides a potential challenge to the emerging consensus about the cognitive processing of derivational complexity. Previous findings from behavioural studies in German have shown decompositional processing of all derived words, whether their meaning is semantically transparent or opaque (Smolka et al 2015; 2018). To test the processing of derivational complexity in German within the neurocognitive context, we used fMRI to probe activation for semantically transparent and semantically opaque spoken German words. We further manipulated the affix type, such that these derivations were either prefixed or suffixed. Participants listened to individual words and occasionally performed a one-back comprehension task to maintain attention. Using univariate and multivariate analyses we show that semantic transparency and affix type combine to influence the processing of derivationally complex words in German, with opaque suffixed words triggering stronger activation in the bilateral network than the other three conditions. This strong bilateral activation patterned with the activation produced by the control condition of simple words, implying that suffixed opaque words are processed and represented as full forms, without reference to their underlying morphological structure. The relative reduction of bilateral activation for semantically transparent and prefixed opaque derivations suggests however that these words might retain traces of morphological structure in their representations. This pattern of results likely reflects the combinatorial nature of German, and while broadly consistent with the existing cross-linguistic evidence, it also points to important adaptations of the general processing mechanisms to individual language environments. Reference: Bozic et al., (2013a). Journal of Cognitive Neuroscience, 25(10), 1678-1691. Bozic et al., (2013b). Psihologija, 46, 437-452. Carota et al., (2016). Journal of Cognitive Neuroscience, 28(12), 1878-1896. Clahsen et al., (2003). Morphological structure in language processing, ed. by R. H. Baayen and R. Schreuder, 125– 55. Smolka et al., (2015). Front. Hum. Neurosci. 9, 62. Smolka et al., (2018). Language, Cognition and Neuroscience, 34(5), 599-614.

Topic Areas: Meaning: Combinatorial Semantics, Morphology

Brain signatures predict communicative function of speech production in interaction

Poster E20 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session E.

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People typically know what they want to communicate before they start speaking. However, brain indicators of communication are usually observed only after speech onset, and it is unclear when any anticipatory brain activity prior to speaking might first emerge, along with the communicative intentions it possibly reflects. Here, we investigated brain activity prior to the production of different speech act types, namely request and naming communicative acts. We hypothesized that activation of the motor system would be found in the production of requests as opposed to naming, due to the inherent action-relatedness of the former. This would extend findings of studies from the modality of speech comprehension (Egorova et al., 2013; 2014; 2016; Tomasello et al., 2019) to speech production. Subjects' EEG responses were measured while they named or requested real objects by uttering single words embedded into language games with a partner, similar to natural communication. The same words were used for both communicative intentions, as well as the reaction of the experimenter was closely matched between naming and request conditions. EEG recordings revealed that starting ca. 600 ms before speech onset, an event-related potential maximal at fronto-central electrodes, which resembled the Readiness Potential (Di Russo et al., 2017), was significantly larger ($p< 0.01$) when preparing for requests as compared with naming actions. Analysis of the cortical sources of this anticipatory brain potential indicates an involvement of fronto-central motor regions for requests but not for naming. These differences could not be accounted for by confounding factors that might have differed between speech acts, such as articulatory EMG activity or acoustic properties of the utterances themselves. Our results indicate that different neuronal circuits underlying the processing of different speech act types activate already before speaking. Moreover, requests – as opposed to naming - were associated with stronger activation of the motor system, which parallels findings in the comprehension modality (van Ackeren et al., 2016; Egorova et al., 2016; Tomasello et al., 2019). These results point to a role of the motor cortex in the brain representation of requests, which may reflect the speakers' expectation of the partner actions typically following requests, e.g. the handing over of a requested object. This is in line with recent view that the motor system is active in a predictive fashion (Grisoni et al., 2019; Pulvermüller and Grisoni, in press). Altogether, these findings support the view that production and perception systems share mechanisms (Pickering and Garrod, 2004; Pickering and Garrod, 2013; Strijkers and Costa, 2016; Pulvermüller, 2018) and speak for an integration of the interlocutor's expected response to the representation of a given speech act. The study was supported by the DFG (Pu 97/231) and DFG Excellence Strategy (EXC 2025 – 390648296), the Freie Universität and the Einstein Center for Neurosciences.

Topic Areas: Meaning: Discourse and Pragmatics, Language Production

A new test of comprehension of irony and indirect request for French acquired-brain-injured individuals: validation and normative data.

Poster E21 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session E.

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Introduction Pragmatic disorders, including nonliteral comprehension, are frequently reported in the clinical descriptions of individuals with acquired brain injury (ABI) following a traumatic brain injury or a stroke in the right hemisphere (Jagoe, 2017). However, these disorders remain underdiagnosed due to the scarcity of adequate materials to assess such disorders in these clinical populations (Ramsey & Black, 2020). In addition, existing tools often lack the psychometric qualities and control of the relevant influencing factors – context, theory of mind, and executive functions. To overcome these limitations, we recently developed a test: the IRRI test. This test includes two tasks, one allowing the assessment of irony comprehension (IR), the other the assessment of indirect request comprehension (RI), and manipulates the influencing factors mentioned above (Cordonier, Fossard & Champagne-Lavau, in press). The aim of the current research was twofold: (1) to evaluate the psychometric qualities of the two tasks (IR and RI) of the IRRI test and (2) to provide normative data for healthy French-speaking people of Switzerland. Method Convergent validity was established with a sample of 33 participants with ABI who completed the IRRI and a test measuring the same construct (MEC, Joanette et al., 2004). Discriminant validity was tested by comparing the performance on the IRRI scores of these 33 ABI participants with 33 matched healthy control (HC) participants. Test-retest fidelity was measured by administrating the IRRI twice to 9 healthy participants with a 6-month interval. The blind scoring of 20% of the data by a second judge finally enables us to determine our tool's inter-judge fidelity. The IRRI test was then administered to 106 HC individuals to establish the normative data. Results and discussion A significant correlation was found between the two tasks of the IRRI test and the MEC (IR: $p < .007$; RI: $p < .0002$), attesting good convergent validity. The two IRRI tasks also allowed to distinguish ABI individuals from HC participants (IR: $p < .002$; RI: $p < .0001$), suggesting good discriminant validity. The test-retest (ICC = 0.913 and 0.948) and inter-judge fidelities (K = .828) were excellent for the two tasks. Regarding normative data, there was no effect of age, education, or gender. The percentile ranges for the total score for each task were developed. The tasks designed in this study fill a significant gap and might contribute to better diagnostics and therapies of pragmatics disorders in ABI participants. References Cordonier, N., Fossard, M., & Champagne-Lavau, M. (in press). Differential Impairments in Irony Comprehension in Brain-Damaged Individuals: Insight From Contextual Processing, Theory of Mind, and Executive Functions. Neuropsychology. Jagoe, C. (2017). Disruption of pragmatics in adulthood. In L. Cummings (Ed.), Research in clinical pragmatics (Series): Perspectives in pragmatics, philosophy & psychology (Vol. 11). Cham, Switzerland: Springer-Verlag Joanette, Y., Ska, B. & Côté, H. (2004). Protocole Montréal d'Évaluation de la communication. Isbergues, France : Ortho Édition. Ramsey, A., & Blake, M. L. (2020). Speech-Language Pathology Practices for Adults With Right Hemisphere Stroke: What Are We Missing?. American Journal of Speech-Language Pathology, 29(2), 741-759.

Topic Areas: Meaning: Discourse and Pragmatics, Disorders: Acquired

A model of on-line temporal-spatial integration for immediacy and overrule in discourse comprehension

Poster E22 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session E.

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During discourse comprehension information from prior processing is integrated and appears to be immediately accessible. This was remarkably demonstrated by an N400 for "salted" and not "in love" in response to "The peanut was salted/in love" (Nieuwland and Van Berkum 2006). Discourse overrule was induced by prior

discourse featuring the peanut as an animate agent. This immediacy effect poses a challenge: how can all previously seen information be kept immediately available? We hypothesize that such immediate discourse overrule requires a model that integrates information at two timescales. One is over the lifetime, and includes event knowledge and word semantics. The second is over the discourse in an event context. In this context, the current research models one aspect of the brain state during discourse processing as a discourse vector, a cumulative aggregate of the word embeddings encountered during the discourse. In this model both timescales are accounted for by temporal-to-spatial integration of experience into distributed spatial representations, providing immediate access to experience accumulated over different timescales. For lexical semantics temporal-to-spatial integration is modeled by a word embedding system (Wikipedia2vec) trained by sequential exposure to the entire Wikipedia corpus (Yamada, Asai et al. 2020). For discourse temporal-to-spatial integration is modeled by a recurrent reservoir network trained to generate a discourse vector for input sequences of words. Recurrent connections in the reservoir preserve activation of all previous inputs, thus respecting the immediacy assumption. The N400 is modeled as the difference between the instantaneous discourse vector and that word. We predict this model can account for semantic immediacy and discourse overrule. The model simulates lexical priming (Chwilla, Brown et al. 1995), discourse overrule in the peanut in love discourse (Nieuwland and Van Berkum 2006) and demonstrates that an unexpected word elicits reduced N400 if it is generally related to the event described in prior discourse, and that this effect disappears when the discourse context is removed (Metusalem, Kutas et al. 2012). This neurocomputational model is the first to simulate immediacy and overrule in discourse-modulated N400, and contributes to characterization of on-line integration processes in discourse.

Topic Areas: Meaning: Discourse and Pragmatics, Computational Approaches

Brain network reconfiguration for narrative and argumentative thought

Poster E23 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session E.

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Introduction. The brain constructs reality through two fundamental cognitive functioning. Narrative thought interprets the events by interlinking them according to temporal causality and implied purpose. Argumentative thought validates the propositions by arranging them into the logical structures framed in language. Most studies in cognitive neuroscience only focus on the neural basis of narrative thought. They highlight the crucial role of the default mode network (DMN) in narrative comprehension. Two hypotheses concern the relations between the neural bases of narrative and argumentative thought. The content-dependent hypothesis proposes that narrative and argumentative thought are irreducible to one another. While narrative thought relies on constructing and updating the "situation model" about the state of affairs, argumentative thought relies on identifying and evaluating the "informal logic" embedded in language usage. Whereas the DMN's function fits the role of situation model construction, brain systems relating to language and reasoning are likely candidates underlying argumentative thought. The content-independent hypothesis, instead, suggests that narrative and argumentative thought are fundamentally the same. Both rely on long-timescale information processing. The DMN should underly both modes of thought by virtue of its wide temporal receptive window. This study aimed to test these two hypotheses by investigating and comparing the neural bases of narrative and argumentative thought. Methods. In this fMRI study, we employed the inter-subject correlation (ISC) and the inter-subject functional connectivity (ISFC) methods to investigate the regional neural responses and interregional functional connectivity induced by naturalistic narrative and argumentative audio texts. In the intact-text conditions, participants listened to the intact texts, thus could construct coherent thoughts. In the scrambled-sentence conditions, participants listened to the same texts but with a random sentence order, thus could only process each sentence's literal meaning. The neural correlates of narrative and argumentative thought were defined by the contrast between the ISC/ISFC in the intact-text conditions to the ISC/ISFC in the scrambled-sentence conditions. Results. The results intriguingly showed both commonalities and differences between the neural correlates of narrative and argumentative thought. The frontoparietal control system was involved in both

modes of thought. The DMN is only engaged in narrative thought, whereas the functional couplings between the intraparietal sulcus in the frontoparietal control system and multiple perisylvian areas in the language system only increased during argumentative thought. Summary. Instead of DMN, the results suggest that the frontoparietal control system may serve as a general working memory system, which iteratively accumulates and updates long-timescale information of both kinds. The DMN, which shows sensitivity to only the narrative thought, may serve to situation modeling. The coordination between the frontoparietal control system and the language system is essential to argumentative thought featured with informal logic structures. Our findings reconcile the content-dependent and content-independent hypotheses, showing how diverse mental activities arise from the segregation and integration of the existing brain systems.

Topic Areas: Meaning: Discourse and Pragmatics, Reading

Left temporal lobe language hubs – a comparative approach

Poster E24 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session E.

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The left temporal lobe is a major brain structure involved in language. Non-human primates, such as chimpanzees and bonobos, have language-like abilities and it has been argued that modifications to temporal lobe connectivity might have enabled semantic processing that later evolved into a highly complex language in humans. Previous studies have suggested that the posterior middle temporal gyrus (pMTG) may represent a crucial hub in lexical-semantic processing. For example, it has been repeatedly shown as involved in semantic learning and argued to function as a lexical interface (Rodríguez-Fornells et al., 2009). Anatomically, it serves as a cortical termination for an extensive number of white-matter pathways from both dorsal and ventral streams (Turken & Dronkers, 2011). However, it is unknown if the pattern of connectivity of this region is unique to humans. In the present work, we explore how the pMTG system changed in evolution by comparing white-matter tractograms of humans and chimpanzees. Additionally, the anterior temporal lobe (ATL) was examined as a second semantic node ('hub-and-spoke' model; Lambon Ralph et al., 2016). High-resolution diffusion-weighted images (DWI) were obtained from 50 humans (Janssen et al. submitted) and 29 chimpanzees (Pan troglodytes, from an archive of scans obtained prior to the 2015 implementation of U.S. Fish and Wildlife Service and National Institutes of Health regulations governing research with chimpanzees, Bryant et al., 2020). In humans, ATL and pMTG regions of interest (ROIs) were extracted from the AAL anatomical atlas; for the chimpanzees, these ROIs were adapted accordingly. Then, in both species, FSL Probtrackx probabilistic tractography was applied to DWIs to define the extent of white matter converging towards these ROIs. Finally, these maps were compared to the distribution of canonical language-related white-matter tracts in a quantitative manner. The probabilistic tracking originating from ATL revealed an extensive system of pathways formed by the ventral white-matter streams in both humans and chimpanzees. Probabilistic tracking stemming from the pMTG seed in humans showed that the ventral system extends to the dorsal pathways for language via the connection with the inferior parietal lobe. In chimpanzees, the connectivity to the dorsal stream was comparatively less robust. Quantification of these interspecies (dis)similarities indicated that the pMTG difference in connectivity was mainly explained by how this circuitry connects towards the dorsal pathways for language (up to 83% of interspecies variability explained by the connection vía the temporoparietal connection of the arcuate fasciculus, $p<.001$). By contrast, for the ATL, the interspecies difference was explained by the connectivity towards the ventral pathways for language (up to 90% by left inferior longitudinal fasciculus, $p<.001$). Our results on the pMTG connectivity highlight the uniqueness of the expansion towards the dorsal language stream. Interestingly, the circuitry related to the ATL is similar between humans and chimpanzees, in both cases showing a robust connection with the IFOF. While the ATL/IFOF system may play a crucial role in

conceptualization (Sarubbo et al., 2019), we suggest that the cortical area enabling a connection from the ventral towards the dorsal (phonological) language networks in humans lies in pMTG.

Topic Areas: Meaning: Lexical Semantics, Language Production

Processing aspects of verb aspect: an ERP study on Russian

Poster E25 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session E.

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Introduction: Russian verbs are marked for both tense and aspect reflecting the temporal characteristics of a situation. Tense is a grammatical category that expresses time reference and uses predominantly morphological inflection. Previous studies showed that inconsistency between a temporal adverb and a following verb regarding time reference can elicit a LAN (left anterior negativity, Baggio, 2008) and a P600 (a positive deflection peaking around 600 ms poststimulus, Baggio, 2008; Dragoy et al., 2012) effect associated with detection of (morpho)syntactic anomalies and sentence reanalysis and repair processes (Coulson et al., 2008; Osterhout and Holcomb, 1992). Verb aspect in Russian represents the internal temporal consistency of a situation, not being a purely grammatical category. It uses derivational morphology, i.e., perfective and imperfective counterparts of a verb are considered to represent different lexical entries. In order to explore this approach, we investigated neurophysiological mechanisms of aspect processing in Russian, using the methods of event-related potentials (ERPs). Methods: Eighteen healthy Russian adults (11 females, mean age = 20 years) participated in the experiment. Each participant was presented with 40 sentences with an incongruence between verb aspect and preceding context and 40 correct sentences. Half of the sentences in each condition included perfective verbs (a), and the other half contained their imperfective counterparts (b). a. Proshloy vesnoy v odnu sekundu/*minut dvadtsat' uchenitsa nachertila kvadrat bez lineyki. Last spring in a second/*about twenty minutes the girl drew a square without a ruler. b. Proshlym letom tri mesyatsa/*v dva scheta arhitektor chertil plan dlya zakazchika. Last summer three months long/*in no time the architect was drawing a plan for a client. The stimuli were presented audially and for 25% of the stimuli participants were asked to judge if a word was present in the preceding sentence. The EEG was recorded using 128 active electrodes mounted on an elastic cap (Electro-Cap International Inc.). The differences between the experimental conditions were analyzed using cluster-based permutation test with 1000 repetitions. Results: Statistical analysis revealed a significant negative cluster for sentences with aspect incongruence as compared to their correct counterparts in the 300-600 ms time window over central and parietal electrodes ($p < 0.05$). Discussion: In contrast to tense violations, the incongruity between verb aspect and preceding context elicited an N400 effect (a negative deflection peaking around 400 ms poststimulus), which is a marker of semantic processing and integration (Kutas & Hillyard, 1980; Wicha et al., 2004). These results reflect the lexical nature of verb aspect in Russian: it confirms the approach according to which perfective and imperfective counterparts belong to different lexical entries.

Topic Areas: Meaning: Lexical Semantics, Syntax

Threshold definition and identification of long-distance connections in probabilistic tractography

Poster E26 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session E.

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Recent methodological advances in the diffusion neuroimaging and tractography approaches have enabled the delineation of white matter fibre pathways in vivo (e.g., Cloutman & Lambon Ralph, 2012). The tractography approach has been used to map the complex interconnected language network in the brain (Catani et al., 2005; Parker et al., 2005; Saur et al. 2008) including both dorsal and ventral pathways. However, one critical challenge is the threshold definition. Currently, there is a lack of any empirically supported standard methodology or criterion for determining thresholds. This results in a certain degree of arbitrariness in threshold selection as well as the definition of consistency across participants. Another relevant issue is the distance effect, in which the accumulation of uncertainty from voxel to voxel as the streamline is propagated tends to result in a decrease in connection probability with increasing path length. It is difficult to determine a threshold value that could identify true positives while minimising false positives in regions close to the seed and false negatives in more distant regions. Thus, the present study was designed to tackle these issues by identifying different thresholds for short- and long-distance connections based on normative distributions of connection values for different distances. To generate normative distributions of various distances, we performed probabilistic tractography in native space of a group of 54 participants' diffusion imaging data from the Human Connectome Project. For each participant, we constructed a connectome based on 230 random region of interests (ROIs) with a size of 16mm covering the entire left hemisphere. The connection values between ROI pairs across participants were grouped into 26 distance ranges. For each distance range, the average connection values across participants were randomly sampled by 100,000 times to generate sampling distributions. To identify the connectivity threshold, we applied three cut-off values (90%, 80% and 70% percentiles). The resulting patterns showed that the connectivity threshold decreased with distance ranges - the short-distance had higher thresholds while the long-distance had lower thresholds. We then created a language connectome based on a set of key brain regions that have been associated with language processing and applied the thresholds accordingly. The result of the language connectome showed expected short-distance connectivity between ROIs in the close regions (e.g., middle fusiform gyrus and posterior fusiform gyrus) and long-distance connectivity between ROIs in distant regions (e.g., orbital part of inferior frontal gyrus and posterior fusiform gyrus). Collectively, these results demonstrate that it is feasible to establish standard and objective thresholds, which allows for minimising false positives between ROI pairs with short distances while increasing the possibility to identify ROIs pairs with long distances.

Topic Areas: Methods, Computational Approaches

The neural mechanisms of feature-based semantic processing: Evidence from high resolution functional neuroimaging

Poster E27 [Poster PDF] [Poster Tour] Visit me at Gather.Town in the Broca room during Poster Session E.

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Prior neuroimaging evidence using multivoxel pattern analyses has offered support for a domain-general system that is active in shifting attention toward concrete (e.g. color, shape) and abstract (e.g. function, thematic context) features during goal-directed object knowledge retrieval. However, precisely how retrieval of these semantic features, as well as their conjunctions, is achieved within this hypothesized attentional system remains unexplored. Here, we employed a high-resolution functional magnetic resonance imaging (fMRI) protocol with the goal of identifying feature-selective attentional signals that would support some domain specificity according to a particular topographical organization within frontal and parietal cortex. Healthy adult participants performed a semantic decision-making task according to which they matched a cue word to one of three targets depending on a single feature (i.e., color, shape, function) or a conjunction of features (i.e., color and shape; color and function; shape and function). Univariate model-based and multivoxel pattern analyses revealed the contributions of frontotemporal and dorsoparietal networks in guiding attention to goal-oriented features and their conjunctions during semantic control. We discuss how these results support a frontoparietal network of regions guiding attention to different concrete and abstract semantic properties during flexible, goal-oriented object knowledge retrieval.

Topic Areas: Control, Selection, and Executive Processes, Meaning: Combinatorial Semantics

Auditory cortical responses to speech and environmental sounds in post-stroke aphasia: Neuromagnetic approach

Poster E28 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session E.

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Stroke-induced aphasia is a devastating and frustrating condition, with great variability in its severity and nature between individuals. Especially difficulties in speech comprehension are behaviourally complex to assess. Knowledge about the functional changes at the cortical level corresponding to the individual aphasia profile could at best build basis for neurophysiologically evidence-based rehabilitation. Humans are particularly good at perceiving behaviourally relevant sounds such as speech even in variable auditory surroundings, a process relying on both bottom-up acoustic analysis and top-down goal-directed attention (Bregman 1990). Background noise compromises speech recognition, and it influences magnetoencephalography (MEG) responses in supratemporal auditory cortices bilaterally in healthy subjects differently for speech than other natural stimuli (Renvall et al. 2012). For speech processing, prior knowledge of, e.g., word-form representations, has been suggested to be most influential when the speech signal is degraded (e.g., Norris et al. 2008). Here we use MEG to study cortical processing of speech and environmental sounds presented alone and in background noise in people who have suffered a left-hemispheric ischemic stroke and have deficits in speech comprehension. The different types of natural, semantically meaningful stimuli (speech, environmental sounds) allow us to tap into the possible stimulus specificity of cortical processing deficit in these individuals, while the use of background stimulus noise can highlight the induced disturbances of relying on existing word-form representations. We measure Finnish-speaking volunteers (aged 18-75 years) who are first behaviourally assessed with linguistic tasks including Western Aphasia Battery (subtests of spoken language), and a set of experimental Finnish tasks (auditory minimal pairs with words and non-words, word-picture matching and synonym-judgment tasks). The behavioural testing serves to ensure the existing speech comprehension deficit and for comparing the behavioural and cortical effects at individual/subgroup level. In the first phase we recruit individuals (n=25-30) with chronic aphasia (> 12 months post-onset). After this we will recruit acute patients with aphasia (< 1 week post-onset) from the neurology wards at the University Hospital in Helsinki. Healthy age-matched participants will be tested as controls. In the MEG measurement, the participants listen to the experimental sounds presented randomly with an interstimulus interval of 3 seconds. The speech sounds are consonant-initial, eight-letter common Finnish nouns. The environmental sounds have been collected from the Internet, and comprise, for example, animal cries, traffic sounds, and nonlinguistic human sounds (e.g., laughing). All stimuli are presented both in isolation and embedded in noise (+18 dB SNR) within the experimental runs. The participants are asked to listen carefully to the stimuli during the measurements (12 min + 8 min with a pause in-between), and respond with a finger lift when they hear a tone beep (7% of the trials). In order to assure that the aphasic participants understand the instructions, the experimental protocol is explained with pictures. Participant recruitment was disturbed due to the pandemic, but our measurements are expected to continue in the Fall 2020. So far, we have behaviourally tested and conducted the MEG measurements with 11 patients, and the data analysis has been initiated.

Topic Areas: Disorders: Acquired, Perception: Auditory

Theta-Gamma rhythms in Speech Production

Poster E29 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session E.

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Background - While brain regions involved in speech and language production have been identified, the underlying brain networks that enable these regions to communicate are complex and encompass many levels of cortical control. Irrespective of the modalities in which stimuli are initially processed by early sensory cortices, naming behaviours consist of understanding the meaning of stimuli, followed by formation and articulation of a relevant response. At a cortical level, this process requires rapid and dynamic sensorimotor coordination across large-scale brain networks. Neuronal oscillations have been argued to provide the link between cognitive processes and underlying neural computations by enabling dynamic coordination between brain regions within a given neural network. In particular, gamma oscillations are generated from local processing of fast-spiking interneurons within task-relevant regions, while theta oscillations are thought to underlie aspects of long-range network functional connectivity. Theta and gamma oscillations are known to interact through a process called phase-amplitude coupling (PAC), in which gamma power is modulated by theta phase. Theta-gamma PAC is thought to be an important mechanism by which the brain is able to modulate local activity across distant brain regions within a functional network, and control behaviour. Here, we investigate theta-gamma cortical dynamics within the speech and language network. Aim – Our main aim is to elucidate cortical oscillatory mechanisms that support sensorimotor integration in spoken language. We plan to characterise the cortical spatiotemporal dynamics of theta and gamma oscillations during word retrieval in overt picture naming. Methods – 30 healthy adults will undergo magnetoencephalography (MEG) while completing an overt picture naming task. Visual stimuli will consist of black and white pictures randomised to a clear or scrambled condition. This will be paired with an auditory stimulus time-locked to the onset of the visual stimulus. The auditory cue will be randomised to one of two conditions; initial phoneme of target word or a noise-vocoded control. Participants will be asked to name items as quickly and accurately as possible. In trials where participants are unable to name an item, they are instructed to respond 'no'. We will separate trials into naming and non-naming ('no' response) trials and run a time-frequency analysis in the theta and gamma bands, including an index of theta-gamma PAC, to test for a main effect of, and interaction between, visual and auditory stimuli in the naming vs non-naming trials. Hypothesis – Theta-gamma coupling reflects functional integration between sensorimotor regions within the spoken language network during naming. We predict theta and gamma activity will be localised to task-relevant regions and gamma power will be modulated by theta phase. Significance – This study will compliment a now large body of work highlighting the fundamental role of neural oscillations in speech production and perception. These findings will further our understanding of how general neuronal computational principles support sensorimotor integration in the context of healthy speech and language production, and how this activity might be disrupted in patients with naming difficulties (e.g. Aphasia).

Topic Areas: Language Production, Multisensory or Sensorimotor Integration

Cortical spectral fingerprints of syntactic and semantic processing during auditory language comprehension: an intracranial-EEG study.

Poster E30 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session E.

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Language comprehension is known to recruit a large fronto-temporo-parietal network (Friederici, 2011, Hagoort, 2013). Few studies have focused on neural dynamics underlying auditory language comprehension, as well as the specific dynamic signatures of semantic and syntactic information processing during sentence comprehension. Previous fMRI studies localized regions involved in these processes but did not inform on the underlying temporal dynamics of auditory language processing. To tackle this issue, we are collaborating with epileptic patients implanted with intracranial electrodes for therapeutic purposes, and measured brain activity. In this study, patients perform an auditory sentences comprehension task designed to dissociate the semantic and the syntactic information processing (including four different auditory stimuli types: sentences, jabberwockys, lists of words and lists of pseudo-words, Mazoyer et al., 1993; Pallier et al., 2011). Thus, we will evaluate: 1) the specific signatures for each frequency band and each experimental condition; 2) the relationship between the auditory signal and dynamic activity at the level of temporal regions (Oganian & Chang, 2019); 3) perform phase and functional connectivity analyses between different cortical regions in order to assessed specific spectral signatures of semantic and syntactic processing. For now, preliminary results showed, in 2 patients, a specific difference in the low-gamma (30-50Hz) and high gamma (50-150Hz) activity for sentences as compared to word lists or pseudo-word lists. Larger differences in oscillatory brain activity were observed at the left superior temporal gyrus networks for the non-syntactic conditions (word or pseudo-word lists) than for sentences. These preliminary results suggest that the failure to integrate new elements with previous ones in an ongoing auditory stream would lead to an increase or a sustain in high frequency activity in specific nodes of the language network. We expect to bring new data on the brain temporal dynamic of auditory sentence comprehension in line with semantic and syntactic information processing.

Topic Areas: Speech Perception, Syntax

Cross linguistic differences can obscure L2 learners' ability to generate predictions: Evidence from ERP

Poster E31 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session E.

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INTRODUCTION: We examined the role of cross-linguistic influence in L2 anticipatory processing, to adjudicate between contrasting proposals regarding L2ers' predictive abilities. While some authors posit that L2ers have reduced ability to predict overall (Grüter et al., 2016), others claim that prediction is similar in the L1 and L2, although learners' predictions can be obscured by L1-L2 differences (Kaan, 2014). RESEARCH QUESTION: When reading wh-question/answer pairs, do L2ers use contextual information and information structure (i.e., knowledge that the slot following an "it-cleft" is reserved for the phrase answering the wh-question) to anticipate the form of English possessive pronouns? Crucially, English possessives differ depending on whether the possessor is male (Tom's mother/father= his mother/father) or female (Anna's mother/father= her mother/father). A similar rule operates in Swedish, but not in Spanish. METHODS: We tested 24 L1-English speakers, 25 L1-Spanish L2-English learners (advanced), and 32 L1-Swedish L2-English learners (advanced). Participants read 64 stories about two characters planning some event: "Tom and Ruth are throwing a party. Tom's mother is social and loves parties. However, Ruth's aunt is shy and hates parties." The stories motivated why one of the characters' relative should be invited (Tom's mother) but not the other character's relative (Ruth's aunt). Then, a wh-question asked comprehenders their opinion about which relative would be invited: "In your opinion, which of the two will they invite to the party, Tom's mother or Ruth's aunt?" The two nouns that could answer the question (Tom's mother/Ruth's aunt) were the Focus nouns. Participants then read one of two responses (presented in RSVP: 450/300ms) while their EEG was recorded. The response always included an it-cleft, which signaled that the upcoming phrase was the Focus noun (the answer) (Alemán Bañón & Martin, 2019). In addition, the expectedness of the Focus noun was manipulated (counterbalanced across the 64 items). Expected_condition: "In my opinion, it is his mother that they will invite"; Unexpected_condition: "In my opinion, it is her aunt that they will invite". Crucially, the prenominal possessives in the responses differed depending on whether the noun was expected (his mother) or unexpected (her aunt) (counterbalanced). This allowed us to measure prediction effects at the possessive, before the target noun appeared. Moreover, both Focus nouns were of the same gender as the unexpected possessive ("mother/aunt" refer to females, as does "her"). Such an agreement dependency only operates in Spanish. Thus, L1-Spanish learners might experience interference from Spanish, while L1-Swedish learners might experience facilitation from Swedish, which has a similar his/her alternation to English. RESULTS/DISCUSSION: Across groups, unexpected nouns elicited a larger N400 than expected ones between 200-500ms in Central-Posterior, $F(1,78)=18.38; p<.0001$. This suggests that the contexts biased participants as intended. Unexpected prenominal possessives also yielded a larger N400 than expected ones between 250-400ms in Central-Posterior, $F(1,78)=5.49; p=.022$. This effect interacted with Group, $F(2,78)=3.67; p=.03$. Follow-ups revealed that the N400 for unexpected possessives only emerged in the

L1-English and L1-Swedish groups. Results suggest that prediction is similar in L1 and L2, although learners' predictions can be obscured when the L1 and L2 conflict (Kaan, 2014).

Topic Areas: Multilingualism, Meaning: Discourse and Pragmatics

Bilingual experience modulates neural oscillatory dynamics in task switching

Poster E32 [Poster PDF] [Poster Tour] Visit me at [Gather.Town] in the Wernicke room during Poster Session E.

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Bilingualism has been found to affect neural underpinnings of domain-general cognition, irrespective whether this manifests in task performance (Grundy et al., 2017). A growing body of literature has also found individual differences in (bilingual) language experience to modulate the nature and extent of neurocognitive adaptations (see DeLuca et al., 2020 for review). EEG captures oscillatory activity produced by different functional networks in the brain, allowing us to examine executive processes with high temporal precision. However, few studies have examined effects of bilingual experience on oscillatory activity underlying executive functions. Herein, we used EEG to examine the hypothesis that bilingual experience would modulate oscillatory dynamics towards increased efficiency in task switching. 111 healthy young adults (76 bilinguals, 35 monolinguals) completed a number-letter switching task (adapted from Rogers & Monsell, 1995) while EEG was recorded. Bilingual participants spoke English plus one other language. The number-letter task contained four blocks of intermixed stay and switch trials sandwiched between single blocks of single-task conditions. Participants also completed the Language and Social Background Questionnaire (Anderson et al., 2018) and Bilingual Switching Questionnaire (Rodriguez-Fornells et al., 2012). EEG was analyzed via time-frequency representations (TFR), with epochs locked to cue-onset. Oscillatory activity and task performance (RTs and accuracy) were examined by switch costs (switch- minus stay trials) across- and within groups, between groups within conditions, and switch cost between groups. Continuous measures of bilingualism, derived from the questionnaire data, were additionally modelled with RTs and oscillatory activity using structural equation modelling (SEM). Switch trials incurred significantly slower RTs than stay trials, and were also associated with significantly higher theta (3-5Hz) power in central electrodes, 150-750ms post cue onset and lower alpha (8-12hz) power in centro-parietal electrodes 400-1000ms post cue onset. There were no significant group differences in task performance (RTs and errors) either for switch costs or within conditions (all ps >0.05). There were no significant group differences in theta- or alpha power for the switch costs, either. However, group differences in oscillatory activity were observed within conditions. Within the switch condition, monolinguals were found to exhibit significantly higher theta power than bilinguals in central electrodes 0-700ms post cue-onset, and greater alpha power in centro-parietal electrodes, 0-1000ms post cue onset. In the stay condition, monolinguals exhibited significantly greater theta power in central electrodes 150-1000ms post cue onset, and greater alpha power in central electrodes 0-1000ms post cue-onset. The higher theta power induced in monolinguals in both conditions suggests a general increase in executive control requirements during the task. The greater alpha power for monolinguals in both conditions suggests increased inhibition of task-irrelevant brain regions to handle switching demands. SEM revealed several relationships between language experiences and neurocognitive outcomes. For instance, the degree of language switching was negatively related to the degree of cue-locked theta- and alpha power. Theta power, in turn, was negatively correlated with RT, whereas alpha power was positively correlated with RT. These relationships support the hypothesis that variations in bilingual language use modulate adaptations to increased efficiency of handling domain-general switching demands.

Topic Areas: Multilingualism, Methods

Coherent patterns of ongoing brain oscillations predict the attainment of foreign-language complexity in older learners

Poster E33 [Poster PDF] [Poster Tour] Visit me at [Gather.Town] in the Wernicke room during Poster Session E.

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Electrophysiological markers of the brain activity at rest have been shown to reflect intrinsic activity from which subsequent cognition is generated and monitored. Learning a new language is one of the most complex human achievements, especially in light of increasing difficulties caused by age-related cognitive declines (Kliesch et al., in review). An EEG study by Prat et al. (2018) showed that resting-state (rs) connectivity in the theta, alpha and beta bands predicted foreign language (L2) scores younger adults. We investigated rs-EEG connectivity markers of L2 development in (Swiss) German, older learners of Spanish. We attempted to elucidate the relationship identified by Prat et al. (2018) by focusing on L2 proficiency decomposed into the triad of complexity, accuracy and fluency (CAF; Housen & Kuiken, 2009). Twenty-six Swiss-German adults aged 64-74 years participated in a 7-month Spanish course for beginners comprising approximately 5 hours of training per week. Receptive and productive L2 were scored weekly, from which measures of accuracy, fluency and complexity were extracted. Each subject's development was quantified as the slope of a linear regression over time. Before the training, 6-minutes eyes-closed rsEEG were recorded. The Fourier-transformed rs data were source-localized in the theta (4-6Hz), alpha (7.5-12.5 Hz) and beta (13-29Hz) bands, and parcellated according to the AAL atlas (Tzourio-Mazoyer et al., 2002). Connectivity was estimated by extracting the imaginary part of coherence for each subject and pairing of the 90 parcels, followed by dimensionality reduction via principal component (PC) analysis, retaining 15 PCs within each frequency band. These PCs were introduced as independent variables in a stepwise regression to predict each of the L2 outcomes. Robustness of the effects was tested by comparing each model's R2 against a permutation-based null distribution. The multilevel model predicting L2 development over time indicated that participants improved their proficiency in all three L2 skills, with steepest slopes observable for accuracy ($b = 0.04$, $t(27.85) = 17.70$) and fluency ($b = 0.05$, $t(26.75) = 12.68$) and less so for complexity ($b = 0.03$, $t(25.96) = 4.67$). The three measures only correlated marginally with one another (range $r = [-0.25, 0.23]$). Results from the stepwise regression indicated a significant relationship between connectivity in the alpha-band and development of L2 complexity ($R2 = 0.71$, $p < .01$). Positive correlations were mainly found spanning from left parietal and postcentral regions into bilateral prefrontal cortices, whereas negative connections were found originating in right posterior regions. Correlation between connectivity in the alpha range and the other L2 measures and between L2 measures and theta and beta band connectivity were not significant. Our findings point to a unique involvement of alpha-oscillations in the attainment of L2 complexity in older learners. As opposed to measures of accuracy, however, it is not clear whether the attainment of complexity is a desirable feature in L2 proficiency, especially at early stages of L2 acquisition, and should therefore also be discussed against the background of studies reporting negative effects of alpha connectivity on cognitive and sociodemographic markers (Becker & Hervais-Adelman, in review).

Topic Areas: Multilingualism, Development

Hearing Loss Is Associated with Cortical Decline in Auditory and Language Areas in Older Adults - A Surface-Based Morphometry Study

Poster E34 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session E.

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Hearing loss (HL) is one of the most prevalent chronic conditions in our aging population. In contrast to a widespread view, age-related HL goes beyond the cochlea comprising numerous changes along the auditory pathway and ultimately the auditory cortex. In order to quantify cortical structural changes associated with age-related HL we conducted surface-based morphometry in older adults with varying degrees of HL and supra-threshold auditory processing abilities. Eighty-four participants (between 63 - 79 years) underwent audiometric testing: An audiogram was recorded and a pure tone average (PTA: 500, 1000, 2000, 4000 and 8000 Hz) calculated. Additionally, we conducted innovative supra-threshold auditory testing aiming at auditory processing abilities, that is, temporal compression (TC) and frequency selectivity (FS). In order to obtain TC and FS, a forward-masking paradigm was used, in which a masking tone followed by a probe tone was presented, whereby gaps between masker and probe (for TC) or the masker frequencies in relation to the respective probe frequency (for FS) varied. Additionally, T1-weighted MRI scans were obtained. Our results revealed that greater PTAs were associated with lower cortical thickness (CT) of a right hemispheric cluster in parts of the superior temporal sulcus (STS) and the lateral portion of the superior temporal gyrus (STG). Interestingly, our analysis also showed that greater PTAs were associated with greater cortical surface area (CSA) of the left pars triangularis and opercularis. Furthermore, several associations between FS and CT and cortical volume (CV) of left auditory related areas were found (comprising parts of STS, lateral STG and planum temporale) and between FS and CV in the right pars orbitalis and triangularis suggesting that lower auditory processing abilities were related to greater atrophy not only in auditory-related areas, but also in higher language-related areas. No clusters were found related to TC. Although the interplay of hearing sensitivity and cortical metrics has been studied in prior research, our study can be viewed as an addition to the existing literature showing associations between age-related decline in supra-threshold auditory processing and lower integrity in auditory-related, but also higher language-related areas of the brain. Further research needs to unravel possible underlying mechanisms as well as causal effects.

Topic Areas: Perception: Auditory, Development

Can you hear what’s coming? The N200/PMN and phonological prediction

Poster E35 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session E.

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The strongest stances on linguistic prediction argue that predictions include phonological information. Previous studies have reported ERP components such as the N200 (Van Den Brink et al., 2001) and the Phonological Mismatch Negativity (PMN; Connolly & Phillips, 1994) as being specifically sensitive to violations of phonological expectations during sentence processing. The present study investigated whether an early negative deflection in the ERP was (a) specifically sensitive to phonological violations and (b) distinct from the N400, which is associated with semantic processing. Participants heard Dutch sentences such as “De bloemist bezorgde bij Lisa een mooi boeket/toetertje/tonnetje.” (English: The florist delivered to Lisa a beautiful bouquet/horn/barrel). Sentence-final words were of three conditions: predictable (boeket); partial-overlap (toetertje), for which there was phonological overlap with the first syllable of the predictable word but a different initial consonant; or no-overlap (tonnetje). The unpredictable conditions were included to test whether ERP amplitude is modulated by phonological overlap or reflects an “all-or-none” mismatch detection process (Newman et al., 2003). We have collected EEG data from 58 participants. Here we present preliminary results from a sample size similar to that of previous work (N=24). The waveforms of the unpredictable conditions diverged from the predictable condition as early as 150ms post-stimulus. To test voltage differences between conditions, we conducted linear mixed-effects regression and pairwise comparisons of the least-squares means in an early time window (150-250ms post-stimulus) and a late time window (300-500ms post-stimulus, typical of the N400). Voltage was averaged across electrodes in anterior and posterior regions of interest (ROI). This analysis revealed a more positive amplitude in the predictable condition compared to unpredictable conditions in both times windows and ROIs. We did not observe a significant difference between the two unpredictable conditions. We also analysed the distribution of the effects with a 2x2 ANOVA, including main effects of ROI and time window, on the z-transformed voltage difference between the no-overlap and predictable conditions. We found no significant main effects or an interaction, indicating that there were no differences in scalp distribution between the two time windows. This was further qualified by Bayes factor analysis. Our results are inconsistent with a distinct early negativity preceding the N400. We instead interpret the findings as an early onset to the N400. The observed effect is consistent with evidence for the early influence of predictions generated from semantic contextual constraint during word recognition (Klimovich-Gray et al., 2019). In sum, our results indicate a failure to replicate a phonology-specific N200/PMN, and therefore do not support the strongest stances on linguistic prediction.

Topic Areas: Phonology and Phonological Working Memory, Meaning: Discourse and Pragmatics

Language in reverse: Neurocognitive correlates of expert phonological encoding in backward speakers

Poster E36 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session E.

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The study of phonemic sequencing has been largely overlooked in neurolinguistic research, especially in models of language expertise. Aware of this gap, we examined cognitive and neural signatures of two expert backward speakers as a window into the mechanisms subserving phonological encoding, in general, and phoneme sequencing, in particular. Backward speech is characterized by an extraordinary capacity to rapidly rearrange the order of phonemes, such that the result is the reversed rendering of the original utterance (e.g. basket is fun /bæskɪt ɪs fʌn/ becomes nuf si teksab/nʌf sɪ tɪksæb/). Our approach included behavioral assessments of forward and backward speech and memory capacities, together with brain functional and structural magnetic resonance imaging acquisition of both backward speakers and a matched control group (n=18). The two backward speakers significantly outperformed controls in reversing words, pseudowords, and sentences (and this advantage was not explained by memory abilities). Heightened reversing skills were accompanied by brain differences. Specifically, voxel-based morphometry analyses revealed greater gray matter volume, diffusion tensor imaging – tractography analyses resulted in greater diffusion over dorsal and ventral tracts, and resting state functional connectivity (rsFC) revealed greater connectivity between areas mediating phonological, associative-visual, and domain-general processes. Yet, each subject showed a distinctive neural configuration, suggesting individual variability in the correlates of expert backward speech which, in turn, may reflect different underlying cognitive strategies. Specifically, Backward Speaker 1 showed greater diffusion (i.e. mean diffusivity, MD) in the bilateral posterior segment of the arcuate fasciculus together with enhanced rsFC between bilateral language-related seeds and other regions subserving different linguistic (e.g. auditory and articulatory) or domain-general functions. On the other hand, Backward Speaker 2 showed greater volume over the bilateral inferior and middle frontal gyrus together with higher MD in the left posterior segment of the arcuate fasciculus and in two right ventral pathways (i.e. uncinate fasciculus and inferior longitudinal fasciculus), as well as enhanced rsFC patterns between language-related seeds and areas involved in linguistic and associative-visual processes (e.g. graphemic processing). In sum, results across the two subjects suggest that expertise in phonemic sequencing is mediated by structural and functional adaptations along the dorsal stream, with additional support from ventral, visual-associative, and domain-general areas. Together, these results offer new insights on an underexplored aspect of phonological encoding, potentially illuminating models of language-related neuroplasticity and individual differences.

Topic Areas: Phonology and Phonological Working Memory, Speech Motor Control

Musicality influences higher-order prosodic processing in a second language

Poster E37 [Poster PDF] [Poster Tour] Visit me at [Gather.Town] in the Wernicke room during Poster Session E.

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Musicality heightens perception of acoustic variation in the prosody of a second language (L2), e.g. pitch and duration. We investigated whether this benefit extends to higher-order processing such as the processing of the prosodic cues to information structure by addressing the question: Does musicality facilitate the processing of accentuation in English sentences with the focus particle only by Dutch learners of English? In English sentences containing only, accentuation determines the locus of contrast (e.g. I have only CARRIED the bag vs. I have only carried the BAG), requiring the processing of accentuation-to-contrast mapping. These sentences may pose a challenge for Dutch learners of English. In Dutch, only ('alleen') typically directly precedes the contrastive focus, whereas in English, only usually precedes the verb, regardless of the focal word. As Dutch listeners expect accentuation to follow alleen, they may show similar expectations in English. We hypothesised that learners with higher musicality are more efficient in higher-order prosodic processing in L2 and predict that they will demonstrate less influence of L1 processing patterns. || Thirty-three advanced Dutch learners of English participated in an event-related potentials (ERP) experiment. They listened to British English trials, each containing a sentence with only and accentuation on either the verb or the object; the sentence was preceded by a context in half of the trials, creating four conditions. Participants also completed a short version of the Profile of Music Perception Skills (PROMS) test to measure their musical perception. The median of these PROMS-scores was used to divide the participants into a low (LM) and high musicality group (HM). We performed mixed-effects modelling (lme4 in R) on averaged data from verbs and objects in three time-windows: 100-200ms, 200-390ms, and 500-900ms (only for objects). CONTEXT, ACCENT, LATERALISATION, ANTERIORITY, and MUSICALITY were the fixed factors and STIMULUS-LIST and PARTICIPANT were random intercepts. Significant interactions with MUSICALITY were analysed further. || In the verb in 100-200ms, the interaction CONTEXT X ACCENT X MUSICALITY (p=.005) showed that although LM showed an expectancy negativity when hearing unaccented verbs regardless of context, HM only did so with context. This interaction was found again in 200-390ms (p=.001): Both groups continued this negativity when hearing unaccented verbs. However, the effect was smaller in HM without context, suggesting weaker accent expectancy as compared to LM. || In the object, we found the interaction ACCENT X MUSICALITY (p<.001) in 100-200ms. LM showed more expectancy negativity in unaccented objects than in accented objects, whereas HM showed the opposite pattern, suggesting accent expectancy in HM but not in LM. In 200-390ms, we found the interaction CONTEXT X ACCENT X MUSICALITY (p<.001). Only HM showed less negativity when hearing unaccented objects with context, suggesting facilitation in the processing of unaccented objects in the presence of context. ||Our study has provided the first evidence for an influence of musical abilities on high-order prosodic processing in L2. Higher musicality is related to less influence from L1 and better online adjustment of expectations of accent placement while listening to sentences with only.

Topic Areas: Prosody, Multilingualism

Detection of spelling errors: ERP study

Poster E38 [Poster PDF] Visit me at [Gather.Town] in the Wernicke room during Poster Session E.

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Herein we present electrophysiological evidence of various neurophysiological mechanisms of detection of spelling errors. Some studies have reported that the sublexical or lexical orthographic processing was indexed by the ERP difference between different types of stimuli (words, pseudohomophones, pseudowords, nonwords, symbols) (Araujo et al., 2015; Kemény et al., 2018; Heldmann et al., 2017). The processing of real spelling errors associated with different linguistic rules is much less examined. In our study, we analyzed two types of spelling

errors in the Russian language: errors in combinations of letters which are illegal in a Russian writing system ("orthographically illegal errors", e.g. "машына" instead of "машина") and errors in the reducing unstressed vowel (phonemes [i, e, a, ɔ, u] in unstressed syllables are converted into phonemes [i, a, u] or [i, ə, u]), i.e., errors in combinations of letters which are legal in a Russian writing system ("orthographically legal errors", e.g. "лисник" instead of "лесник"). Participants were native speakers of Russian (N = 36; M age = 24.5; SD = 5.0). During ERP recording, participants were instructed to read the words presented on the screen silently. The participants had to decide whether the word was spelled correctly by pressing the corresponding response button. The stimuli were presented in a pseudorandom order. All words were nouns and consisted of 5-6 letters. Each stimulus was presented until the response. The interstimulus interval varied from 1300 to 2300 ms. Only correct trials (when a correctly spelled word is recognized as a correctly word or a misspelled word is recognized as a misspelled word) were analyzed. Detection of "orthographically illegal errors" was associated with early ERP components changes: compared to correctly spelled words, the P90, and P160 amplitudes were significantly larger when the word was misspelled and might reflect sublexical orthographic processing. Detection of "orthographically legal errors" was associated with the later phonological and lexical orthographic processing, categorization and memory: compared to misspelled word the left occipito-temporal N220 amplitude was significantly larger when the word was written correctly, probably this might reflect a perceptual effect of familiarity for correctly spelled words as for well-known visual word forms (Proverbio et al., 2008); P300 was larger for misspelled words than for correctly spelled words; it may mean that the categorization process for misspelled word requires more mental effort than for correctly spelled word; compared to misspelled word the N400 amplitudes in the time window 400-550 ms was significantly larger when the word was written correctly, but the N400 amplitudes in the time window 550-700 ms was significantly larger when the word was misspelled; higher N400 amplitude might reflect the fact that lexical access was hindered (Kriukova, Mani, 2016) and for misspelled word this hindering appears later than for correctly spelled word; compared to misspelled word the LPC amplitudes was significantly larger when the word was written correctly and might reflect active reanalysis in correctly spelled word condition. Detection process of spelling errors may thus depend on types of spelling errors. This work was supported by grant RFBR № 20-013-00514.

Topic Areas: Reading, Writing and Spelling

Inner speech in silent reading of direct versus indirect quotes does not rely on covert articulation

Poster E39 [Poster PDF] [Poster Tour] Visit me at [Gather.Town] in the Wernicke room during Poster Session E.

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[INTRODUCTION] Fictional characters in written stories are often brought to life with vividness and complexity in their voices. Such imaginary voices are often experienced by the reader as inner speech, particularly in silent reading of direct speech (e.g. She said: "I am hungry") as compared to indirect speech (e.g. She said that she was hungry). While quotation-induced inner speech was previously found to activate the right temporal voice area (R-TVA) of the auditory cortex (Alderson-Day et al., 2020; Yao, Belin, & Scheepers, 2011, 2012), its neural bases beyond TVAs are yet to be fully explored. The current study tested whether quotation-induced inner speech is also driven by forward model simulations from the articulation system (Oppenheim, 2013). By manipulating the quotative verbs (e.g., He shouted vs. whispered), we used functional magnetic resonance imaging (fMRI) to examine whether the voice perception and the covert articulation systems could be differentially engaged by direct vs. indirect speech that were spoken loudly or quietly. To this end, independent localiser tasks for voice perception and covert articulation established regions of interest (ROIs) in which blood-oxygen-level-dependent (BOLD) responses to silent reading can be quantified for individuals. [METHODS] All scans were acquired on a 3T scanner using a dual-echo EPI sequence. In the main reading scan, 24 native speakers of English silently read 120 written stories containing direct and indirect speech sentences that were

spoken either loudly or quietly in a 2 x 2 repeated measures within-subject design. They then underwent a voice localiser scan where they passively listened to 20 blocks of vocal and nonvocal auditory stimuli (Belin, Zatorre, Lafaille, Ahad, & Pike, 2000) and an articulation localiser scan where they either silently rehearsed or passively viewed 20 blocks of pseudoword pairs (e.g., 'tipsy topsy'). [RESULTS] In line with previous research, the voice localiser task differentially engaged bilateral STG/STS areas (i.e. TVAs; Belin et al., 2000) and the articulation localiser task differentially engaged the left premotor cortex (L-PMC) and the left Sylvian parietal temporal region (Spt) (Hickok, Buchsbaum, Humphries, & Muftuler, 2003). BOLD responses were modelled at the 1st level, averaged within the ROIs, and submitted to 2nd level Speech x Loudness x ROI ANOVAs for voice and articulation ROIs, respectively. Within the voice ROIs, BOLD signal was significantly stronger in L-TVA than R-TVA overall, $F(1,23)=4.44$, $p<.05$. While BOLD responses to both direct- and indirect-speech reading were high in L-TVA, they were significantly lower during indirect-speech (but not direct-speech) reading in R-TVA, $F(1,23)=10.84$, $p<.01$. Within the articulation ROIs, ANOVA on BOLD responses showed no significant effects. [CONCLUSION] Our results replicated previous findings that direct (vs. indirect) speech reading differentially activates R-TVA, but did not find similar effects in covert articulation areas. Speech loudness did not affect BOLD signals in TVAs or articulation areas. These findings suggest that quotation-induced inner speech may be perceptually simulated and may not rely on the articulation system. The perceptual features of this inner speech may be impoverished, particularly in the dimension of loudness.

Topic Areas: Reading, Prosody

Temporal processing of a signed language: effect of modality and language status.

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Spoken language shows a quasi-periodic temporal structure, which facilitates the efficient decoding and extraction of linguistic information from the acoustic signal. Deficits in temporal processing have been associated with poor reading and language comprehension. Signed languages have a different temporal structure than that of spoken languages: the central role of the spatial dimension allows for the parallel presentation and processing of linguistic information. This study investigates temporal processing of a signed language and disentangles the impact of sensory modality (visual and acoustic) and language status. To do this, we compared a spoken with a signed language – Spanish and Spanish Sign Language (LSE) – and signed language with a visual non-linguistic signal characterized by a coherent temporal structure. Twenty-three bimodal bilinguals (Spanish native speakers; native or high proficient LSE users) took part in the experiment, which included three separate tasks with different types of material: Spanish sentences, LSE sentences and visual non-linguistic stimuli (symbols traced by a moving dot). All stimuli were distorted using local time-reversal: the signal is divided into windows of a set duration, and each window is temporally reversed while maintaining the relative order of the windows. For each task, we used reversal windows of six different sizes, and measured accuracy in perceiving the increasingly distorted signal. To characterize how the reversal window size modulates the accuracy scores, we ran a one-way repeated measure ANOVA for each task with post-hoc comparisons across consecutive reversal windows. (We also ran a mixed-effect model to confirm the analysis.) The results show that locally time-reversed distortion affects these signals differently. Spanish is characterized by a perceptual threshold (corresponding to 40 ms reversal window), after which language intelligibility rapidly decreases and is almost completely lost at approximately 85 ms. This result reproduces the findings in the literature, pointing towards a common cognitive mechanism employed in temporal processing of different spoken languages. Conversely, in LSE there was a gradual and constant decrease in intelligibility as reversal windows grew, but no clear threshold could be identified. LSE is also more resilient to temporal manipulation compared to Spanish: participants' performance never drops below 50% even with the most severe distortion. In the visual non-linguistic task the accuracy gradually decreases, similarly to LSE, but accuracy drops to 20% in the most distorted

condition. Overall, the visual modality shows a straightforward pattern in temporal processing (for both linguistic and non-linguistic signals): accuracy is proportional to the degree of temporal distortion, making it possible to extract some information even when the signal is highly distorted. This contrasts with the sudden loss of intelligibility that characterizes spoken languages. LSE and visual non-linguistic signal differ in the range of accuracy: the spatial redundancy of linguistic information in LSE compensates for the temporal distortion of the signal, resulting in higher intelligibility even at longer reversal windows. In conclusion, these findings suggest that the temporal processing of signed language arises from the complex interaction between the properties of the visual system and the special characteristics of the language signal.

Topic Areas: Signed Language and Gesture, Speech Perception

An fMRI study of initiation and inhibition of manual responses in people who stutter

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Introduction: Developmental stuttering is a speech motor disorder characterised by difficulties with initiation of speech and frequent interruptions to the speech flow. Previous work suggests that people who stutter (PWS) have an overactive response suppression mechanism (Neef et al., 2018). Accordingly, imaging studies consistently reveal over-activity of the right inferior frontal cortex in PWS (Brown et al., 2005), an area robustly implicated in inhibitory control of both manual and spoken responses (Xue et al., 2008). Here, we used a manual response version of the stop-signal task in fMRI to investigate neural differences related to response initiation and inhibition in PWS. Method: We analysed behavioural data during a manual stop-signal task in 38 people with moderate to severe stuttering and 21 matched controls. Manual responses involved a button press in response to an arrow presented visually. FMRI data obtained in 30 of the participants who stutter and 17 controls were analysed. Results: We found that PWS were slower to respond to simple 'go' stimuli than PWTF, but there was no difference in stopping behaviour. Our fMRI results were consistent with these behavioural results. The fMRI analysis revealed the expected networks associated with manual response initiation and inhibition in both groups. However, all contrasts between the two groups were characterised by overactivity in PWS relative to controls. This overactivity was significantly different compared with controls for response initiation but not for response inhibition. Conclusions: One explanation for these results is that PWS are consistently in a heightened inhibition state, i.e. areas of the inhibition network are more active, generally. This interpretation is consistent with predictions from the global response suppression hypothesis (Neef, Anwander, & Friederici, 2015).

Topic Areas: Speech Motor Control, Disorders: Developmental

Audio-visual comprehension of degraded speech: Does visual speech enhance auditory entrainment of MEG signals?

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Verbal communication in a noisy environment can be challenging especially for hearing impaired individuals. Seeing the face and mouth movements of a communication partner greatly improves speech understanding but, the neural mechanisms behind this intelligibility benefit from visual speech are not fully understood. Extensive research demonstrates that neurons in the auditory cortex synchronize, or entrain, to the quasi-rhythmic components of speech especially when speech is more intelligible. In this experiment we investigated the hypothesis that visual speech signals enable stronger entrainment to auditory speech signals, thus facilitating comprehension. We collected MEG recordings from 14 participants while they watched and listened to video clips of a native English speaker producing single sentences. We manipulated acoustic clarity (high vs. low using noise vocoding) and the availability of visual speech (present or absent) in a 2 x 2 factorial design resulting in 4 conditions: auditory-only high clarity (AOhigh), auditory-only low clarity (AOlow), audio-visual high clarity (AVhigh) and audio-visual low clarity (AVlow). A condition with silent visual-only speech (VO) was also included. Participants were presented with 55 different sentences in each of the 5 conditions in random order and after each sentence repeated as many words as they could. Word report accuracies were collected and averaged for each condition. To measure neural entrainment to the acoustic and visual speech signals, we extracted two features from the video clips: i) the acoustic envelope of the auditory speech signal and ii) the time course of the instantaneous area of the speakers' lip aperture (visual speech envelope). We computed the spectral coherence of these two signals with the MEG recordings in sensor and source space. As expected, behavioural results showed that both increased acoustic clarity and additional visual speech information led to increased word report accuracy. We compared two conditions with matching word report accuracies with different sources of information (AOhigh vs AVlow) which revealed individual differences in perception of audio-visual speech that were predicted by participants' lip reading ability. Individuals with better word report accuracy in the VO condition benefitted more from additional visual input, than from increased acoustic clarity ($r(14)=0.782$, $p<.001$). Sensor space MEG analysis revealed that both auditory and visual speech entrained brain responses as indicated by above-chance coherence between magnetometer signals and acoustic/visual speech envelopes. Cluster-based permutation tests revealed bilateral clusters for auditory entrainment and a posterior cluster for visual entrainment both spanning frequencies between 2-6 Hz. Our source space analysis identified non-overlapping auditory and visual sensory areas entrained by unintelligible auditory and visual speech compared to null distributions obtained from permuting sentences and MEG recordings. The availability of visual speech signals (for both AV speech conditions compared to AO speech) was associated with increased entrainment to the auditory envelope in right occipital cortex. We are currently using partial coherence analyses to explore: (i) whether this effect is due to above-chance coherence of auditory and visual speech envelopes (at 2-8Hz), or (ii) reflects auditory information constraining processing of visual speech and considering, (iii) how individual differences in lip-reading ability influence neural observations.

Topic Areas: Speech Perception, Perception: Speech Perception and Audiovisual Integration

Cerebro-acoustic coherence while listening to stories in quiet predicts word-in-noise recognition

Poster E43 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session E.

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Brain activity entrains to the fluctuations of sound pressure in auditory signals. When listening to speech such "cerebro-acoustic coherence" (CACoh) has been shown to be especially prominent at frequencies corresponding to the syllable rate of speech. Here, we estimate CACoh (or simply speech tracking) in a magnetoencephalographic (MEG) dataset of 53 participants actively listening to short stories and evaluate whether the degree of CACoh predicts performance on an independent word in noise (WIN) recognition task. Stimuli consisted of 14 short stories (mean 20.3s, SD 2.8s) read by a single male speaker. Recordings were transcribed and semi-manually annotated with the help of forced-alignment to provide timecourses of phrasal, word, and syllabic events. CACoh was calculated in three different frequency bands, reflecting these timecourses (phrases, 0.2-2Hz; words, 2.4-4.9Hz; syllables, 3.4-6.5Hz) using gaussian-copula mutual information (GCMI), which reflects the information amount shared between continuous time-series (in bits). At each of these frequencies, sensor-level analysis revealed scalp-topographies indicating bilateral relationships between the cerebral and speech signals as reflected by GCMI. Source reconstruction was used to localise these effects in the brain. At the phrasal frequency, maximum speech tracking was observed in left and right thalamus source voxels and at the right hemisphere, in sources in the superior temporal gyrus (with GCMI > 0.089). At the word frequency, sources in right Brodmann area 22, along with sources in right primary auditory cortex showed strongest speech tracking, followed by sources in left auditory regions (primary auditory cortex, Brodmann areas 21 and 22, all with GCMI > 0.043). At the syllable frequency, clusters compatible with sources in and around bilateral auditory cortices were especially highly coherent with speech (GCMI > 0.035). In the right hemisphere, CaCoh was highest in a cluster including the auditory cortex and posterior superior temporal cortex, extending into the temporo-parietal junction, while in the left hemisphere, CaCoh was strongest in the superior temporal gyrus. These loci have repeatedly been associated with speech tracking and syllabic parsing. However, it is not known whether the mechanisms that lead to the cerebro-acoustic coherence observed here are functionally relevant in speech processing. If this is the case, it might be reflected in a relationship between CACoh and a separate auditory task. Hence, we investigated here whether the capability of speech tracking, on a subject-by-subject level, can predict performance on an independent word-in-noise (WIN) recognition task. Using the 5% of source voxels with highest CACoh, we tested the relationship between CACoh in each frequency range and speech-in-noise recognition performance (deconfounded for age, sex and handedness). At the syllable level we find a significant relationship with WIN performance ($rho = -0.31$, $p < 0.03$), but not in any other range (all $p > 0.05$). Thus, the fidelity and ease with which the brain tracks spoken syllables reflects the system's resilience to background noise, suggesting that the mechanisms underlying CACoh reflect a crucial contribution to speech processing.

Topic Areas: Speech Perception, Perception: Auditory

Cortical stimulus-tracking depends on expertise

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When people perceive speech, low-frequency (< 10 Hz) activity in the brain synchronizes with bursts of sound and visual motion. This phenomenon, called cortical stimulus-tracking, is often strongest in sensory cortex, but it also appears in frontal cortex. In this study, we investigate the roles of these cortical areas during stimulus-tracking. We test whether stimulus-tracking depends on expertise: Is stimulus-tracking stronger when people have experience with the stimuli being perceived? We then examine how the effects of expertise differ between frontal and sensory cortex. We used electroencephalography (EEG) to measure visual stimulus-tracking in participants who were experts in either sign language or ballet dancing. Participants watched silent videos of sign language and ballet. We measured stimulus-tracking by computing coherence between EEG recordings and motion in the videos (quantified as aggregated pixel-wise change). Baseline levels of coherence were computed by randomly shifting the visual motion time-course and re-computing coherence. Based on prior results, we focused on coherence from 0.5-2 Hz at frontal and occipital regions. We predicted that frontal coherence would be strongest when participants watched videos in their domain of expertise (signers watching sign, dancers watching dance), whereas occipital coherence would not depend on expertise. We analyzed periodic and aperiodic structure in dance and sign language using the FOOOF algorithm. Dance stimuli were weakly periodic around 4.4 Hz, whereas sign language did not display any periodic components. Our EEG results showed that frontal stimulus-tracking depends on participants' expertise, whereas occipital stimulus-tracking does not. At frontal channels, fluent signers showed stronger coherence to sign language than to dance. Expert dancers, by contrast, showed stronger frontal coherence to dance than to sign language. At occipital channels, coherence to sign and dance did not differ between signers and dancers. Examining the full frequency range and scalp topography, signers showed coherence to sign language that peaked around 1 Hz over a broad area of central, frontal, and occipital channels. Signers did not show clear coherence to dance at any frequencies. Dancers, however, showed strong coherence to videos of dance, peaking between 0.5 and 1 Hz at central channels. Dancers showed moderate coherence to videos of sign language, centered over occipital channels around 1 Hz.

In summary, we found that expertise influenced stimulus-tracking at frontal channels, but not at occipital channels. This suggests that activity in frontal cortex may reflect higher-level predictive processes, whereas activity in occipital cortex may be driven by lower-level features of the stimulus. Our results are unlikely to reflect “entrainment in the narrow sense”, in which ongoing cortical oscillations are adjusted to match oscillations in the stimulus. Instead, temporal predictions in frontal cortex may flexibly adjust to quasi-periodic (or aperiodic) structure in the stimuli. Taken together, these results suggest that neural stimulus-tracking depends on a domain-general predictive mechanism. By flexibly adjusting low-frequency neural activity, the brain may align periods of increased neural excitability with bursts of information in structured sequences.

Topic Areas: Speech Perception, Perception: Speech Perception and Audiovisual Integration

Homophonic speech sequences in French: The role of acoustic and contextual cues for disambiguation

Poster E45 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session E.

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Despite the lack of clear word boundaries in spoken language, the human ability to recognize speech seems to be effortless. Listeners divide continuous speech into linguistically and psychologically significant units to access meaning. Speech segmentation has been proven to be affected by both the listeners’ sensitivity to acoustic cues and sub-phonemic properties (Davis et al. 2002; Mattys, 2004), and contextual information and lexical competition (Norris, 1994; Dahan & Brent, 1999). Fine acoustic details can influence word boundaries perception (Friederici & Wessels, 1993; Davis et al, 2002), particularly when contextual information is insufficient (Mattys et al. 2005). Yet, it remains unclear how low-level signals can affect higher-order information, i.e., how the speech recognition system reacts when exposed to unmatched acoustic and sentential information. We aimed to investigate the cost of mismatching the fine acoustic cues of the speech signal during sentence processing. More precisely, we wanted to explore whether and how such fine acoustic details affect semantic processing. In the present experiment, we recorded French sentences containing homophonic sequences, article+noun combinations that can be segmented differently, such as “l’affiche” (“the poster”) and “la fiche” (“the sheet”), both pronounced /lɑfiʃ/. We recorded the Event-Related brain Potentials (ERPs) to three different conditions: baseline, congruent, and incongruent, each of which comprised 46 sentences. To avoid differences, congruent and incongruent sentences were created by cross-splicing the article-noun sequences within sentences. For example, two meaningful sentences were selected for the pair “la fiche”-“l’affiche”: (1) “La secrétaire médicale a perdu la fiche du patient” (“The medical secretary lost the patient's chart”) and (2) “Le Théâtre National a choisi l'affiche du spectacle” (“The National Theatre has chosen the poster for the show”). We extracted “l’affiche” from (2) and placed it in (1), generating the incongruent (3) “La secrétaire médicale a perdu l’affiche du patient”. A similar manipulation was done for the congruent condition: we swapped the two “la fiche” from (1) and (4) “Le comptable rempli la fiche de ses employés” (“The accountant fills out his employee chart”). While sentences were not highly predictable, the congruent homophone choice was consistently more predictable than the incongruent. EEG data were acquired using Curry 8.0 XS software (Neuroscan SynAmps 2/RT; 64-electrode Quik-Cap Neo Net, adjusted to the International 10/20 standard system). We used EEGLAB toolbox (Delorme & Makeig, 2004) for offline analyses. Epochs were extracted from -200 to 1100 ms after stimulus onset, with a baseline period of -200 to 0 ms. Sources for each independent component were evaluated with ICLabel plugin (Pion-Tonachini et al., 2017). To assess for semantic processing differences, we focused our preliminary analyses on the N400 component and found a statistically significant effect of topographical distribution in our regions of interest (ROI) and an effect of interaction between conditions and ROIs. Topographic analyses revealed mean amplitude significant differences between frontal and parietal brain regions, suggesting the presence of an N400-like component in central to parietal sides. This would suggest that listeners consider fine acoustic cues when challenged with mismatching acoustic and sentential information.

Topic Areas: Speech Perception, Perception: Auditory

The preverbal infant brain encodes speech in terms of orthogonal phonetic features

Poster E46 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session E.

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Speech is an extremely variable signal and yet, we perceive it in the form of stable, invariant segments. Such an ability is essential for adults, in order to comprehend language, and even more crucial to preverbal infants, who need to discover phonological, lexical and syntactic regularities to acquire language. How can the brain achieve such challenging task? In our study we assessed the possibility that a factorized representational system might be an efficient neural strategy to deal with speech inconsistencies. We hypothesized that the phonetic features traditionally described by linguists might be the basic decomposition axes harnessed not only by the adult (e.g. Mesgarani et al. 2014, Arsenault and Buchsbaum, 2015) but also by the infant brain, currently thought incapable of authentic phonetic processing (Kuhl, 2004). To test our idea we examined the perception of natural syllables by 3-month-old infants using a prototype 256-channels electroencephalographic system (EEG) and time-resolved multi-variate pattern analysis (King & Dehaene, 2014). During 1 hour and often asleep, infants were exposed to six consonants, whose manner and place of articulation varied orthogonally, associated to two vowels, "i" or "o". The stimuli were pronounced by a female and a male speakers in several utterances to ensure conspicuous acoustical variability among tokens with the same phonetic profile. Trained on brief periods all along the ERPs, our classification algorithms were able to reliably separate trials according to both the manner (starting from 100ms after stimulus onset) and the place of articulation (up to 700ms after syllable onset). Once observed such performances, we used a hierarchical generalization approach to define the specificity and granularity of the underlying neural code. Crucially, classifiers trained on single harmonic and vocalic contexts were able to generalize on the alternative speaker and vowel conditions, disclosing an acoustically invariant phonetic code. When training was conducted on single phonetic dimensions (e.g. manner classifiers were trained on labial/alveolar/velar consonants separately), full generalization across featural contexts was observed up to ~450 ms, revealing that during a first processing stage phonetic features were encoded separately and orthogonally. Later on, a degradation in the generalization performance indicated the occurrence of a second processing phase based on a different representational format. A multiple regression analysis applied to the error patterns of syllable-identity classifiers revealed that, at such later times, phonetic features were merged into comprehensive consonant-identity codes. The latter remained distinct from the representation of the subsequent vowel, accounting for the different weights attributed to consonants and vowels in linguistic computations. In conclusion, contrary to mainstream accounts postulating articulatory motor plans and productive skills as prerequisites for phonetic perception, we show that the preverbal brain is already equipped with a phonetic space which provides a structured combinatorial code for speech analysis. On the one hand, the factorized representational system we individuated is robust to surface variability and thus able to account for the stability of speech percepts at any age. On the other, its efficiency in high-dimensional contexts makes it an ideal tool for the bootstrapping of language acquisition.

Topic Areas: Speech Perception, Development

Electrophysiological Indices of Phonemic Discrimination Relate to Receptive and Expressive Language Skills in Young Children

Poster E47 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session E.

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Electrophysiological measures of language processing within early childhood may provide important information about early neurolinguistic development. We investigated associations between the amplitude and latency of the P1 and N2 event-related potential (ERP) components in response to spoken nonwords, and clinically relevant measures of language performance within a sample of typically developing 2 and 3-year-old children. Methods: Fifty-eight children (mean age = 32.8 months) were presented with two phonemically similar nonword tokens within an old/new auditory perception paradigm. Children heard repetitions of one token for an initial block followed by a randomized presentation of the same (now familiar) token and a new phonetically similar token. P1 and N2 component responses were examined to measure sensitivity to familiar versus novel stimuli. Clinical measures of speech and language skills, including a parent report of expressive vocabulary, standardized language assessment, and mean length of utterance, were also collected. Results: Individual P1 and N2 amplitude differences between the familiar and novel tokens (measured as novel minus familiar) were positively correlated with measures of language, including Expressive Language and the Auditory Comprehension Scales the Preschool Language Scale, Fifth Edition. Specifically, larger differences in ERP response between familiar and novel tokens was associated with better language scores. The same amplitude differences were also correlated with articulation errors, measured within the Goldman Fristoe Test of Articulation. Discussion: These results suggest that phonemic sensitivity, measured by the P1 and N2 components, may reflect the integrity of neural networks that are important for both speech perception and production in young children.

Topic Areas: Speech Perception, Development

The causal role of language-specific brain regions in contextual updating of ambiguous word meanings

Poster E48 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session E.

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Contextual cues are particularly important during language comprehension when words are semantically ambiguous (e.g. NOTE). Exposure to a lower-frequency meaning (e.g., hearing “note” in a music-related context) can boost the longer-term availability of that meaning, an effect termed Word Meaning Priming (WMP) and thought to reflect changes to flexible lexico-semantic representations (Rodd et al., 2020). We explored the contribution of language-specific and domain-general Multiple Demand (MD) regions (Duncan 2010; Fedorenko et al., 2011; 2013)—two brain networks implicated in high-level linguistic interpretation—to understanding semantically ambiguous words in context and WMP. Volunteers (n=18) with chronic, adult-onset, focal brain lesions to cortical areas, without obvious language or cognitive impairment, were recruited for a two-phase experiment. Lesion overlap with language and MD networks was estimated with large-n probabilistic activation maps from fMRI in healthy participants (following Woolgar et al., 2018). In phase 1 (Coherence Judgement Task), volunteers listened to 20 coherent sentences each containing two AMBIGUOUS words disambiguated to less frequent meanings (“The PITCH of the NOTE was extremely high”), 20 matched sentences without ambiguities (“The salary of the lawyer was quite large”), and 40 anomalous sentences (“The research had a goat in its moon”). Participants judged whether each sentence made sense. In phase 2 (Word Association Task), following a 30-minute delay, volunteers heard 80 ambiguous words presented in isolation, of which half had been presented in phase 1 (primed) and half were new (unprimed; counterbalanced across participants). For each word, participants said the first related word that came to mind. Responses were coded as consistent (e.g. “NOTE-music”) or inconsistent (“NOTE-write”) with the phase 1 meaning, and the proportions of consistent responses compared between the primed and unprimed words to measure WMP. The Coherence Judgement Task results showed that all participants could discriminate coherent from incoherent sentences (mean d-prime = 3.75, range = 2.72 – 4.20) and produced few errors (mean 0.03, range 0 – 0.08) with no difference in accuracy between ambiguous and unambiguous sentences or due to primary lesion location or extent. Coherence judgement times were significantly longer when sentences contained ambiguous words (777 ms vs. 654 ms: β=0.047, $p < 0.05$), but the size of this Ambiguity Effect did not relate to the location or extent of the brain lesion. The Word Association Task results showed a higher proportion of phase-1 consistent responses for primed compared to unprimed words (0.32 vs. 0.27: β=0.499, $p < 0.005$), reflecting an increase in availability of the primed, less frequent meaning (WMP). Reduced WMP in individuals (estimated using mixed-effect model residuals) was associated with larger lesions in the Language system ($r = -0.80$, $p < .05$) but not in the MD system, and was not driven by participants who had more difficulties with comprehension (no association between size of WMP and the Ambiguity Effect). Findings demonstrate a causal role of language-specific regions in utilising context to flexibly update lexico-semantic representations, and contribute to accumulating evidence that core aspects of language comprehension depend on specialised, not domain-general regions (Blank & Fedorenko, 2017; Diachek et al., 2020).

Topic Areas: Speech Perception, Meaning: Lexical Semantics

Neural entrainment to languages of different rhythm

Poster E49 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session E.

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Cortical oscillations at different frequencies entrain to speech signal at hierarchical linguistic units, including syllables in the theta range (3-8 Hz) (Giraud & Poeppel, 2012). Current neuroscientific studies focus on the role of theta entrainment only in acoustic processing and intelligibility (Etard & Reichenbach, 2019), but overlook the fact that syllable complexity varies considerably across languages (Greenberg, 1999), which is associated with linguistic rhythm (Langus et al., 2017). Linguistic rhythm classifies languages according to the beat of the speech signal. For syllable-timed, stress-timed, and mora-timed languages, the beat fluctuates on syllables, feet, and morae, respectively. Several behavioral experiments show that adults segment speech signals according to their native linguistic rhythm (Cutler et al., 1986; Otake et al., 1993), but the neural underpinnings of this specialization are not understood. We recorded participants' EEG activity while they listened to (saltanaj) resynthesized sentences from different rhythms (Ramus & Mehler, 1999). Participants performed a task involving monitoring syllables in the sentences. We computed the phase locking value (PLV) between neural oscillations and speech envelope (Lachaux et al., 1999). We tested: 1) 30 native speakers of a syllable-timed language (Catalan or Spanish), who listened to resynthesized Catalan/Spanish, Dutch and Japanese sentences, 2) 22 native speakers of a stress-timed language (English), who listened to resynthesized English, Spanish and Japanese. We hypothesized that 1) Sample 1 would have higher PLV for syllable-timed sentences than stress- or mora-timed sentences, 2) Sample 2 would have higher PLV for stress-timed sentences than syllable- or mora-timed sentences, 3) PLV for syllable-timed sentences would be higher in Sample 1 than in Sample 2, but PLV for mora-timed sentences would not differ between the samples. We averaged PLV over participants and trials for each condition, and tested for differences using non-parametric tests. For Sample 1, PLV for mora condition was significantly higher than syllable and stress conditions, and syllable condition was significantly higher than stress condition. For Sample 2, PLV for mora and syllable conditions were significantly higher than stress condition, but mora and syllable conditions did not differ from each other. For Spanish sentences, native speakers of Spanish ($N = 18$) showed significantly higher PLV than native speakers of English. PLV for Japanese sentences did not differ between the Spanish and English speakers. On the one hand, our results show that entrainment to speech envelope in theta frequency increases with reduced syllabic complexity in the languages' repertoire, therefore not supporting language-specificity. On the other hand, we observed stronger entrainment to Spanish sentences by native speakers of Spanish than by English ones, suggesting a neural tuning for native rhythm.

Topic Areas: Speech Perception, Perception: Auditory

Hemispheric lateralization and interhemispheric effective connectivity predict binaural integration of phonemic information

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Dichotic listening has been used extensively in the field of speech perception to investigate the neural mechanism of hemispheric lateralization and auditory attention. Typically, individuals with less lateralized brain activation and stronger anatomical connections show enhanced auditory information transfer across hemispheres as reflected by a higher number of left ear reports during dichotic listening. What is less clear, is whether the integration of complementary dichotic stimuli also relies on interhemispheric auditory information transfer or solely relies on subcortical auditory integration. In a previous study, we found evidence for the first hypothesis, showing that bilateral transcranial alternating current stimulation over the posterior superior temporal lobe modulates binaural integration of phonemic information. Here, we tested whether the propensity to integrate complementary dichotic stimuli is related to higher levels of interhemispheric connectivity and a more bilateral response of the auditory cortices. Twenty-eight participants performed a dichotic listening task during functional magnetic resonance imaging (fMRI). Listeners were simultaneously presented with an ambiguous syllable (intermediate between /da/ and /ga/) in the right ear (RE) and a potentially disambiguating cue in the left ear (LE). This cue was the third formant (F3) having the spectral characteristics of the F3 of either a /da/ (high F3, ~ 2.9kHz) or /ga/ (low F3, ~2.5kHz) syllable. Under such conditions, the perceived phonemic identity (/ga/ or /da/) of the stimulus depends upon auditory integration of the cues in the left and right ears. The presentation of target trials for binaural cue integration was interspersed with control trials (an unambiguous syllable (/da/ or /ga/) was presented to the RE and the corresponding F3 to the LE). In contrast to the target trials, control trials could be readily interpreted based on monaural RE information. Imaging sessions consisted of five fMRI runs: One run passive listening to the stimuli (~11min), followed by four runs (~7min each) in which participants were asked to indicate, by button press, which syllable they had perceived (syllable identification task). Target trials for binaural integration evoked greater bilateral activity than unambiguous control stimuli in Heschl's Gyrus (HG), planum temporal (PT) and posterior superior temporal sulcus (pSTS). Importantly, dynamic causal modeling revealed that effective connectivity between right and left HG was positively correlated with participants' binaural integration score. Furthermore, the analysis of hemispheric lateralization indicated that a higher binaural integration score is associated with a less lateralized (i.e., more bilateral) BOLD response to dichotic stimuli in both conditions. Finally, we found more bilateral brain responses during the syllable discrimination task than during passive listening. Our results imply that auditory information transfer as reflected by interhemispheric effective connectivity is crucial for the integration of binaurally presented phonemic information. Further, we found that a task that demands for binaural integration leads to more bilateral BOLD responses, suggesting that binaural integration is related to bilateral processing in the auditory cortical speech network. These results contradict the notion that binaural integration of dichotic speech cues relies solely on subcortical auditory integration at the level of the superior olivary complex and the inferior colliculus.

Topic Areas: Speech Perception, Perception: Auditory

Beyond directional asymmetries and phonological representations – identifying additional influential factors in MMN effects

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Introduction: In recent years, much research has been done on investigating the mental representation of vowels and directional asymmetries in vowel discrimination. Here, two competing models are often discussed in

this context: the Featurally Underspecified Lexicon (FUL) model (Lahiri & Reetz, 2002) and the Natural Referent Vowel (NRV) framework (Polka & Bohn, 2011). Both approaches are predicting directional asymmetries, but have substantially different assumptions about the mental representation of speech sounds and the features involved in vowel discrimination. While the first mentioned model takes abstract and sparse phonological features into account, the latter one predicts vowel discrimination with the help of articulatory-acoustic properties of the vowels. We conducted a Mismatch Negativity (MMN) experiment in a passive oddball design and a reaction time (RT) study in an active oddball paradigm with German native speakers to investigate directional asymmetries for five German long vowel contrasts and to compare the aforementioned models. While most studies presented isolated vowels, we investigated the mental representation of German vowels in a more naturalistic setting with minimal pairs. Furthermore, we investigated the influence of several theoretical, acoustic and sensational factors to shed light on their impact on vowel processing on both data sets. Results: We found directional asymmetries in both data sets which can be explained by either the phonological or the phonetic model. While in the RT data asymmetries can be fully explained by the phonological approach, the results of the MMN study are somehow challenging. The patterns of some contrasts can be explained within the NRV framework, but both models failed to offer an explanation for all the found asymmetric and symmetric patterns. Furthermore, we examined additionally the influence of several factors via multiple regression analyses on both data sets. We included not only factors which are known to influence the MMN (e.g. changes in F1 or F2, frequency) and theoretical implied factors (e.g. number of features) but also factors beyond the well-known phonological and acoustic ones (e.g. perceived loudness of vowels, degree of openness). The analyses revealed that perceived loudness (although normalized intensity) has a greater influence on the MMN effects than considered in the literature. This factor is also highly correlated with the degree of openness of the vowel. Additionally we found evidence for different discrimination strategies as a function of attention. While the aforementioned factor has influence on the pre-attentive neuronal data, it receded into the background in the active and attentive behavioral data. To summarize, the implications are two-fold: (1) Results provide further evidence that discrimination strategies vary between tasks as a function of attention, and (2) we provide evidence for the influence of perceived loudness on pre-attentive vowel processing in MMN data. Therefore, we encourage further studies to take stronger factors beyond the well-known into account when analyzing and interpreting neuronal and behavioral data.

Topic Areas: Speech Perception, Perception: Auditory

Language experience determines asymmetry of auditory-motor interactions for speech processing

Poster E52 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session E.

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Introduction: Speech processing is asymmetrically organized in the human brain. There is strong evidence to indicate that processing of phonemes relies on a left-lateralized auditory system whereas processing of speech prosody involving pitch changes is right lateralized. In tonal languages, such as Mandarin, however, pitch can also change the meaning of a word. In tonal language speakers, processing of both tones and phonemes are left lateralized. Auditory speech processing asymmetries are determined therefore by their linguistic function and shaped by language experience. Here, we investigated the contribution of motor cortex to auditory speech processing and its hemispheric asymmetry. We investigated auditory-motor processing asymmetries in speakers of tonal and non-tonal languages, in whom pitch changes serve different linguistic functions. Methods: We used repetitive transcranial magnetic stimulation (rTMS) to temporarily disrupt speech motor cortex in each hemisphere separately in tonal and non-tonal language speakers. The virtual lesion approach provided by rTMS offers a convincing test of causality in terms of temporarily interfering with the function of an area. Automatic speech processing was examined without behavioral tasks by using electroencephalography (EEG) to record mismatch negativity (MMN) responses elicited by either a phoneme (‘ba1’) or a tone (‘da4’) infrequent change in a sequence of frequent ‘da1’ syllables. Results: We stimulated the left speech motor cortex in 15 non-tonal language speakers and 16 tonal language (Mandarin) speakers. In the non-tonal language group, TMS disruption of left speech motor cortex significantly suppressed the amplitude of MMN responses elicited by the phoneme change 162–224 ms after stimulus onset (‘ba1’) but did not significantly modulate MMN responses to the tone change (‘da4’). In contrast, in the tonal language group, disruption of left speech motor cortex significantly suppressed the amplitude of MMN responses elicited by the phoneme change 134–190 ms and 196-224 after stimulus onset (‘ba1’) and the tone change 154–224 ms after stimulus onset (‘da4’). We then applied the same stimulation over the right speech motor cortex in another 15 non-tonal language speakers and a further 16 tonal language (Mandarin) speakers. In the tonal language group, TMS disruption of right speech motor cortex did not significantly modulate MMN responses elicited by either the phoneme change (‘ba1’) or the tone change (‘da4’). In contrast, in the non-tonal language group, the same TMS over the right speech motor cortex resulted in a different pattern: it had no effect on MMNs elicited by the phoneme change (‘ba1’), but significantly suppressed the amplitude of MMN responses elicited by the tone change 158–230 ms after stimulus onset (‘da4’). Conclusion: We present causal evidence that the contribution of the left and right speech motor cortex to auditory speech processing is determined by the functional role of acoustic cues in the listener’s native language. Such asymmetry observed in the motor system could modulate the auditory processing asymmetries. Our study emphasizes the importance of understanding the interactions between bottom-up auditory mechanisms and top-down influences, when investigating hemispheric asymmetry of speech processing.

Topic Areas: Speech Perception, Prosody

The role of lexical information in oscillatory tracking of syntactic structure

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Existing work suggests that neural oscillations track syntactic structure during speech comprehension (Ding et al., 2016), but the role of word-level lexical processing is still debated (Frank & Yang, 2018). Neuroimaging evidence has shown that lexical information cannot fully account for other syntax-relevant findings, since processing delexicalized structures – obtained replacing real words by pseudowords – recruits cortical regions that partially overlap with the left-hemisphere fronto-temporal language network supporting (lexicalized) sentence processing (Pallier et al., 2011). Support for syntax tracking with delexicalized stimuli also comes from computational studies (Martin & Doumas, 2017), but to date no equivalent oscillatory evidence has been provided. In this magnetoencephalography study in Spanish, we address the role of lexical information in the context of oscillatory tracking of syntactic structure. Following Ding et al., (2016), we implement the frequency-tagging paradigm but in the visual modality by rhythmically presenting sequences of real words or pseudowords to be grouped into certain (de)lexicalized structures at different frequencies. Our aim is to examine whether oscillatory tracking also emerges in delexicalized structures and, if so, to what extent lexicalized and delexicalized structures give rise to similar effects regarding their spatial distribution and oscillatory strength. Participants (n = 33) were presented with trials of 12-second sequences of 24 chunks with written words (500 ms per chunk: 300 ms display + 200 ms blank screen; stimulus presentation frequency: ~ 2 Hz), corresponding to three different grouping types: 1 chunk [Article Noun] (frequency of interest: ~ 2 Hz), 2-chunk (verbal) phrases [Infinitive-Verb] [Article Noun] (~ 1 Hz), and 3-chunk sentences [Auxiliary] [Participle-Verb] [Article Noun] (~ 0.67 Hz). Each grouping type was presented either using Spanish real words or replacing content words (noun and verb) by pseudowords. Function words (article and auxiliary) were not modified. Participants performed a probe-recall task after 25 % of the trials. Results of sensor-averaged oscillatory power show the presence of

peaks at ~ 2 Hz (i.e., stimulus presentation rate) in all conditions. This effect concentrates over occipital sensors – related to visual perception – but also extends to left-temporal sensors only in real-word conditions, probably reflecting additional lexical processing in memory-related regions for stored words. Moreover, power peaks at ~ 1 Hz and ~ 0.67 Hz are observed for (de)lexicalized 2-chunk phrase and 3-chunk sentence grouping types, respectively, suggesting that syntactic-structure tracking can occur independently from lexical information. These effects emerge over left fronto-temporal sensors, likely involving the classical language network, but also display certain lexically-mediated differences in oscillatory strength. 2-chunk phrase-frequency effects are generally diminished with delexicalized compared to lexicalized stimuli, while 3-chunk sentence-frequency peaks show comparable effects regardless of their lexical status. This differential lexical effect might be related to the additional syntactic cue provided by the auxiliary in sentence conditions. Accordingly, lexical processing could strongly impact the strength of syntax-tracking effects only when syntactic context is minimal, as in phrase conditions. Thus, our sensor-level results suggest that lexical processing might play a context-sensitive modulatory role but does not completely drive oscillatory tracking of syntactic structure.

Topic Areas: Syntax, Meaning: Lexical Semantics

Implicit-statistical learning in aphasia and its relation to lesion location

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Introduction: Implicit-statistical learning (ISL) research investigates whether domain-general mechanisms are recruited in the linguistic processes that require manipulation of patterned regularities (Misyak & Christiansen, 2012). Neuroimaging research yielded robust evidence to suggest that ISL mechanisms activate anatomical regions which overlap with those activated by syntactic processing (Bapi et al., 2005). Aphasia is a language disorder caused by brain damage in the left fronto-temporal-parietal network (Caplan, 2015). Research shows that people with aphasia (PWA) with frontal lobe lesions (f-PWA) manifest convergent deficits in syntax and ISL mechanisms however direct empirical evidence is limited (Zimmerer et al., 2014). So far, ISL mechanisms in PWA with posterior lesions (i.e. temporal or parietal lobes) (p-PWA) have not been systematically investigated. We examined two complementary hypotheses: 1) the anatomical hypothesis, that f-PWA display more severely impaired ISL abilities than p-PWA and 2) the behavioural hypothesis, that the magnitude of impairment in ISL mechanisms correlates to syntactic deficits in aphasia. Methods: We tested 13 PWA, 5 f-PWA and 8 p-PWA, and 11 healthy controls on a non-linguistic visual statistical learning (VSL) task (van Witteloostuijn et al., 2019). The VSL task consists of two phases, the familiarization phase is an online reaction times (RT's) based task during which the participant is exposed to the visual stimuli; the post-familiarization phase consists of tasks that measure the magnitude of the offline learning effect. Additionally, PWA completed the Russian Aphasia Test (RAT) and two measures were derived, syntactic competence (combined score of tasks: sentence comprehension & sentence production) and lexical competence (combined score of tasks: word comprehension, naming). Linear mixed-effect models were built to evaluate group differences on online and offline VSL tasks. The relationship between VSL task performance and linguistic deficits in aphasia were assessed through correlational statistics. Results: There is no evidence that p-PWA display stronger learning effect than f-PWA on online and offline VSL tasks. Instead, healthy subjects performed significantly better that all PWA combined on the online task (RT's measure, $\Delta z = 0.104$, 95% CI [0.017…0.192], $t = 2.366$, $p = 0.018$) and the offline task (accuracy measure, log odds = +3.217, CI 95% = [1.296 … 8.775], $p = 0.013$). Lastly, the accuracy on the VSL task and syntactic competence weakly correlated in PWA, independently of lesion location ($r = 0.156$, CI 98.75% = [0.015 … 0.290], $p = 0.005$). The accuracy on the VSL task did not correlate to lexical competence in PWA. Conclusion: Our first key finding regarding the hypothesized anatomical localization of ISL mechanisms remained unsupported, and we demonstrate that patients whose frontal regions were spared, but whose posterior regions were in fact lesioned, manifest impaired ISL mechanisms. Our second key finding is that the magnitude of the learning effect on the VSL task correlates to syntactic, but not to lexical competences of PWA. This suggests that a) domain-general ISL mechanisms at least partially overlap with mechanisms recruited in language processing and b) ISL mechanisms are recruited in the linguistic modules that require exploitation and manipulation of patterned regularities, such as syntax.

Topic Areas: Syntax, Disorders: Acquired

Neural representations of motor component of handwriting in French/Arabic biscripters

Poster E55 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session E.

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Introduction. Biscriptalism is the ability to write with two different graphic systems (for example in Arabic and in Latin alphabets). Despite an increasing number of biscripters, especially in countries using non-Latin scripts, this phenomenon is poorly studied. When an expert writer is writing letters, he should recall the corresponding motor programs and execute the appropriate hand movement. In Latin scripts, these processes rely on a network distributed mostly over the left hemisphere in right handers. The key nodes of this writing network are the left dorsal premotor cortex, the primary motor cortex, the superior parietal lobule, the fusiform gyrus and the right cerebellum. In Arabic scripters, and a fortiori in Arabic/Latin biscripters, this network has not been described. In this study, we tested whether the motor specificities of Arabic and Latin graphic systems lead to spatially segregated activations within the writing network in biscripters. Methods. 28 right-handed adult biscripters had to copy Arabic and Latin single letters without visual feedback in an event-related design (7 sessions). The letters were matched on their grapho-motor complexity. A MRI-compatible digitizing tablet allowed to record the kinematic data, and to calculate the latency and writing duration for each letter produced. Data were acquired on a 3-Tesla MRI Scanner (Magnetom-Prisma, Siemens). The images were processed with SPM12. To model the BOLD signal optimally, we accounted for the writing duration of each trial in the first-level models. We also created extra nuisance regressors of no-interest in the individual statistical models to account for head motion and physiological variations. Second-level analyses were carried out to compare between Arabic and Latin letters. Results. The whole brain analysis revealed that while both alphabets engage the writing network, Arabic letters recruit this network more strongly, particularly the left dorsal premotor cortex and a set of dorsal parietal regions. Interestingly, the Arabic letters also strongly activated the right superior parietal lobule. No components of the writing network were more strongly activated by Latin than Arabic letters, but Latin letters lead to stronger activation in the inferior post central gyri left and right. Discussion. Writing Arabic and Latin letters differed at neural level. Writing Arabic letters engaged dorsal-parietal and premotor regions more strongly than Latin letters. These regions compute visuomotor information for the perception and production of complex trajectories of the hand. The fact that writing Arabic letters also involves the right superior parietal lobule might be related to the right-to-left writing direction of Arabic letters. Latin letters engaged sensorimotor regions known for their involvement in spoken language processing. Overall, the differences observed between French and Arabic may indicate that biscripters manage the co-existence of two writing systems by increasing the associations between certain features of the letters (visuospatial vs phonological/articulatory) and the computation of sequences of graphomotor strokes within the writing network. We are currently running a Representational Similarity Analysis to asses this hypothesis and understand which components of the letters (phonological, motoric, visuospatial) are processed in the region displaying differences between French and Arabic.

Topic Areas: Writing and Spelling, Multilingualism

Mispelled or misspelled? N400 lexicality effects in a spelling recognition task

Poster E56 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session E.

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In the lexical decision task, pseudowords that are orthotactically and phonotactically legal often elicit larger amplitude N400s than real words. This finding is counterintuitive, as it suggests that pseudowords elicit more effortful lexico-semantic processing than real words. One proposal to account for this effect has been that pseudowords trigger an effortful search process before a decision threshold is reached and they can be classified as nonwords. To test this hypothesis, we examined the N400 lexicality effect in a spelling recognition task in which participants decided whether stimuli were correctly or incorrectly spelled. Incorrectly spelled words (e.g., absalute, comunity) were chosen such that the base word could be easily identified; as a result, classifying the incorrectly spelled words did not require an exhaustive search through the lexicon. Nevertheless, we found that misspelled words elicited larger amplitude negativities within the N400 window than their correctly spelled base words. This lexicality effect onset earlier when the incorrectly spelled word was easy to identify compared to when it was more difficult, as determined by average behavioral performance. Overall, these data indicate that the N400 lexicality effect is not (only) related to an exhaustive search process for pseudowords.

Topic Areas: Writing and Spelling, Methods

Syntactic vs. Lexical Effects in Syntactic Frequency Tagging

Poster E57 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session E.

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Introduction. Language comprehension is traditionally assumed to involve parsing of the hierarchical syntactic structure of the input. Ding et al. (2016) corroborated this view neurophysiologically by presenting listeners with isochronous word sequences (e.g., new plans bring hope, 250ms/word) and demonstrating that listeners automatically track regularities in the syntactic structure: the MEG power spectrum contained a peak at the word rate (as expected given the constant duration), but also peaks corresponding to 2-word phrases (new plans, bring hopes) and 4-word sentences. Given that nothing in the acoustic signal marked syntactic structure, the effect was attributed to spontaneous parsing into hierarchically organized constituents. This interpretation was challenged by Frank&Yang (2018) who noted a confound in the stimuli: syntactic regularity could be predicted by word-level properties. Namely, when words from Ding's sequences were represented by semantic distributional vectors (word2vec, Mikolov, 2013) and analyzed like physiological data were, the results mirrored Ding's ones. Although this does not logically rule out the hierarchical interpretation, it does provide a simpler, lexical explanation for their findings. In our MEG study on Russian (preliminary data only) we dissociate the hierarchical and lexical views by manipulating the syntactic structure while keeping lexical properties intact. Sample sentences: [cook of-Dina]NP [is-making pancakes]VP ('Dina's cook is making pancakes', Genitive condition); [cook]NP [for-Dina is-making pancakes]VP ('The cook is making pancakes for Dina', Dative condition). The two conditions contain the same words and differ in a single phoneme (case marker of the 2nd noun, Diny/Dine). Hence, Frank & Yang's word-level model showed no difference in the peaks at the two-word frequency. Accordingly, it predicts no differences in the physiological data. The syntactic structure, however, is distinct: Genitive contains two 2-word phrases, whereas, in Dative, a 1-word NP is followed by a 3-word VP. Thus, under the hierarchical view, the 2-word-frequency peak should be larger in the Genitive vs. Dative condition. Comparing 2-word peaks will let us dissociate the two views. Methods. 64 pairs of two conditions were created. Syllables were independently synthesized and exactly 320-ms-long. Words/phrases/sentences were formed by concatenation. Participants will listen to 24 Genitive and 24 Dative trials (10 sentences each). A memory task will follow each trial to encourage attentive listening. MEG recorded with a Neuromag system will be linearly filtered and split into epochs corresponding to sentences 2-10 of each trial. The data will be spatially filtered to maximize the phase-locked power at each frequency bin. The power at each bin will be divided by the average power at the four flanking bins (two on each side) to calculate the signal-to-noise ratio (SNR) which will be normalized to the SNR at the word frequency. SNRs at the two-word frequency will be compared across conditions using a Bayesian one-tailed paired t-test using an informed prior. We will collect 20 participants, and then continue in the increments of 5 until we get a BF < ⅙, BF > 20, or collect 50 participants - whichever comes first. This plan was analysed using Bayes Factor Design Analysis.

Topic Areas: Speech Perception, Syntax

Age-related changes in neural network dynamics during speech in noise comprehension

Poster E58 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session E.

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Semantic context can facilitate speech comprehension under challenging listening conditions. On the neural level, this comprehension benefit is reflected by increased activity in left-hemispheric semantic regions (1). Whilst being considered a robust effect in healthy young adults, the behavioural comprehension benefit and its neural implementation are less evident in older adults. Here, we investigate age-related differences in the ability to comprehend speech in challenging listening conditions. We conducted an event-related fMRI study with 60 healthy participants (30 young, mean age: 25 years, 15 female and 30 elderly, mean age: 63 years, 21 female). Only participants with relatively well preserved peripheral hearing abilities (pure-tone audiometry < 25 dB) were included. Participants listened to sentences varying in semantic predictability of the sentence-final keyword (high vs. low) and intelligibility (speech-shaped noise at six levels of signal-to-noise ratio). Crucially, intelligibility levels were constructed in relation to each subject's individual speech reception threshold, determined in an adaptive tracking procedure before the experiment. During scanning, participants performed an overt repetition task. Repetition accuracies were analysed with psychometric functions that were fitted to the proportion of correctly repeated keywords for high and low predictable sentences respectively. Functional MRI data were preprocessed and analysed in SPM12. Within-group effects were analysed using a flexible-factorial design, between-group effects were analysed using a two-sample t-test. Preliminary behavioural analysis of the threshold parameter of participant's psychometric curves revealed a significant effect of predictability ($F(1,54)=78.87$, $p<0.001$), suggesting that both age groups profited from contextual information at intermediate intelligibility during speech comprehension in noise. No age-related differences were found. Despite relatively well preserved hearing abilities in the older age group, there was a significant difference in peripheral hearing between both age groups ($t=2.84$, $p=0.007$), highlighting the importance of individualizing stimuli in such experimental settings. Further, preliminary within-group analyses of the context-dependent interaction in the neuroimaging data revealed a left-hemispheric network of semantic brain regions, comprising clusters in left angular gyrus (AG), posterior middle temporal gyrus (pMTG), inferior temporal gyrus, supramarginal gyrus and precuneus. Similar to the behavioural results, we found no differences between the groups in neural processing. Interestingly, a conjunction analysis revealed left AG and pMTG, two regions associated with semantic control, to be consistently activated by both groups. Both regions are associated with semantic control processes. This finding is in line with a recent meta-analysis reporting that only older adults with poor behavioural performance show reduced activity in left AG and pMTG during semantic tasks (2). Next, we will investigate age-related differences in the effective connectivity within the semantic network. (1) Obleser, J., Wise, R. J. S., Dresner, A. M., & Scott, S. K. (2007). Functional Integration across Brain Regions Improves Speech Perception under Adverse Listening Conditions. Journal of Neuroscience, 27(9), 2283–2289. (2) Hoffman, P., & Morcom, A. M. (2018). Age-related changes in the neural networks supporting semantic cognition: A meta-analysis of 47 functional neuroimaging studies. Neuroscience & Biobehavioral Reviews, 84, 134–150.

Topic Areas: Speech Perception, Perception: Auditory

The effects of accent and likelihood on spellings of unknown words for L2 speakers of English

Poster E59 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session E.

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In opaque languages, like English, converting the auditory form of a word into the written item can be quite a challenge. Nevertheless, there is research suggesting that this occurs somewhat automatically and that people create orthographic skeletons—predictive spellings—when they first hear a word, even without exposure to its written form. In addition, predictability helps later reading, meaning that words with spellings that are easier to predict are also easier to read. In English, in particular, there are multiple orthographic representations for most phonemes, and thus most words allow for several possible spellings. Adult, proficient readers of English are familiar with the regularities and spelling probabilities within the language and thus opt for the most common or more likely spelling for a word. Less proficient readers, such as children, on the other hand, are less likely to choose the most common spellings for phonemes. So far, little is known about how L2 learners manage this ambiguity. For them, this has several added challenges. On the one hand, they have a reduced familiarity with spellings (much like the case of children) and sounds of that language. On the other hand, they are influenced by their first language phonological-orthographic correspondences. Our goal is to understand how this translates into the spelling of unknown words for non-native speakers of English (L1 speakers of Spanish). We focused on consonants with more than one likely spelling (e.g., /f/ which can be spelled 'f' or 'ph' or /k/ which could be 'c' or 'k') and on vowels that are marked by a final, silent e (e.g., /aɪ/ which in English could be spelled right or rite, but in Spanish would be 'ai'). To test this, we manipulated the spelling of the key consonant in the closest neighbour, establishing preference for one consonant spelling over another. In a separate set of words, we manipulated whether the silent e or the alternative spelling was more likely—as measured by bigram frequency of the pseudoword. Then, we had participants (L1 speakers of Spanish with a medium to high level of their L2 English spell pseudowords read in one of two accents: a native accent (standard American) or a foreign accent (read by a native Spanish speaker, from the same population as the participants). Participants listened to the words once and then typed the closest approximation possible to what they heard. First, we compared how close to the predicted spelling the produced strings were—as measured using ALINE distance—for pseudowords in one accent and the other, to establish whether the foreign accent facilitated comprehension on a by-phoneme level. Then, we compared the likelihood of choosing one consonant spelling or another based on the closest neighbour and whether that interacted with the accent of the speaker. Finally, we compared the likelihood of using the silent e, the alternative, or the (incorrect) Spanish spelling according to accent and likelihood of each spelling (as defined by bigram frequency). Results are still preliminary and data collection is currently ongoing online.

Topic Areas: Writing and Spelling, Speech Perception

Bilingual and tone language experience affect infants' lexical tone perception

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Presenter Note: Due to the time zone difference between you and me, I may not always be there to take your notes or answer your questions. However, your thoughts and comments are very valuable. If convenient, please send them to l.liu@westernsydney.edu.au or liquanl@uio.no. Many many thanks in advance for your time and input. Liquan

Liquan Liu[1,2], Varghese Peter[1], Gabrielle Weidemann[1]; [1]Western Sydney University, [2]University of Oslo

Behavioural studies have reported differences in lexical tone perception between tone- and non-tone-language learning infants. The former keeps and the latter loses their tonal sensitivity in the first year after birth (Mattock

& Burnham, 2006). Nevertheless, tonal sensitivity rebounded among non-tone-language learning infants in the second year (Liu & Kager, 2014; Götz, Yeung, Krasotkina, Schwarzer & Höhle, 2018). Moreover, infants' (bilingual) language experiences appear to modulate the pace of rebound (Liu & Kager, 2017). These findings suggest the possibility that infants remain sensitive to non-native tones is present after perceptual attunement, though not surfaced behaviourally. In this study, we explored infants' neural sensitivity to tones using electroencephalogram and whether infants' prior linguistic experiences alter their lexical tone perception? Forty-eight 11-12-month-old infants from three types of language backgrounds participated in the study: monolingual Australian English infants (N = 20), bilingual Australian English infants without tone or pitch-accent language experience (N = 14) and bilingual Australian English infants with tone language experience other than Mandarin Chinese (N = 14). To be defined as a bilingual, a participant's non-dominant language was no less than 20% of their total language exposure. Participants underwent a passive EEG oddball paradigm comprising a contracted Mandarin T1-T4 tonal contrast used in previous behavioural studies (Liu & Kager, 2014; 2017). Distinct neural processing patterns were observed across infants from different language backgrounds. While monolingual Australian infants exhibited no significant sensitivity, their non-tone-language learning bilingual peers showed positive mismatch responses (MMR). Meanwhile, bilingual tone-language learning infants revealed adult-like mismatch negativity (MMN) to tones. Results illustrate that: 1. Infants' lexical tone processing is present on a neural level even when behavioural evidence can be absent, probably modulated by the acoustic salience of specific tone contrasts (Burnham & Singh, 2018). 2. Such sensitivity can be immature, as reflected by infants' MMR instead of MMN responses (Peter, Kalashnikova, Santos & Burnham, 2016). 3. Both specific (tone-language) and general (bilingualism) linguistic experience can facilitate infants' tone perception, with more matured effects exhibited in the former. References [1] Mattock, K., & Burnham, D. (2006). Chinese and English infants' tone perception: Evidence for perceptual reorganization. Infancy, 10(3), 241-265. [2] Liu, L., & Kager, R. (2014). Perception of tones by infants learning a non-tone language. Cognition, 133(2), 385-394. [3] Götz, A., Yeung, H. H., Krasotkina, A., Schwarzer, G., & Höhle, B. (2018). Perceptual reorganization of lexical tones: effects of age and experimental procedure. Frontiers in Psychology, 9, 477. [4] Liu, L., & Kager, R. (2017). Perception of tones by bilingual infants learning non-tone languages. Bilingualism: Language and Cognition, 20(3), 561-575. [5] Burnham, D. K., & Singh, L. (2018). Coupling tonetics and perceptual attunement: The psychophysics of lexical tone contrast salience. The Journal of the Acoustical Society of America, 144(3), 1716-1716. [6] Peter, V., Kalashnikova, M., Santos, A., & Burnham, D. (2016). Mature neural responses to infant-directed speech but not adult-directed speech in pre-verbal infants. Scientific reports, 6, 34273.

Topic Areas: Speech Perception, Multilingualism

Poster Session F

An investigation of the relationships between right hemisphere structural MRI measures and language abilities in left hemisphere stroke survivors

Poster F1 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session F.

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Previous work in aphasia indicates that functional and structural changes in both the lesioned (typically left) and unaffected (typically right) hemisphere can be related to aphasia outcomes. However, the mechanisms behind these differences remain unclear, particularly for the contributions of the right hemisphere. For example, it is unclear if right hemisphere recruitment is helpful or detrimental to language abilities. It also is unclear if right hemisphere differences reflects cognitive resources recruited to support speech processes or if they reflect functional reorganization of language networks. The present study aimed to contribute to this discussion by investigating the relationship between language performance, cognitive performance, and structural measures in the right hemisphere of left hemisphere stroke survivors. T1-weighted MRI and a battery of cognitive tests were obtained from 31 chronic left hemisphere stroke survivors and 44 neurologically-intact control participants that were matched to the stroke survivors on age, gender, and education level. Stroke survivors completed a large behavioral test battery, including the Boston Diagnostic Aphasia Exam's auditory comprehension and picture description task subtests and the WAIS-IV's working memory and processing speed indices. Freesurfer software was used to segment each participant's T1 MRI and compute the following measures in 16 a priori regions of interests (ROIs) in the right hemisphere for each individual: gray matter volume, cortical thickness, white matter volume, and white matter intensity. Two-sample t-tests were used in each ROI for each structural measure to identify ROIs in which there was a significant difference between the stroke and control groups. Pearson correlations also were computed within the stroke survivor group to determine the relationships between structural measures in each ROI and the behavioral measures. Multiple comparisons were controlled for using the Benjamini-Hochberg false-discovery rate adjustment. T-test results indicate the following: the stroke group's cortical thickness measures were significantly smaller than controls in several right hemisphere ROIs including insula, superior frontal, orbitofrontal, and inferior frontal gyrus ROIs. In addition, the stroke group exhibited lower white matter intensity than the control group in several right hemisphere ROIs that are homologues of well-established critical left hemisphere language regions, including middle temporal, inferior parietal, supramarginal, and inferior frontal gyrus ROIs. The Pearson correlations indicate that stroke survivors with greater white matter intensity in right middle frontal and right superior temporal ROIs exhibited greater fluency as measured by the picture description task, while greater cortical thickness in the right superior temporal ROI was found to be related to better performance on the auditory comprehension task. Better processing speed scores were significantly correlated with greater cortical thickness in the right pars triangularis, middle frontal, and superior frontal ROIs. Greater working memory was significantly associated with greater cortical thickness in right Heschl's gyrus. Overall, the present study provides support for the idea that greater cortical thickness in some right hemisphere regions may be related to better language and cognitive performance in left hemisphere stroke survivors, and chronic left hemisphere stroke survivors have reduced gray and white matter measures in right hemisphere regions known to support language in post-stroke aphasia.

Topic Areas: Disorders: Acquired, Control, Selection, and Executive Processes

The role of the right hemisphere in receptive and productive language recovery: an activation likelihood estimate study

Poster F2 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session F.

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Studies investigating language recovery in aphasia find two primary recovery patterns: persons with aphasia (PWA) recruit either 1) left perilesional brain regions or 2) right hemisphere homologues more so than control subjects during language tasks. While both recovery patterns have been associated with greater language recovery, these studies primarily focus on language production, not comprehension. Thus, it is not clear if right hemisphere involvement during language recovery differs for receptive and productive processes. The present study uses activation likelihood estimates (ALE), a coordinate-based meta-analysis method, and qualitative meta-analysis techniques to examine the role of the left and right hemispheres in language recovery during both language production and comprehension tasks in post-stroke (chronic) aphasia. Peak activation coordinates (fMRI and PET) were extracted from 68 studies in PWA (12 perception, 56 production) and 137 studies in controls (98 perception, 39 production). All MNI coordinates were transformed into Talairach space. ALEs were then calculated using GingerALE 3.0.2. Single condition ALEs used a cluster-level correction for multiple comparisons set to p=.05 (10,000 permutations) with a cluster forming threshold of p<.001. The threshold for the contrast analyses was set to p=.05 (uncorrected; 10,000 permutations) with a 200 mm3 minimum volume since this analysis uses thresholded ALE maps. Single condition ALE results for the control subjects include: left frontal and temporal activation for both production and comprehension, however bilateral superior and middle temporal gyri cluster volumes were larger for comprehension than production. Single condition ALE results for PWA include: activation in the right inferior frontal, medial frontal, precentral, and middle temporal gyri during production tasks and activation of left inferior frontal (pars orbitalis), middle temporal, and superior temporal gyri during comprehension tasks. Contrast analyses comparing activation for PWA and controls revealed greater activation of the left inferior frontal (pars orbitalis), precentral, and middle temporal gyri for PWA compared to controls during comprehension tasks, however, PWA did not activate any brain region more than controls during production tasks. While ALEs could not be computed between activation and behavioral performance of PWA due to few studies reporting these relationships, a qualitative summary indicates the brain regions associated with better performance without treatment vary depending on the task. For example, better single word reading was related to right frontal and middle temporal gyri activation, while better auditory sentence comprehension positively correlated with activation of bilateral anterior temporal lobes and left posterior superior temporal cortex. Overall, our preliminary results suggest that activation patterns in PWA differ for productive and receptive language processes: PWA activate right hemisphere homologues during language production tasks (consistent with previous work) and left perilesional regions during comprehension tasks. Our meta-analyses also highlight the relative lack of functional neuroimaging studies of language comprehension in PWA, and the need for more studies to determine how activation patterns as measured by fMRI are related to both productive and receptive language recovery in PWA.

Topic Areas: Disorders: Acquired, Speech Perception

Automatic analysis of voice quality and prosody in patients with Mild Cognitive Impairment

Poster F3 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session F.

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Introduction. While the effects of cognitive decline on speech production of patients with Mild Cognitive Impairment (MCI) are not as extensively studied as other aspects of cognitive decline, recent studies show speech impairments in these individuals [1]. Our earlier work analyzed segmental and prosodic features of speech production and showed that vowel formant frequencies and vowel duration can distinguish patients-with-MCI from controls with 83% mean cross-validated accuracy [1]. This new research aims to identify whether voice quality and speech fluency distinguish patients-with-MCI from controls, to provide objective markers from speech and ultimately improve diagnosis of this condition. Methods. 55 people participated in a Cookie theft picture description task from the Boston diagnostic aphasia examination; 26 patients-with-MCI and 29 healthy controls (HC) from Sweden. The recordings were acoustically analyzed and measures of i. voice quality (i.e., breathy/creaky voice, cepstral peak prominence (CPP) spectral energy, dysphonia, articulatory effort, jitter, shimmer, harmonicity), and ii. speech fluency (i.e., speech and articulation rate) were elicited from the recordings. Results. Voice quality measures demonstrate significant differences between patients with MCI and HC. Patients with MCI produce speech that differs from HC in phonation and voice quality, which is measured using objective markers presented in this section and determine differences in the fine-control of the sublaryngeal and laryngeal systems. We found significant differences of patients with MCI from HC with respect to the difference of the first harmonic and third amplitude (H1-A3). Patients with MCI differed significantly from HC with respect to their CPP: there is an overall lower CPP in patients with MCI compared to HC, which suggests weaker voice. Also, patients with MCI differed significantly from HC with respect to shimmer and center of gravity. Also, there were no significant differences between patients with MCI and HC in jitter. Patients with MCI produced significantly longer syllables and slower articulation rate from HC. Discussion. Cognitive decline in patients with Mild Cognitive Impairment (MCI) is manifested as a noticeable memory difficulty in remembering events and situations, impaired language, speech, decision making, planning, interpreting instructions, and orientation. Given that MCI patients are a high risk group for developing AD, there is a dire need to elicit objective measures that can enable the early and quick identification of patients with MCI, to provide treatment promptly, facilitate MCI prognosis, and ultimately improve life quality both for patients with MCI and for their family members. This study provides novel findings that show impairment of speech production in patients with MCI with respect to (i) voice quality and (ii) speech fluency and demonstrates that these measures can provide objective diagnostics of patients with MCI. The acoustic measures presented can facilitate the automatic analysis of speech in the clinic quantifying speech production and ultimately provide accessible acoustic diagnostic markers of patients-with-MCI. References 1. Themistocleous C, Eckerstrom M, Kokkinakis D. Identification of Mild Cognitive Impairment From Speech in Swedish Using Deep Sequential Neural Networks. Frontiers in Neurology. 2018;9:975.

Topic Areas: Disorders: Acquired, Speech Motor Control

The neurotopography of local rs-fMRI signal indexes language deficits

Poster F4 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session F.

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Resting-state fMRI (rs-fMRI) is emerging as a key tool for understanding aphasia, both because of the relative ease of data collection, and because it provides rich information about neural activity. While the majority of rs-fMRI analyses focus on connectivity, recent work (e.g., Demarco & Turkeltaub, 2020; Guo et al., 2019) shows that the neurotopographic distribution of the rs-fMRI signal may distinguish lesioned from healthy tissue and index language deficits. The study we report on here investigates: (1) whether the neurotopographic distribution of fALFF (fractional Amplitude of Low Frequency Fluctuations; Zou et al., 2008) differs significantly between individuals with post-stroke aphasia (PSA) and healthy controls, and (2) whether the severity of language deficits across three domains (agrammatism, anomia, dysgraphia) is differentially associated with the distribution of fALFF. Methods: 121 participants, 64 (21 females) subsequent to a single left-hemisphere stroke, and 57 healthy individuals (35 females) matched for mean age and education. Language domain scores were obtained for: agrammatism: (Northwestern Assessment of Verbs and Sentences; Thompson, 2011); anomia: (Northwestern Naming Battery; Thompson & Weintraub, 2014); dysgraphia (PALPA 40; Lesser & Coltheart, 1992). Per-voxel fALFF values (excluding lesioned voxels and voxels with fALFF values under 0.098) were grouped into the 48 bilateral gray matter parcels of the Harvard-Oxford Atlas (Desikan et al, 2006). Voxel values were mean normalized and parcel averages were used as the dependent variable in linear mixed-effects models (LMEM)—resulting in up to 96 observations per participant. This allowed evaluation of differences between PSA and healthy controls in the relative distribution of fALFF across the anatomical parcels. Two models were evaluated: Model 1 compared PSA to controls, and Model 2 evaluated fALFF associations with language deficits. Random effects by-parcel allowed for the simultaneous estimation of parcel-specific effects without further need for multiple comparisons correction (Chen et al., 2019). Both models were fit in R with the package brms (Bürkner, 2018). Results (significant at $p < 0.05$): Model 1 identified PSA vs. control differences: (1) fALFF higher for controls vs. PSA: three bilateral temporo-parietal clusters (SMG/MTG/STG), anterior temporal fusiform (TFCa) and medial pre-frontal cortex; (2) higher PSA vs. controls: two bilateral anterior clusters (frontal-parietal opercula and insula) and two posterior clusters (superior LOC and occipital pole); (3) Hemispheric differences: fALFF lower for PSA in L-TFCa. Model 2 identified deficit- specific associations with fALFF: (1) agrammatism: positive association in L-anterior STG, L-planum temporale, L-frontal and L-parietal operculum; (2) anomia: negative association in L-frontal operculum, L-insular cortex, and TFCa, and positive association in anterior SMG; (3) dysgraphia: positive association in TFCa and posterior MTG and STG. Conclusions: This study identified several brain regions in which individuals with post-stroke aphasia showed atypical neurotopographic distribution of resting-state BOLD signal compared to controls. We also identified regions that were differentially associated with the severity of deficits in specific language domains. These results have implications for understanding the consequences of stroke on resting state BOLD and how these signal differences may contribute to disruptions to specific components of the language system.

Topic Areas: Disorders: Acquired, Language Therapy

Decreased beta desynchronization in Broca's area during nonword production in children with childhood apraxia of speech

Poster F6 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session F.

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Childhood apraxia of speech (CAS) is a neurological speech disorder characterized by poor planning of speech sound sequences in the absence of neuromuscular deficits. Individuals with CAS exhibit symptoms such as inconsistent speech production, vowel errors, prosodic disturbances, and difficulty with coarticulatory transitions. Poor response to intervention is common for those with CAS, and speech difficulties may have negative impacts on self-esteem, academic achievement, and social interactions. Within the Directions into Velocities of Articulators model (DIVA) framework, two main deficits may underlie CAS. The first possible deficit is a weakness in feedforward control, hereafter referred to as motor planning. Under this hypothesis, neural encoding of auditory and somatosensory information is intact but the pre-motor planning area for speech (Broca's area) fails to develop an accurate motor sequence for the intended utterance. The second possible deficit is an overreliance on afferent sensory feedback mechanisms, such as auditory representation of the intended sound as well as proprioceptive information regarding the location of the articulators (e.g. the lips, cheeks, and tongue) which is needed to properly plan and produce speech, as well as evaluate the accuracy of the executed movement. In the current pilot study, children with (N = 8) or without (N = 7) CAS completed two tasks while magnetoencephalography (MEG) recordings were acquired. These tasks were designed to evaluate the neural markers of CAS and determine whether deficits in feedback mechanisms and pre-motor planning exist in isolation or in tandem. The first task aimed to evaluate somatosensory feedback processes by lightly stimulating participants at two articulator locations: the lip and the tongue, while MEG data were acquired. Participants then completed a non-word repetition task to allow for the evaluation of pre-motor planning and early auditory processing. We evaluated neural activation and event-related beta desynchronization in three regions of interest: primary auditory (A1), primary somatosensory (S1), and Broca's area. Data from this pilot study indicate (1) that early A1 processing of consonant-vowel-consonant (CVC) stimuli is intact for CAS, (2) somatosensory processing deficits were not exhibited for CAS, and (3) pre-motor planning is abnormal for CAS. Our results suggest a motor planning deficit in CAS, though a larger sample would be needed to further confirm these results.

Topic Areas: Language Production, Disorders: Developmental

Parallel Processing of Semantics and Phonology in Spoken Production

Poster F7 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session F.

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Spoken language production involves lexical-semantic and phonological encoding. The time course of the two cognitive processes has been a theoretically important question in the domain of language production. The predominant view has been that semantic and phonological codes are processed in two sequential steps, with semantic processing preceding phonological processing. However, a few recent evidences seem difficult to reconcile with a sequential view but rather support a parallel view. To revisit the debate, we here used event-

related potentials (ERPs) combined with the blocked cyclic naming paradigm. Behaviorally, we demonstrated that objects were named slower in the context of items from the same semantic category than from different categories. Similarly, phonological context caused similarity-based interference when this overlap was distributed unpredictably across positions in words. Crucially, ERP data demonstrated that the semantic effect and phonological effect emerged at the similar latency (~180 ms after picture onset) and time window (180-400 ms). These findings suggest that access to phonological information takes place in parallel with semantic processing at a relatively early stage during spoken planning.

Topic Areas: Language Production, Phonology and Phonological Working Memory

Quantitative and qualitative differences in performance within the semantic and letter fluency tasks

Poster F8 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session F.

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INTRODUCTION: Traditionally, verbal fluency research has differentiated between semantic (SF) and letter fluency (LF). However, although linguistic research has strongly suggested that there are pronounced differences in the processing of different types of semantic categories, most researchers in this domain have uncritically assumed that there are no category-specific effects in verbal fluency. Limited research on SF has thus far revealed that disproportionate performances across different categories are in certain contexts associated with category size, while clinical populations might show normative deficits in one category, but not the other. Nevertheless, this issue remains poorly investigated, particularly in LF. METHODS: We recruited 16 Croatian-speaking students from the University of Zagreb. For verbal fluency, we administered the categories animals and trees (SF), and the letters K and M (LF) (60 s). Participants further performed on a neuropsychological battery encompassing the Trail Making Test (TMT), Wisconsin Card Sorting Test (WCST), digit span, and lexical decision (LD). Paired-sample t-tests, and Spearman correlation coefficients and regression analyses were used for statistical analyses. RESULTS: On the animal compared to the tree task participants produced more words, had lower intrusion rates, produced larger clusters, and were faster in inter-cluster transitions. Furthermore, while the total production of animals was positively predicted by the number of clusters, in trees it was positively predicted by cluster size. A negative relationship between performance on TMT and speed of inter-cluster transitions was found in trees, and a positive relationship between performance on WCST and the same fluency variable in animals. Higher digit span was associated with lower clustering rates in animals, but with higher clustering rates in trees, while accuracy on abstract LD trials was positively associated with total production on trees. Analyses of LF revealed that participants produced more words and were faster in inter-cluster transitions on the K compared to the M task. Total production in K was predicted by cluster size, but in M it was predicted by switching. Accuracy on TMT negatively predicted total production and the number of clusters for M. Also, performance on WCST was positively associated with clustering rates and inter-cluster transition speed on M. CONCLUSIONS: Our results indicate that there are important differences in the phenomena and processes underlying performance on different SF and LF tasks. While the differences in the two SF tasks might be partly explained by presumed differences in category size, higher rates of intrusions in the tree task suggest that the boundaries of the category trees are less fixed compared to the category animals. Additionally, disproportionate relationships with neuropsychological variables suggest that clustering in trees might rely more on working memory and abstract semantic processes. Regarding LF, we found that performance on K relies more on clustering compared to M, while the neuropsychological data suggested that performance on the M task was inversely associated with visual attention, possibly suggesting that visuospatial imagery strategies might hinder optimal performance. Also, data suggest that clustering on the M, but not the K task is an executively relatively demanding process.

Topic Areas: Language Production, Meaning: Lexical Semantics

Reconfiguration of functional brain networks underlying the distinctions between automatic and controlled handwriting

Poster F9 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session F.

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Introduction. Handwriting is essential for success in most spheres of life. Skilled handwriting is a highly automatic motor processing, and the transition from controlled to automatic processing informs the mastery of handwriting. But, the brain mechanisms underlying the distinction between automatic and controlled handwriting processes are largely unknown. Methods. Using functional magnetic resonance imaging (fMRI) in a copying task with varying speed control demands, this study examined the differences in functional networks between automatic and controlled handwriting in adult writers (N = 53). Results. Network analysis showed significant differences in functional connectivity within and between the frontoparietal network (FPN), the default mode network (DMN), the dorsal attention network (DAN), the somatomotor network (SMN) and the visual network (VN) between automatic and speed-controlled handwriting irrespective of written materials, which are thought to reflect general executive control and task-relevant visuomotor operations. However, there were no differences in brain activation between automatic and controlled handwriting. Conclusion. These results suggest that reconfiguration of functional network architecture, rather than regional activation, underlies the dissociations between automatic and controlled handwriting. Our findings shed new light on the neural mechanisms of handwriting mastery and handwriting impairments in individuals with neurological disorders.

Topic Areas: Language Production, Writing and Spelling

Examining how baseline frontal lobe functions influence therapeutic effects of High-Definition transcranial Direct Current Stimulation on verbal retrieval deficits related to traumatic brain injury

Poster F10 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session F.

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Introduction: Impaired retrieval function is a common chronic cognitive sequalae from traumatic brain injury (TBI) and evidence-based treatment is lacking. The underlying neural circuit subserving lexico-semantic retrieval has been proposed to involve the dorsomedial frontal region neighboring the pre-Supplementary Motor Area and the dorsal Anterior Cingulate Cortex (pre-SMA/dACC). Verbal retrieval function has recently been shown to improve with High-Definition transcranial Direct Current Stimulation (HD-tDCS) targeting the pre-SMA/dACC, but it remains unresolved as to who would respond better to HD-tDCS. Here we examined how the integrity of frontal lobe function at baseline can discriminate between responders who receive HD-tDCS treatment. Methods: Veterans with a history of TBI and subjective complaints of verbal retrieval deficits confirmed by objective measures were randomly assigned (ratio of 2:1) to the active (N=18) or the sham (N=7) group. In the active group, anodal HD-tDCS was administered at 1mA to the pre-SMA/dACC over 20 minutes daily for a total of 10 sessions. Neuropsychological assessment was administered at baseline, immediately after (within a week), and 8 weeks after completion of HD-tDCS. Generalized linear mixed modeling was applied to examine effects of condition (active vs sham), time point (pre, post-immediate, post-8 weeks) and their interaction. We then divided individuals into higher frontal lobe function (HFL, N = 8/3 for active/sham, respectively) vs lower frontal lobe function (LFL, N = 10/4 for active/sham, respectively) groups. Secondary analysis included group (HFL vs LFL) in addition to condition and time point, and their interactions. Results: We found improvements in verbal retrieval and cognitive control measures (D-KEFS naming, $p = 0.003$; D-KEFS inhibition-switching, $p = 0.002$) in response to active HD-tDCS immediately after and sustained at 8 weeks after HD-tDCS. Verbal memory recognition showed a delayed effect at 8 weeks (RAVLT-recognition, $p < 0.001$). In secondary analysis, we found that HFL group had a delayed improvement at 8 weeks in animal fluency only with active HD-tDCS, while such effect was observed neither in sham HFL nor in active/sham LFL ($p = 0.002$). In the active HD-tDCS groups, LFL improved in Trails-B after HD-tDCS completion (immediately and at 8 weeks) while HFL did not ($p = 0.025$). Conclusion: Our findings corroborate the utility of using HD-tDCS targeted at the pre-SMA/dACC to selectively improve TBI-related verbal retrieval deficits. In addition, the integrity of the underlying neural circuits, as indexed by baseline frontal lobe function, may guide clinicians in choosing appropriate individuals for the desired therapeutic outcome.

Topic Areas: Language Therapy, Meaning: Lexical Semantics

Multimodal MRI correlates of positive treatment outcomes in non-fluent/agrammatic primary progressive aphasia

Poster F11 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session F.

Presenter Note: For any questions or comments, please contact Eduardo Europa <eduardo.europa@ucsf.edu> or Maya Henry <maya.henry@austin.utexas.edu>.

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Nonfluent/agrammatic variant primary progressive aphasia (nfvPPA) is characterized by progressive motor speech impairment and/or agrammatism with predominant left fronto-insular atrophy. Script training improves fluency and intelligibility in nfvPPA, but neural mechanisms supporting treatment are not well understood. The purpose of the current study was to examine the relation between treatment outcomes and baseline structural and functional neuroimaging measures. For this study, 21 individuals with nfvPPA completed Video-Implemented Script Training for Aphasia (VISTA), with twice-weekly clinician-led sessions over 4-6 weeks targeting accurate production and conversational usage of personally relevant scripts. Daily homework consisted of unison speech production practice of scripted material with an audiovisual model of a healthy speaker. Multimodal MRI data were collected and analyzed using a region-of-interest (ROI) approach. ROIs were selected from an inferior frontal gyrus (IFG)-seeded speech production network derived from resting-state functional MRI (rsfMRI) data in healthy controls (Mandelli et al., 2016). The network comprised 13 cortical and 2 subcortical regions connected by 8 white matter tracts. Neuroimaging measures included: cortical thickness and subcortical gray matter volumes (from N=21 participants); fractional anisotropy (FA) from white matter tracts (N=17); and correlations between rsfMRI timeseries' of pairwise ROIs (N=16). For every ROI in each modality, a linear mixed effects model was constructed with percent correct, intelligible scripted words as the dependent variable; timepoint (pre/post-treatment), neuroimaging measure, and global aphasia severity (i.e., Western Aphasia Battery Aphasia Quotient) as fixed effects; and subject as a random effect. The interaction between timepoint and neuroimaging measure was of primary interest. Significance was determined after false discovery rate correction for multiple comparisons ($p<0.05$). Results from the analysis revealed interactions between timepoint and cortical thickness in left inferior frontal (pars opercularis), middle frontal, precentral, and supramarginal gyri, left middle and inferior temporal gyri, and right lateral occipitotemporal sulcus. An interaction between FA and timepoint was noted in the right aslant tract. Of the 105 ROI pairs evaluated in the functional connectivity analysis, significant interactions between pairwise connectivity and timepoint were demonstrated in 5 left intra-hemispheric pairs (4 fronto-frontal and 1 fronto-striatal connection), 5 right intra-hemispheric pairs (4 fronto-occipital and 1 fronto-frontal connection), and 16 inter-hemispheric pairs (9 fronto-frontal, 2 fronto-cingulate, 1 fronto-temporal, 1 fronto-occipital, 1 temporo-cingulate, 1 temporo-occipital, and 1 parieto-cingulate connection). Findings identify several neuroimaging measures associated with treatment outcomes in nfvPPA, with potential ramifications for treatment candidacy decision-making. Gray and white matter results align with processes implicated in script training via speech entrainment, including lexical-semantic processing (left inferior temporal gyrus), phonological working memory (left supramarginal gyrus), articulatory planning (left middle frontal and precentral gyri), syntactic production (left pars opercularis and posterior middle temporal cortex), face processing (right occipitotemporal cortex), and inhibitory motor control (right aslant tract). Results from the rsfMRI analysis confirm the importance of inter and intra-hemispheric connections with left IFG and underscore the importance of right hemisphere frontal and temporo-occipital connectivity in treatment response. Additional research with larger cohorts is warranted to investigate the relative contributions of each neuroimaging modality to treatment response in nfvPPA.

Topic Areas: Language Therapy, Speech Motor Control

The effect of task on sentence processing in the language and multiple demand brain networks

Poster F12 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session F.

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Language is a highly salient stimulus: when people read or hear a sentence, they often can't help but extract its meaning. This effortless nature of language comprehension suggests that language processing in the brain is primarily input-driven and is relatively invariant to top-down task demands. Indeed, the fronto-temporal language brain network is active during language comprehension even during passive reading/listening (e.g., Fedorenko et al., 2010; Scott et al., 2017; Wehbe et al, 2014). In contrast, another brain network—the fronto-parietal multiple demand (MD) network—is highly sensitive to task demands across domains (Duncan & Owen, 2001; Duncan, 2010, 2013) and has been argued to contribute to language processing when it requires deliberate effort (Wright et al., 2011; Diachek et al., 2020). Here, we build on earlier, cross-study comparisons to comprehensively investigate the sensitivity of the language and the MD networks to task demands during sentence processing within a single experiment. We used fMRI to compare brain responses to sentences under five different task conditions: (a) passive reading with a button press at the end of each sentence; (b) reading with the "any word" memory probe task ("was this word in the preceding sentence?"); (c) reading with the "last word" memory probe task ("was this the last word of the preceding sentence?"); (d) reading with a yes/no comprehension question at the end of each sentence; and (e) reading with a valence judgment at the end of each sentence ("was the overall meaning of the sentence positive or negative?"). Tasks a-c and tasks d-e were matched in the number of presented words. We contrasted activity elicited by sentences with activity elicited by nonword sequences (for a-c, the task was the same as for the sentence condition; for d-e, the "any word" memory probe task was used for the nonword condition). Thirty-one participants were included in the analyses: all but one participant completed at least 3 tasks, and 14 completed all 5 tasks. We found that the language network consistently responded to sentences across all five task conditions. The strength and extent of activation was modulated by the number of words (with tasks d-e, which included more words per block, eliciting greater activation than tasks a-c) and, to some extent, by task difficulty (with task b, "any word" memory probe, eliciting greater activation than task c, "last word" memory probe). Critically, however, the same voxels responded to sentences across tasks, and the activation patterns within the language network were highly correlated across tasks. In contrast, robust responses in the MD network were observed only during cognitively taxing tasks, with passive sentence reading eliciting little to no activation, conceptually replicating Diachek et al. (2020). Overall, we show that the language network is active whenever it is presented with linguistic input, whereas the MD network is only active in the presence of a cognitively demanding task. Our results shed new light on the interplay between language and cognition and highlight the input-driven nature of core language processing.

Topic Areas: Meaning: Lexical Semantics, Meaning: Combinatorial Semantics

Anatomo-functional characteristics of the basal temporal language area: density mapping analysis in the MNI standard space

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Introduction: Although the basal temporal language area (BTLA) was firstly described by Lüders in 1987 using high frequency electrical cortical stimulation, the role of this area in language functions has not been well elucidated. We attempted to clarify anatomo-functional characteristics of BTLA by evaluating the degree of impairments in 6 language tasks using the density mapping analysis in the MNI standard space. Methods: We recruited 12 left temporal lobe epilepsy patients who underwent chronic subdural electrode implantation (a total of 134 electrodes, 4 to 20 per patient) and had language mapping by high frequency electrical cortical stimulation for presurgical evaluation of epilepsy surgery. A total of 71 BTLA electrodes (2 to 13 per patient) were identified in the anterior ventral temporal region. All the BTLA electrodes were coregistered into the MNI standard space with the information of the language mapping scores for 6 tasks (picture naming, paragraph reading, auditory sentence comprehension, kanji word reading, kana word reading). The value map of the scores was divided by the map of all observed electrodes, including 63 non-language electrodes, to yield the density map for language functions. Results: Language electrodes with multiple task impairment were clustered into the anterior end of fusiform gyrus (FG) where it fuses with inferior temporal gyrus (ITG), the anterior to middle FG, and the lateral portion of the middle ITG in a descending order. The average distance from the temporal tip for each locus was around 35 mm, 50 mm, 60 mm, respectively. The tasks that required visual or auditory comprehension were commonly impaired in the anterior end of FG. In this region, different degrees of impairment were observed among the visual comprehension tasks: picture naming impaired more than paragraph reading, kanji word reading more than Kana word reading. Regarding the middle part of the ventral temporal area, sentence or word reading tasks were impaired medially in the middle FG, while auditory sentence comprehension task laterally in the lateral portion of mid IFG. Conclusion: All the task impairment, irrespective of input modality, converged at the anterior end of FG, where it fuses with ITG. In contrast, modality specific impairment was observed posteriorly at the middle part of the basal temporal region. These findings indicate the anterior ventral temporal area (i.e., anterior end of FG) is one of the hubs of the amodal semantic memory, while the middle part of the ventral temporal area is modality specific region for semantic processing.

Topic Areas: Meaning: Lexical Semantics, Perception: Speech Perception and Audiovisual Integration

Enhancing context-based word learning in ageing with high-intensity interval exercise: an fMRI study.

Poster F14 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session F.

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High-intensity interval exercise (HIIE) has been suggested as one approach that can boost word learning in healthy young adults, however this is yet to be investigated in healthy old adults and the neural mechanisms supporting the acute effects of exercise on word learning are yet to be examined. This study investigated the effects of HIIE on learning and retention of new words and explored neural correlates of post-exercise context-based word learning using functional Magnetic Resonance Imaging (fMRI). Twenty-nine healthy older adults (mean age= 66.4 ± 4.7; 15 females) completed this study. Fourteen participants (8 females) performed a stretching exercise bout and the remaining 15 participants (7 females) performed a HIIE bout. After exercise, participants completed an fMRI word learning task, which included 20 non-readable (NR) sentences (i.e., strings of symbols used as a control condition), 30 congruent pairs of sentences ending with the same new word (e.g., (1) I made a cup of hot blick, (2) the guests were offered coffee or blick) and 30 incongruent pairs of sentences ending with the same new word, however not leading to the same meaning. Participants were instructed to learn the meaning of congruent pairs only. Immediate and one-week delayed word recognition was assessed. In the recognition task, each new word was presented with two possible meanings and in the case of congruent meanings, participants were instructed to select the correct meaning whereas were asked to press a reject button for incongruent meanings. One-way ANOVAs were conducted to investigate between-group differences. Processing of imaging data and exploratory whole brain analyses were performed. T-tests were conducted to compare group differences in blood oxygen level dependent (BOLD) signal and to investigate task-related BOLD signal irrespective of exercise condition. Analysis did not reveal differences in recognition performances ($p>.05$) with both groups at approximately 45% of correct congruent new words at immediate and 33% at delayed recognition. No differences were observed in BOLD signal, with the HIIE group showing similar activation relative to the stretching group when successfully deducting the meaning of congruent sentences. Irrespective of exercise group, analysis revealed significant differences in BOLD signal when viewing correctly learned congruent pairs, relative to NR sentences. This difference was characterized by BOLD signal increases in 11 regions, including language-related regions. A significant difference in BOLD signal was also observed in the left middle occipital gyrus when viewing correctly learned congruent pairs, relative to incongruent pairs. This study was the first to examine the effects of HIIE on context-based word learning in ageing and to investigate underlying neural correlates. Results do not suggest that HIIE, relative to stretching, has the potential to enhance context-based word learning in ageing, while previous studies have observed beneficial effects of exercise when using associative learning paradigms in healthy young adults. Irrespective of exercise, the completion of the word learning task revealed activation of classical language networks, however further investigation with a large sample is needed to confirm these findings and to allow for better identification of approaches to promote word learning in ageing.

Topic Areas: Meaning: Lexical Semantics, Methods

The influence of sleep on associative novel word learning in healthy older adults

Poster F15 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session F.

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Research has demonstrated that sleep can influence memory consolidation and some forms of novel word learning in young adults. In older adults, the role of overnight sleep in associative novel object-word pair learning compared to wakefulness is yet to be investigated. As there are changes in word learning, sleep architecture and memory consolidation across the lifespan, the present study aimed to investigate the role of sleep in associative novel word learning in older adults. The present study also explored whether the addition of

semantic information could enhance new word learning for the novel object associations. Thirty-six healthy older adults (mean age = 68.48, SD = 6.25, range = 60-84) participated in this between-group randomised study and attended two testing sessions. Participants were required to learn three word names of twenty novel objects. Each name contained a legal nonword (e.g., Smeek) paired with either two semantic attributes (semantic condition) or two proper names (name condition). The first session involved five learning phases, each followed by a test of recall. Recognition of the object names (i.e., the nonword names) and recognition of the semantic attributes/proper names was also assessed. Recall and recognition of the object names was also tested at the second session 12 hours later after a period of overnight sleep (n = 17) or daytime wakefulness (n = 19). Participant levels of alertness were measured with a psychomotor vigilance task and sleepiness scale at each of the sessions. Sleep habits were assessed through standardised sleep questionnaires and sleep duration (total sleep time) was objectively monitored using actigraphy (Actigraph wGT3X-BT). Behavioural analyses were conducted on the accuracy (percentage correct) and reaction time (latency of response) data. A repeated measures ANOVA (Group x Condition x Trial) was used to analyse the recall data at the first session. Across the five learning trials recall accuracy improved (p<.001), with no differences for group (sleep, wake) or condition (semantic, name). Results from independent T-Tests for recall data at the second session indicated no significant difference between groups (sleep, wake) for either the semantic (p=.730) or name (p=.763) conditions. Independent T-Tests were also used to analyse recognition accuracy and reaction time data at both sessions for the novel word recognition and semantic attribute/proper name recognition tasks. No significant differences between groups (sleep, wake) were evident at either session. This was the first study to examine the role of overnight sleep compared to daytime wakefulness in novel word learning for novel object associations in older adults. These results indicate no benefit of overnight sleep in the acquisition of novel words associated with or without the provision of additional semantic information in older adults. This is in contrast to findings demonstrating that sleep can enhance novel word acquisition in younger adults, suggesting that there may be age-related differences in sleep-dependent novel word learning.

Topic Areas: Meaning: Lexical Semantics, Development

F0 variation simultaneously conveys multi-level prosodic information: Evidence from perception of focus and surprise in Mandarin Chinese

Poster F16 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session F.

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F0 variation is a crucial feature in speech prosody, which can convey linguistic information such as focus and paralinguistic meanings such as surprise. How can multiple layers of information be simultaneously encoded with F0 in speech: are they divided into discrete layers of pitch or overlapped in a gradient fashion without clear divisions? We investigated this question by assessing pitch perception of focus and surprise in Mandarin Chinese. Twenty native Mandarin listeners rated the strength of focus and surprise conveyed by the same set of synthetically manipulated sentences, i.e., they listened to the same set of stimuli twice, with the only difference in task instructions (one for rating the strength of focus, the other for surprise). An fMRI experiment was conducted to assess the neural correlates of the listeners' perceptual response to the stimuli. The results showed that behaviourally, the perceptual threshold for surprise was higher than that for focus. Moreover, the pitch range of 5-12 semitones above the baseline signalled both focus and surprise, suggesting a considerable overlap between the two types of prosodic information within this range. The neuroimaging data positively correlated with the variations in behavioural data. Also, no further significant behavioural differences or brain activities were shown after reaching a certain pitch level for the perception of focus and surprise respectively. Together, the results suggest that different layers of prosodic information are encoded through F0 in a gradient fashion with much overlap: higher level (paralinguistic) information is encoded by using additional pitch ranges beyond that used by lower-level (linguistic) information, without harming the encoding of the lower-level information.

Topic Areas: Prosody, Speech Perception

Dynamic encoding of English pitch accents in EEG responses to continuous speech: effects of native language experience and attention

Poster F17 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session F.

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Native English listeners rely on fundamental frequency (F0) in the speech signal to distinguish between categories of intonational prominences (pitch accents), contrasts which are used to mark speakers' attitudes towards the information being conveyed (e.g., certainty, surprise, incredulity). The neural encoding of pitch accents is poorly understood, and prior neuroscience research on intonation investigated only native listeners in attended speech paradigms, leaving open the question of how the neural encoding of pitch accents is modulated by language experience and attention. Additionally, prior neuroscience work modeled F0 as a continuous acoustic-phonetic variable at the sentence level. Pitch accents, however, are phonologically linked to individual syllables, and their perceptual identification depends strongly on F0 changes in and around those syllables. Here, we used a phonologically-motivated transcription of pitch accents (Tones and Break Indices; ToBI) in continuous speech to investigate the effects of language experience and attention on the neural encoding of pitch accents at the syllable level. Specifically, we examined the neural encoding of four English pitch accent categories (H* = high-falling; L* = low; L+H* = early rising; L*+H = late rising) in time-locked EEGs collected from native (N = 15) and non-native (N = 15) speakers of English both attending (duration = 30 mins) and ignoring (duration = 15 mins) English read narrative speech. To investigate the neural encoding of English pitch accents over time, we grand-averaged time-locked EEGs by pitch accent category (pitch accent-related potentials; ARPs) within each language group (natives vs. non-natives) and condition (attended vs. ignored speech). Grand-averaged ARPs were then segmented into time frames using a sliding window (duration = 100 ms, overlap = 75 ms). For each group and condition, we calculated the mean relative Euclidean distance between grand-averaged ARP segments within the same time frame. We used this metric (mean PAP distance) to assess neural encoding quality over time (greater ARP distance = greater differences between ARPs = better neural encoding). We conducted bootstrapping analyses to identify statistical differences in neural encoding quality over time between groups and conditions. We found two peaks of neural encoding quality at approximately 100 ms (P1) and 300 ms (P3) after the stimulus onset (ps < 0.01). Stimulus onset was defined as the time point within a 1 s temporal window around the ToBI label that maximized F0 differences between pitch accent categories. Native listeners exhibited a greater P1 magnitude than non-native listeners, who in turn exhibited a greater P3 magnitude than native listeners (ps < 0.01). However, group differences in peak magnitude were stronger in P1. Similarly, when speech was attended, peak magnitude increased more in P1 than P3. Our results provide a precise temporal characterization of the neural processing of pitch accents in continuous speech as a function of language experience and attention. We show that the neural encoding quality improves when speech is native and attended. Notably, these language and attention dependent improvements in neural encoding quality occur at approximately 100 ms after the stimulus onset.

Topic Areas: Prosody, Multilingualism

The Effect of Cognitive Abilities on Anomia Therapy Outcomes in Persons with Aphasia

Poster F18 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session F.

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Aphasia is an acquired language disorder that affects an estimated 2.5 million Americans (Simmons-Mackie, 2018). The purpose of the current study is to better understand the relationship between cognitive processes in chronic aphasia and language recovery. We hypothesize that cognitive assessment scores will be related to treatment outcomes. Thirteen participants with chronic aphasia (aged 47-75, 3 f) participated. Each individual completed two language assessments -- the Western Aphasia Battery (WAB; Kertesz, 2006) and Cognitive Linguistic Quick Test (CLQT; Helm-Estabrook, 2001) -- and four cognitive batteries -- the Test of Everyday Attention (TEA; Robertson et al., 1994), Wechsler Memory Scale (WMS; Wechsler, 1997), Wisconsin Card Sorting Task (WCST; Grant & Berg, 1993), and Rey Complex Figure Test (RCFT; Meyers & Meyers, 1995). Participants also completed three tasks that investigated attention, learning, and cognitive control. The attention task (Villard & Kiran, 2015) measures variability in nonlinguistic sustained, selective, and alternating attention within and across sessions. The probabilistic learning task (Vallila-Rohter & Kiran, 2014) uses nonlinguistic paired-associate and feedback techniques to measure learning. The cognitive control task (Gray & Kiran, 2015) measures cognitive control via nonlinguistic task-switching. Participants completed 10 weeks of abstract semantic associative network training (AbSANT; protocol described by Sandberg and Gray, 2020). Direct training effects (abstract word performance) and generalization effects (concrete word performance) were monitored using generative naming probes. Spearman correlations were conducted between treatment effect sizes and assessment performance. The following correlations with the direct training effect size were significant: WCST categories completed ($r=0.910$, $p=0.002$), WMS backwards spatial span ($r=0.829$, $p=0.021$), TEA map searches 1 and 2 ($r=0.672$, $p=0.047$ and $r=0.800$, $p=0.010$ respectively), TEA telephone search ($r=-.750$, $p=0.020$), and sustained auditory attention trial-to-trial variance ($r=-0.654$, $p=0.015$). Nonlinguistic cognitive domains including visuospatial memory, recognition memory, visual selective attention, and sustained auditory attention appear to be related to successful treatment outcomes. Generative naming requires working memory and the context-categories (e.g., hospital) used in therapy may elicit visuospatial working memory to imagine the context while generating words. The correlations with attentional measures aligns with the notion that sustained and selective attention are important for language therapy and general and may specifically be important to successfully complete the components of AbSANT. Finally, the number of categories completed on the WCST strongly correlated with direct training effects. Thus, flexible thinking abilities may be imperative to successful outcomes for this treatment as this therapy involves discussion of a variety of aspects of abstract words. These cognitive domains may predict treatment outcomes because this particular anomia therapy requires intact critical thinking skills. These results should be interpreted with caution due to the limited sample size and no multiple comparison correction. This work aligns with previous work identifying cognitive aspects in anomia treatment outcomes in aphasia (Lambon-Ralph et.al, 2010) and extends this work by identifying specific cognitive domains that may be particularly important.

Topic Areas: Disorders: Acquired, Control, Selection, and Executive Processes

Predicting trajectories of recovery from aphasia

Poster F19 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session F.

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In this “sandbox series” presentation, we describe our plans to develop a multivariate model for predicting trajectories of recovery from aphasia from imaging and demographic data that are collected in the course of routine clinical care. While much has been learned about the neural basis of language, it remains challenging to predict the nature and extent of recovery from aphasia after stroke. Previous studies have mostly focused on chronic lesion-deficit relationships [1-3], with only one large scale study to our knowledge incorporating time as a crucial explanatory variable [4]. We recruit patients at the bedside 2-5 days after left hemisphere stroke, and assess their language function with the Quick Aphasia Battery (QAB) [5]. Individuals with aphasia are followed longitudinally and assessed similarly at 1 month, 3 months, and 12 months after stroke. At the time of writing, we have consented 365 patients, including 247 with acute aphasia. Follow up data have been obtained from 101 patients at 1 month, 98 patients at 3 months, and 56 patients at one year, with 25 pending. Data collection is presently ongoing via Zoom as far as possible. We plan to design a model using support vector regression (SVR) [6] to predict language outcomes at each time point, quantified in terms of the eight domain-specific subscores of the QAB. The independent variables will be lesion location on acute clinical imaging, demographic variables such as age, sex, and education, and measures of general brain health, e.g. measures of leukoaraiosis and generalized atrophy. Lesion location and extent will be delineated on DWI, FLAIR, or CT imaging as appropriate using ITK-SNAP [7]. The resulting binary lesion masks will be normalized to MNI space using unified segmentation and DARTEL [8]. Feature reduction will be carried out with principal components analysis. SVR with a leave-one-out cross-validation procedure will be used to predict each patient's QAB subscores across multiple dimensions of language at each of the four timepoints. The accuracy of the predicted subscores will be assessed by comparing them to the actual scores obtained. To date, lesion delineation has been completed for 135 patients, and a preliminary analysis of a small subset of patients has suggested that QAB scores can be predicted with a promising degree of accuracy. The creation of a successful model to predict longitudinal language outcomes from acute clinical data could lead to improved allocation of resources in healthcare settings and more appropriately tailored treatments for individual patients. The model could also provide a valuable baseline for evaluating whether different patterns of functional reorganization are associated with better or worse outcomes than might be expected. References: [1] Zhang et al. Hum Brain Mapp 2014; 35: 5861-76. [2] Yourganov et al. Cortex 2015; 73: 203-15. [3] Pustina et al. Hum Brain Mapp 2017; 38: 5603-15. [4] Hope et al. NeuroImage Clin 2013; 2: 424-33. [5] Wilson et al. PLoS One 2018; 13: e0192773. [6] Vapnik, Statistical Learning Theory 1998; Wiley, New York. [7] Yushkevich et al. NeuroImage 2006; 31: 1116-28. [8] Ashburner. NeuroImage 2007; 38: 95-113.

Topic Areas: Disorders: Acquired, Computational Approaches

Cortical Discrimination of Speech Contrasts in Young Children with Developmental Language Disorder

Poster F20 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session F.

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Developmental Language Disorder (DLD) affects approximately 7% of children and is characterized by significant, persistent difficulties in native language acquisition, with no apparent biomedical cause (Leonard, 2018). Theories regarding the etiology of DLD suggest that this condition may arise from functional differences in the neural processing of speech (e.g. Edwards & Munson, 2017). However, whereas some studies have shown atypical cortical responses to speech in individuals with DLD, as evidenced by smaller, delayed or asynchronous event-related potential (ERP) components such as the Mismatch Negativity (MMN), T-Complex or Late Discriminative Negativity (LDN), other studies have not (see Evans & Brown, 2016 for a review).For adults with typical language development (TLD), cortical measures of speech discrimination have been shown to be enhanced by higher-level linguistic representations (Gansonre, Højlund, Leminen, Bailey & Shtyrov, 2018) and prior language knowledge (Sohoglu, Peelle, Carlyon & Davis, 2012). However, it is unclear whether such top-down linguistic influences are present in children during native language learning, and if these effects vary with language proficiency. The current study aimed to investigate differences in cortical responses to speech contrasts in children with TLD and those with DLD. Twenty-seven monolingual Spanish-speaking children (aged 4.9-5.7 years) were recruited from the same preschool in Chile, 16 of whom had a pre-existing diagnosis of DLD, and 11 who had TLD. Electroencephalography (EEG) was recorded while children were passively presented with a repeated Spanish monosyllabic nonword (288 standards, probability 50%), interspersed with changes to the initial phoneme, using a multi-feature paradigm (Näätänen, Pakarinen, Rinne & Takegata, 2004). Mismatch responses (MMRs) were recorded to four deviant stimuli (each 12% probability), involving phonological (non-native nonwords and native nonwords), semantic (content words and function words) and lexical (native nonwords versus words) contrasts. Difference waves were calculated over early (100-300 ms post-stimulus) and late (350-550 ms) time windows at electrode Fz (Bishop, Hardiman & Barry, 2010), and phonological awareness skills were assessed to examine possible associations with MMR amplitude. Contrary to our predictions, MMR mean amplitude did not differ significantly between groups for any stimulus type or time window at Fz, and did not correlate with phonological skills, despite significantly poorer phonological awareness in the DLD than in the TLD group. However, preliminary results using ERP mass univariate analyses across all electrodes indicate that MMR incidence differed between groups, with the DLD group showing statistically significant MMRs for all deviant types, and the TLD group only showing significant MMRs for native and non-native nonwords. Visual inspection of significant MMR effects across all electrodes indicated more positive, prolonged, and widely distributed effects for the DLD than the TLD group. These results suggest that differences in the cortical responses to speech between DLD and TLD groups over this age range may not arise from conventional amplitude analyses but may be evident in the topography, time-course and polarity of activation patterns. Further analyses will apply multivariate methods to examine potential individual/group differences in cortical responses to speech in this sample.

Topic Areas: Disorders: Developmental, Speech Perception

Behavioral and neural differences between stutters and non-stutters during a semantic task are impacted by attention allocation on stimuli

Poster F21 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session F.

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People who stutter may not only exhibit deficits in extracting semantics from auditory speech (O Séaghdha & Frazer, 2014) but also in more general abilities such as attention allocation (Doneva et al., 2018). However, none of previous studies has examined whether attention allocation affects behavioral and neural differences between stutters and non-stutters during semantic processing. Using a mix-designed fMRI, this study examined this question. At the beginning of each block, a semantic prompt (e.g., animal) was first presented. Each trial started with a picture presented for 2700ms as a distractor/interference. 200ms after the picture onset, the target Chinese written disyllabic-word appeared on the screen and lasted for 2500ms together with the picture. Participants needed to judge whether this word belonged to the semantic category of the block prompt. Each block consisted of 20 trials and 4 conditions. There were two conditions among Yes-trials depending on whether the picture shared the same semantic category as the block prompt – 'yes': prime condition (PC); 'no': non-prime condition (NPC). Similarly, among No-trials, there were two conditions, again, depending on the semantic relationships between the picture and the block prompt – the same: interference condition (IC); different: non-interference condition (NIC). The group differences of interest were on [NPC>PC] and [IC>NIC], separately. The former condition contrast required less visual attention than the latter one. A priori calculated sample size was at least 19 participants for each group. For now, only data from 16 stutters and 17 non-stutters (all adults) were collected. Among the Yes-trials, there were significantly shorter RTs for PC than NPC, $F(1,30)=12.1$, $p=.002$, $f=0.643$, across all participants. The main effect of group and the interaction were not significant. As for the No-trails, there was no significant main effect of group. The main effect of condition, $F(1,30)=14.7$, $p<.001$, $f=0.7$, (NIC>IC) and the interaction, $F(1,30)=6.09$, $p=.019$, $f=0.45$, were both significant. The IC RTs were significantly longer than the NIC only in stutters, $t(30)=4.32$, $p<0.001$, $d=1.57$. Image data were $p<.05$ FWE corrected at cluster-level. Across all conditions, stutters showed significantly weaker activations than non-stutters in extensive brain regions including bilateral middle temporal gyri, bilateral posterior inferior temporal gyri, right inferior frontal gyrus and right fusiform gyrus. There was no significant group difference at the whole brain on [NPC>PC]. But the interaction of group by [IC>NIC] was significant – non-stutters induced larger deactivation than stutters in rostral anterior cingulate gyrus (rACG) for IC, but no group difference for NIC. Taken together, behavioral and neuronal differences between stutters and non-stutters during the semantic task was only found on the condition with high attention allocations(IC>NIC). Stutters' weaker activations across all conditions may reflect their less efficient abilities than non-stutters to extract semantics from written words. Because the rACG deactivation has been attributed to the elimination of unrelated interference to improve task performances (Marek et al., 2010), the weaker deactivation of this area in stutters for IC may arise from their inabilities of effectively inhibiting disturbing pictures. After finishing data collection, group-differences in dynamic causal networks will be further examined.

Topic Areas: Disorders: Developmental, Meaning: Lexical Semantics

Intracranial EEG evidence of semantic interference and phonological facilitation in spoken word production

Poster F22 [Poster PDF] [Poster Tour] Visit me at [Gather.Town] in the Broca room during Poster Session F.

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Behavioral and classical electrophysiological methods (scalp EEG) provide important information about the timing of different processes involved in spoken word production, while functional Magnetic Resonance Imaging (fMRI) allows the localization of these mechanisms. However, these techniques do not allow for both spatial and temporal resolution simultaneously, and scalp EEG is sensitive to articulatory-motor artifacts. The present study aims to investigate the phenomena of semantic interference and phonological facilitation during spoken word production using intracranial electroencephalography (iEEG). This technique, which consists of recording EEG signal from electrodes implanted in several cortical areas belonging to the language network, is used in patients with medically intractable epilepsy as presurgical evaluation. We will present preliminary data collected from patients with electrodes implanted in the dominant hemisphere, who completed a Picture-Word Interference task (PWI). Participants named a set of target pictures while ignoring a written distractor word that was categorically (e.g., fox-HORSE) or phonologically (hose-HORSE) related or unrelated (violin-HORSE). This paradigm has shown, consistent results across the last 30 years for both semantic interference and phonological facilitation and has helped shape the two-step processing architecture of contemporary production models. In addition, competitive lexical selection models attribute the semantic interference effect to increased competition between related lemmas, delaying word production, while non-competitive selection accounts attribute this delay to a post-lexical mechanism that outweighs conceptual priming. By contrast, all models attribute the locus of phonological facilitation to the word-form retrieval stage. Our planned Local-Field Potentials (LFPs) and time-frequency analyses will interrogate high gamma band (80-120 Hz) and beta band (12-30 Hz) activity as a function of distractor type. The outcomes of this study will provide important insights into brain networks involved in speech production and on the timing of each stage. Additionally, the use of iEEG will provide insight into the role played by the Inferior Temporal Gyrus, the Temporal Pole and the Baso-temporal language areas in speech production that are not usually investigated with other neuroimaging techniques (e.g. fMRI) due to artifacts or signal dropouts. While recruitment has been impacted by COVID-19, we expect to collect data from ~15 patients across three sites (Mater Hospital – Brisbane – Australia; Cleveland Clinic - Ohio – USA; Pittsburgh University – Pennsylvania – USA) to complete the full study.

Topic Areas: Language Production, Methods

Cross-species connectivity gradients uncover multiscalar human temporal lobe adaptations

Poster F23 [Poster PDF] [Poster Tour] Visit me at [Gather.Town] in the Broca room during Poster Session F.

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The primate temporal cortex is thought to be a unique specialization and different to the lateral expansions seen in other mammalian orders . Even within the primate order, the temporal lobe is thought to have undergone significant expansion and reorganization, particularly in the great ape and human lineage. However, the relative contribution of specific subregions to this reorganization remains elusive. Recently, a framework for cross-species comparison was proposed that places species with homologous white matter tracts in a common space. Here, we extend that framework with the use of Laplacian Eigenmaps to unveil conserved and divergent principles of organization of the Human, Chimpanzee and Macaque temporal association cortices and to shed light on the relative importance of particular temporal subregions in the Human specific reorganizations. Publicly available connectivity blueprints for Human, Macaque and Chimpanzee were used. Connectivity blueprints are obtained by computing the probabilistic tractography matrices seeding from the cortical surface to the rest of the brain and multiplying them with individual tract maps for 22 common tracts. Thus, at the vertex level, they represent the probability of streamlines from a given vertex to connect to each of the 22 chosen tracts. Cortical ROIs for Temporal association cortex were drawn and used to select only the connectivity blueprints within the ROI. Connectivity blueprints of both hemispheres for all species were concatenated and the cross-species similarity matrix was calculated for which a set of 4 cross-species connectivity gradients were computed. Finally, the maximum cosine similarity between every human and non-human vertices was computed, and the subsequent distribution was modelled as mixture of three beta functions, each reflecting different scales of non-human primate to human reorganization, which assigned human temporal lobe vertices to each of the three possible classes. The cross-species embedding revealed a shared common 1st gradient of connectivity ranging from the inferior (ITG) to superior temporal giri (STG). This suggests a shared architecture for the temporal lobe white matter across these three species, consistent with the role of longitudinal tracts in this brain region. The other three gradients separated human-specific connectivity blueprints from non-human specific ones, with the 2nd gradient ranging from non-human primate inferior temporal gyrus to the human-specific posterior medium temporal gyrus (pMTG), giving more evidence for the arcuate fasiciculus (AF) driven distinct connectivity signature of the human pMTG. Finally, the classification of human vertices according to their probability of belonging to any of the three beta functions used to model the differences between human vertices and non-human ones gives strong evidence for conservation in the STG, temporal pole and fusiform gyrus, moderate human reorganizations in the ITG and right pMTG, and massive reorganization of the left pMTG. We applied a cross-species connectivity embedding that identified common and species specific principles of organization and revealed multiscalar lateralized human specific white matter reorganization in the human temporal lobe. This work paves the way for establishing trajectories of white matter reorganization across evolution and their functional consequence, particularly in the light of the human-unique cognitive skill for language.

Topic Areas: Methods, Animal Communication

The L1 & L2 syntactic P600 across visual & auditory modalities: preliminary ERP findings

Poster F24 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session F.

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While L2-learning effects on neurophysiology are well-known, modality-specific L2-learning effects are not. Language-independent and L1 studies show that auditory processing has an advantage over visual processing, for example, with faster reaction times; by mediating visual word recognition; and, by reading disorders outnumbering listening disorders. Additionally, spoken languages vastly outnumber sign languages (approx. 7000 to 143). Taking all of this together, we hypothesize that language is preferentially acquired in the auditory modality, manifesting as more efficient neurophysiological nativization in auditory processing. Since longer-term

L2 learners show more native-like neural responses, this hypothesis can be empirically tested by comparing L2 and L1 ERPs. To that end, we are conducting ERP experiments to analyze the syntactic P600 in both modalities in L1 and L2 speakers of Spanish. Our preliminary data consists of 10 L1 speakers (9 males, 28.7±4.6 years) and 5 L2 speakers (3 males, 20.8±1.5 years), all right-handed. Each participant completed both the visual and auditory experiments, which were counterbalanced and created according to a Latin Square design. Each stimulus was a Spanish sentence presented by word or phrase with a structure of subject-verb-complement (Tú escuchas música en el carro / You listen to music in the car). Syntactic violations were verb conjugation errors (Tú *escuchan / You *listens) that disagreed with the immediately preceding, explicit subject. Orthographic and phonological violation conditions were also included but will be analyzed at a later time. Visual stimuli durations were set equal to auditory stimuli durations, ensuring a natural pacing. Visual ERPs were time-locked to critical word onset, while auditory ERPs were time-locked to critical syllable onset, as has been done in other studies. This was done to account for the unavoidable reality that visual information is instantly available in its entirety, while spoken word information necessarily unfolds in a temporal order. Behavioral results showed that auditory syntactic violations are more accurately identified than visual violations in both L1 (97% vs 93%) and L2 speakers (84% vs 76%), although the t-tests showed the effect was not significant (p=0.198 and p=0.095, respectively). ANOVA of the time window 600-1000 ms showed that there was a significant main effect of condition (p=0.007). Post-hoc analyses showed that this effect was only significant in L2 speakers (p=0.014) and not in L1 speakers (p=0.093). If the interpretation that the P600 indicates reanalysis is to be accepted, this could signify that reanalyzing violated sentences imposes a greater cognitive load on L2 speakers. Comparing modalities, the L1 auditory P600 mean amplitude was greater than the visual. For L2 speakers, visual P600 mean amplitude was slightly greater, but in some lower-proficiency speakers, the visual P600 did not present, and only began to emerge with higher-proficiency. For L2 speakers, the auditory P600 preceded the visual by about 100 ms. In sum, our data suggest that language is indeed preferentially acquired in the auditory modality, as evidenced by higher accuracy and faster L2 nativization in the auditory modality, although more data is required for statistical robustness.

Topic Areas: Multilingualism, Perception: Auditory

On the L2 insensitivity to subcategorization violations

Poster F31 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session F.

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This study discusses the impact of conflicting L1 subcategorization restrictions in L2 computation. While event concepts of common verbs are likely to be the same for speakers of different languages (e.g. eat, sleep), the argument structure of a verb (e.g. the types and numbers of noun phrases a verb takes) is linguistic knowledge, and could vary from language to language. For example, in English, “listen” is intransitive and requires a preposition to introduce a second argument, whereas in Mandarin, “listen” can take a second argument directly. We hypothesized that English native speakers can easily reject subcategorization violation sentences like My sister listened the music, but Mandarin L2 speakers of English may often erroneously accept such sentences. Therefore, we constructed sentences with verbs of different subcategorization restrictions in L1 and L2. These sentences were of Subject-Verb-Object structure, with the verb varying between conditions: (1) Grammatical and (2) Ungrammatical, and the rest of the sentences were identical. Verbs in the Grammatical condition were transitive in both languages (e.g. record), whereas verbs in the Ungrammatical condition rarely take direct object in English but are ambitransitive in Mandarin (e.g., listen). EEG data analysis was time-locked to the determiner and the noun following the verbs (record/*listen the music). To ensure that not all sentences with an intransitive English verb were ungrammatical and vice versa, we added filler sentences with grammatical intransitive verbs and with ungrammatical transitive verbs. To show that the L2 were able to parse English sentences, we adapted sentences with phrase structure violations from Neville et al. (1991) as our control items. Participants were L1 speakers of English (n=22) and L2 speakers of English whose L1 was Mandarin (n=28). All the L2 participants were proficient in English, having passed a standardized English proficiency test beyond B2 level. Materials were presented using RSVP (600ms/word), with an end-of-sentence grammaticality judgment task. Behaviorally, the L2 group was only partially sensitive to subcategorization violations, detecting them only ~50% of the time (compared to 90% accuracy on grammatical items). ERP results showed a significant interaction between group and grammaticality, with a P600 effect in the L1 but no sign of a P600 in the L2 group, indicating that subcategorization information of a verb in L2 was not immediately available when computing sentences online. We further ran a split by performance analysis to examine if correct and incorrect rejections of subcategorization violations led to different ERP responses relative to the grammatical baseline in the L2. Preliminary analysis showed that neither correct nor incorrect rejections were statistically different than the grammatical baseline, with no sign of a P600 in the correct rejection condition, providing further confirmation that although the L2 might have the subcategorization knowledge offline, they could not use such information online. In the control comparison, we observed a widespread negativity at 350-550ms time window in both groups, indicating that the L2 group was sensitive to phrase structure violations. Taken together, these results showed that when L1 and L2 are in conflict, L2 processing of subcategorization is particularly challenging.

Topic Areas: Multilingualism, Syntax

Predicting Real-World Bilingual Language Use from Language History Questionnaires and Laboratory Assessments of Vocabulary and Proficiency

Poster F32 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session F.

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Investigations of the cognitive and neural correlates of bilingualism to date have relied largely on self-report language history questionnaires (LHQs) to estimate the extent to which a bilingual uses their two languages. Here, we measured real-world language use in a linguistically diverse sample of undergraduates by employing an experience sampling method known as the Electronically Activated Recorder (EAR). We had two primary objectives: (1) Determine which LHQ self-report questions contribute unique variance to participants' actual frequencies of code-switching and non-English language use, and (2) Determine which laboratory assessments of vocabulary size and proficiency contribute significantly to participants' actual frequencies of code-switching and non-English language use. We examined how accurate participants are at gauging their own patterns of language usage and whether LHQs and laboratory-based proficiency tests are valid measures of real-world bilingual language use. Seventy-three undergraduate participants completed the study across two testing sessions. All participants were current residents of Southern California, and most (55%) were heritage bilinguals. In the first session, participants were given a tutorial on using and wearing the EAR and completed behavioral tasks including the Multilingual Naming Test (MINT). Between Sessions 1 and 2, participants wore the EAR for four consecutive days as they went about their daily lives. The EAR app made 40-second auditory recordings every 12 minutes during waking hours. In the second session, participants returned the EAR and completed an in-house LHQ and semantic fluency task in their two most dominant languages. Only 46 participants completed the behavioral tasks (MINT and semantic fluency) because they were not implemented until partway through data collection. Each participant's speech was transcribed and coded independently by two trained coders to quantify the frequency of use of various languages, frequency of code-switching, and more. The reliability (ICC) between coders was .88. Participants code-switched during 0-30.55% of their sound files (M=6.02%, Median=3.17%). Multiple regression analyses revealed that self-reported frequency of switching during a conversation (M=3.01, 1-5 scale), self-reported Non-English speaking proficiency (M=5.53, 1-7 scale), and English semantic fluency scores (M=51.54 words) were significant predictors (p's < .05) of actual code-switching frequency captured via the EAR, R2=.53. In addition, participants used their non-English language during 0-97.8% of their sound files (M=14.92%, Median=7.55%). Multiple regression analyses demonstrated that self-reported current non-English language use (M=5.81, 0-10 scale) and estimated number of months residing in the U.S. (M=205.8; a proxy of immersion experience) significantly predicted (p's < .05) actual frequency of non-

English language use, R2=.44. Neither MINT nor semantic fluency scores were significant predictors of EAR-measured non-English language use. From these results, we can conclude that a select few questions from the LHQ (self-reported code-switching during conversations, Non-English speaking proficiency, frequency of Non-English use, and length of time in the U.S.) and verbal fluency account for substantial variance in actual language use and appear to be the most valid for corroborating participants' real-world language use as measured with the EAR. Going forward, we can utilize this information to craft more efficient and standardized LHQs and laboratory-based assessments of the bilingual experience.

Topic Areas: Multilingualism, Methods

Argument Structure Processing in Native and Non-Native Mandarin Speakers

Poster F33 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session F.

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INTRODUCTION: Different languages employ different strategies to communicate who does what to whom. While English primarily relies on word order to express agent and patient roles, Mandarin gives more weight to semantic information. These conflicting processing strategies mean Mandarin-English bilinguals must balance the competing cues of word order and semantics. Previous research has shown these bilinguals' argument structure interpretation differs from that of monolinguals' in both languages (Liu, Bates, & Li, 1992; Su, 2001), although questions remain about Mandarin argument structure processing in native speakers (e.g., semantic reversals eliciting N400 (Bornkessel-Schlesewsky et al., 2011) or P600 effects (Chow & Phillips, 2013)). METHODOLOGY: We used EEG to measure native (monolingual, n=34) and non-native (English L1, Mandarin L2, n=21) processing of Mandarin argument structure using noun-noun-verb sentences. Sentences had either one semantically plausible agent that varied in animacy (e.g., the servant the mirror polished or the magpie the cage trapped) or ambiguous argument roles with the same animacy status (e.g., the dog the rooster chased). We also used Mandarin's coverbs BA and BEI, which assign agent and patient status to their preceding noun phrase, respectively, permitting the creation of semantically plausible (e.g., the child BA the apple ate) and reversed (e.g., the child BEI the apple ate) sentences. Participants read the sentences word-by-word (SOA 750 ms) and judged which noun was the agent. RESULTS: In the absence of coverbs, native speakers' agent selection relied on semantic plausibility, but not word order (1st/2nd noun). However, with a coverb, they instead relied on BA and BEI. Non-native speakers' judgments largely mirrored those of native speakers, but varied with Mandarin proficiency, with lower proficiency participants unwilling to assign agent status to inanimate nouns in the absence of a coverb. For the EEG data, we analyzed epochs spanning the entire sentence, not just the final verb like previous studies. With a pre-sentence baseline, BEI semantic reversal sentences elicited sustained negativities starting on BEI, while BA sentences did not show differences until the second noun. At the disambiguating verb, BA sentences showed an N400 semantic reversal effect while BEI sentences showed no difference. A linear mixed effects model for the BA sentences revealed a significantly greater N400 for implausible semantic reversals than congruent sentences (95% CI for coefficient [0.42, 1.00] uV, $p<0.001$), and a trend for smaller N400s in L2 Mandarin speakers than L1 speakers (95% CI for coefficient [0.01, 1.31] uV, $p=0.05$). There were no significant interactions. CONCLUSIONS: These data demonstrate that non-native Mandarin speakers can use similar neurocognitive strategies as native speakers to assign agent and patient status. Importantly, and in contrast to previous studies, Mandarin native speakers' online processing was found to rely on both structure (BA and BEI) and plausibility. EEG data suggest that BEI impacts argument assignment earlier than BA, perhaps reflecting an 'agent-first' default strategy (requiring a reanalysis only for BEI) or the lower frequency of BEI compared to BA. Unlike many studies, we recruited functionally monolingual native speakers, and are confident they were not influenced by knowledge of another language.

Topic Areas: Multilingualism, Syntax

Cross-Language Neural Interconnection of Phonological Awareness and Morphological Awareness in Simultaneous Chinese-English Bilingual Children

Poster F34 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session F.

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How do bilingual children build neural representations for each of their languages? Theories of bilingualism suggest that bilinguals' two languages are interconnected within one mind and brain, but some aspects of bilingual competence are more closely interconnected than others. Research with adult second language learners finds that bilinguals' neural representations become increasingly similar with greater proficiency. Yet, little is known about the emerging dual-language representations in young bilingual learners, especially concerning the aspects of bilingual competence that underlie literacy development. Specifically, word reading is supported by children's emerging phonological and morphological awareness skills, or the ability to actively manipulate units of language sound and meaning, respectively. To uncover the nature of neural interconnection between two languages in phonological and morphological literacy skills, we tested young and early-exposed bilingual learners of structurally distinct languages, English and Chinese (N = 42, ages 5-10). During fNIRS neuroimaging, children heard three words and decided which of the two words matched either phonologically or morphologically. The data were analyzed with representational similarity analysis of channels in left inferior frontal and temporo-parietal areas. Results revealed similar patterns of neural activation between the two languages during the phonological task but distinct activation patterns during the morphological task. The findings advance bilingual literacy frameworks by suggesting that phonological literacy skills are more cognitive-general, whereas morphological skills are more language-specific. Our findings also inform broader theoretical perspectives on brain development and bilingualism, revealing efficiency in the neural organization for skills similar across two languages but specificity for those structurally-unique skills.

Topic Areas: Multilingualism, Development

Explicit feedback drives the formation of cortical representations of novel auditory categories via corticostriatal pathways

Poster F35 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session F.

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Learning to categorize variable acoustic signals into discrete categories is critical to cognition and auditory perception. Auditory category learning can be facilitated by explicit feedback; however, the underlying neural mechanisms are still unclear. A working hypothesis posits that the feedback-sensitive corticostriatal networks facilitate the formation and updating of cortical representations of auditory categories via reinforcement-based learning (Dual-learning systems model; Chandrasekaran et al., 2014). To test this hypothesis, we recruited participants (N = 60) and randomly assigned them into either the feedback-based (FB; N = 30) or no-feedback (NF; N = 30) learning experiment while they learned to categorize novel sounds to four categories with or without feedback during functional magnetic resonance imaging (fMRI) scanning. We used novel speech-like sounds as stimuli that were artificially generated by spectral-temporal modulations of broadband noise. Successful category learning requires learners to integrate acoustic information from the two dimensions. To examine the dynamic formation of category representations underlying FB and NF auditory category training, we combined computational modeling, multivariate representational similarity analysis (RSA), and univariate parametric modulation analysis. To model sound-category associations and their trial-by-trial changes (i.e.,

updates) during training, we employed computational associative learning (AL) algorithm to fit learners' categorization responses. Sound-category associations are represented by a sound-by-category matrix that is updated gradually during training when a learner makes responses to each sound. This AL algorithm can be applied to both FB and NF scenarios while enabling us to track trial-by-trial and accumulating updates of the associations. Therefore, with the modeling, we generated block-by-block model-based representational dissimilarity matrices (RDMs) of the sound-category associations for RSA and trial-by-trial association updates for the PMA to examine the emerging neural representations of the auditory categories and identify brain regions that are sensitive the updates of the sound-category association. Behaviorally, using response modeling we found that categorical response patterns in the FB group significantly outperformed the NF group, suggesting feedback enhances the formation of categories. The model-based RSA showed that the emerging multivoxel-pattern representations of the sound-category associations were found in the distributed fronto-temporoparietal regions in the FB group compared with that of in the NF group. While the neural representations in the NF group restrict in the dorsal auditory regions. The PMA further revealed significant trial-by-trial correlations between sound-category association updates and feedback-related blood-oxygen-level-dependent (BOLD) activities in the bilateral putamen, caudate nucleus, and ventromedial prefrontal cortex (vmPFC) regions in the FB group compared with the NF group. Individuals with higher PMA correlations in the frontostriatal regions were associated with more robust emerging representations in the representational regions found in the FB group but not in the NF group. These results demonstrate that feedback signals not only significantly facilitate behavioral categorical responses but also induce greater representations of newly acquired auditory categories, which may be driven by trial-by-trial feedback-related neural responses of the frontostriatal network. Our findings provide evidence of DLS and new insights into the mechanism of the feedback-driven formation of neural representations underlying auditory category learning.

Topic Areas: Perception: Auditory, Speech Perception

Context-dependent encoding of vowel formants in human Superior Temporal Gyrus

Poster F36 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session F.

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Vowels are a central component of speech. Across human languages vowel identity is determined by the central frequencies of the first two peaks in the vowel spectrum, called first (F1) and second (F2) formants (e.g. /u/ and /i/ both have low F1 values, but /i/ has a higher F2). In natural speech, formants vary continuously and category boundaries in the two-dimensional formant space differ between speakers and languages. Yet, vowel sounds are perceived as belonging to discrete categories, normalized for speaker identity, and reflective of language-specific categories. Previous work has shown that neural responses in human superior temporal gyrus (STG) differentiate between vowels. Yet, it is not known how STG vowel representations support these key aspects of vowel perception. Here, we address this in three experiments, combining high-density intracranial recordings and computational modeling. We tested whether neural responses in STG reflect (1) continuous vowel formant values, or (2) vowel categories, irrespective of within-category formant variation and normalized for speaker and language context. In Experiment 1, thirteen native Spanish speakers listened to Spanish sentences, naturally produced by a variety of speakers. Linear encoding models showed that neural populations in bilateral mid-STG monotonically encoded continuous values of one or both formants. At the population level, this resulted in a representation of the entire two-dimensional formant space. In contrast, we found no selectivity for individual vowel categories. Rather, a subset of formant-encoding populations showed nonlinear sigmoidal encoding of single formants, with sensitivity peaking around vowel category boundaries, projected to the encoded formant dimension. Comparing neural responses to sentences produced by different speakers, we found that sensitivity ranges of these sigmoidal encodings shifted to match differences between speakers' formant ranges. To test whether tuning to category boundaries reflects a listener's native language, in Experiment 2, six additional

monolingual English speakers listened to the same Spanish sentences. The same formant space is split into over nine vowels in English, but into only five vowels in Spanish. Therefore, if sensitivity of local neural populations in STG is tuned to native category boundaries, at the population level, the distribution of sensitivity peaks would reflect the larger number of category boundaries in English than in Spanish. Indeed, we found that while Spanish speakers' formant sensitivity ranges were clustered around a small set of vowel boundaries, in English speakers they were more evenly distributed across the entire formant frequency range. Finally, Experiment 3 tested whether neural responses reflect each formant independently or a joint representation. To this end, four monolingual English speakers listened to synthetic vowel tokens, with independently varying F1 and F2. On select neural populations, responses were better described by a two-dimensional formant receptive field than by projects onto single formants, providing evidence for integration across the entire spectral content of vowels. Overall, our results demonstrate that local populations in STG encode vowel formants non-linearly, with sensitivity to vowel formants peaking at native language vowel category boundaries. This encoding is flexibly normalized to speaker-specific vowel spaces, providing the basis for representation of vowel categories.

Topic Areas: Perception: Speech Perception and Audiovisual Integration, Perception: Auditory

Improving phonological working memory: the effect of combining verbal working memory training and anodal High Definition transcranial direct current stimulation to the presupplementary motor area

Poster F37 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session F.

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Background Phonological working memory (PWM) refers to the cognitive processes that allow for the temporary storage and maintenance of auditory linguistic information (Perrachione et al., 2017; Baddeley, 2012) and is subserved by a network of structures, including those located in pre-motor areas. PWM is hypothesized to be integral in foreign language learning in adults (Papagno et al., 1991), as well as implicated in multiple disorders, such as developmental language disorder (Torrens & Yague, 2018), intellectual disability (Schuchardt et al., 2011), and decreases in ability in elderly adults (Grivol & Hage, 2011). Objective To investigate whether there would be no difference in post-test nonword repetition accuracy at the phoneme level between sham and active groups following 20 minutes of anodal HD tDCS to preSMA administered in conjunction with a nonword repetition task. Methods 28 college-aged adults (18-25 years; 19 female, 8 male, 1 nonbinary) with normal hearing, and no history of language or neurological disorders completed the experiment. The protocol consisted of three phases: 1) nonword repetition pre-test; 2) training of nonword repetition with either active anodal HD tDCS or sham; and 3) nonword repetition post-test. Each of the three portions consisted of a nonword repetition task where participants heard a series of 4-, 5-, 6-, and 7-syllable English-like nonwords taken from the Gupta et al. (2004) study. Subjects were told they would hear each word once and after hearing the word they were instructed to try to repeat the word as quickly and accurately as possible. For the training portion the participants were randomly selected to receive either 20 minutes of active anodal HD tDCS stimulation, or sham stimulation while concurrently rehearsing nonwords. All participants were fitted with a cap with five electrodes inserted into it for the stimulation montage, placed according to the 10-10 EEG system for electrode positioning (Starstim, Neuroelectrics, Barcelona, Spain). Sound stimuli were presented from a laptop in a silent room via blue tooth speaker at a comfortable listening level. Subjects' responses were recorded, and these responses were later scored for their correctness at the phoneme level by a blinded trained research assistant. Results From pre-testing to post-testing there was no significant difference in performance for the sham group. However, there was a significant decrease in performance for the active stimulation group, such that performance in the active condition was significantly better pre-anodal HD tDCS stimulation. Discussion The results from this study show that preSMA is part of the neural circuitry involved in phonological working memory. Further, these results indicate that, in typical young adults, anodal direct current to the pre-

SMA negatively impacts behavioral performance on non-word repetition tasks traditionally used to assess phonological working memory.

Topic Areas: Phonology and Phonological Working Memory, Language Production

Within-subject design reveals converging cortical regions for orthographic, phonological and semantic processing in Chinese reading

Poster F38 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session F.

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INTRODUCTION. A meta-analysis on 26 fMRI studies reveals that the activation for orthographic, phonological and semantic processing of Chinese characters converges at the left middle/inferior frontal gyrus (BA 46/9), left mid-fusiform gyrus (BA 19/37) and left superior parietal lobule (BA 7), while diverges at the left inferior parietal lobule (BA 40), inferior frontal gyrus (BA 44/45/47) and the right mid-fusiform (Wu, Ho & Chan, 2012). However, as the design of the reading tasks targeting the same process can vary substantially in a meta-analysis, the patterns of convergence or divergence could be obscured by factors such as different baseline tasks and response modality. To tackle these issues, we devised a within-subject design using three character reading tasks for the respective reading processes. METHODS. Thirty-one native Mandarin speakers were recruited in Beijing and scanned with a Siemens Prisma 3T scanner at Peking University. To investigate orthographic processing, a component matching task was used. Two characters appeared on the screen simultaneously and participants judged whether they shared the same component / radical. A line judgement task in which participants judged whether two line patterns were identical served as the baseline task. The phonological and semantic tasks were designed similarly but participants judged whether the two characters were homophones and synonyms respectively. A font-size judgement task served as the baseline task for these two reading tasks. The visual complexity of the characters, indicated by the number of strokes, and their frequency were controlled across the three tasks. To match the baseline tasks, 23 participants returned on another day and performed the same reading tasks with an interchanged baseline task. Conjunction analysis and paired t-test were used to identify the convergent and divergent regions of activation among the three tasks. Preprocessing and statistical analysis were performed with SPM12. RESULTS. The contrast maps of individual tasks revealed that the activation followed the same general patterns despite a change in the baseline task, so only the analysis of the first scanning session will be reported. Activation in typical regions responsible for Chinese character reading, such as the left middle frontal gyrus, left mid-fusiform gyrus and left superior parietal lobule were found in the conjunction analysis. Interestingly, the dorsal portion of the middle frontal gyrus (Exner's area, BA 6), which is less frequently reported and responsible for converting orthographic representation into motor sequence specific for writing (Roux et al., 2009), was also commonly activated. Paired t-tests showed that bilateral fusiform gyrus (BA 19/37) and superior bilateral lobule activated more strongly during the orthographic component matching task than the other tasks, while semantic processing uniquely recruited the inferior frontal gyrus (BA 45/47). CONCLUSION. Apart from minor deviations in activation sites, orthographic, phonological and semantic processing in Chinese reading share a largely similar brain circuit. Common activation in the Exner's area points to the intertwined relationship between reading and writing in Chinese (Tan et al., 2005). Further investigation on the connectivity among these regions may reveal a deeper distinction among the cognitive mechanisms of the three reading processes.

Topic Areas: Reading, Methods

Disruption of left inferior frontal cortex eliminates the word predictability benefit in memory: An event-related rTMS study

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Despite the computational difficulties of language comprehension, humans can understand language with remarkable precision. Prior context can be used to predict features of upcoming words (e.g., semantics, phonology) and this predictability benefit increases the efficiency of comprehension. At the same time, little is known about the fate of predictable and unpredictable words in long-term memory and the neural systems governing these processes. Several influential theories of language prediction suggest that the speech production system, including the left inferior frontal cortex (LIFC), is recruited in predictive processes, but evidence that LIFC plays a causal role is lacking. In two experiments, we examined the effects of predictability on memory and tested the role of LIFC by disrupting its function. In Exp 1 (N = 30), participants performed a category decision task in which they were presented with a category cue (e.g., A type of tree), followed by a target word that was predictable (high typicality, oak), unpredictable (low typicality, ash) or incongruent (tin). Immediately after the task, an incidental cued recall task was completed. Results from Exp 1 demonstrated a predictability benefit such that predictable words were better remembered than unpredictable words, suggesting that prediction may help to facilitate memory. In Exp 2 (N = 31), a different sample of subjects performed the same task while receiving event-related inhibitory repetitive transcranial magnetic stimulation (rTMS 5 Hz, 5-pulse train) over left or right IFC. Stimulation was time-locked to the defining word of the category cue prior to the target word (i.e., at tree in A type of tree), when predictive processes should be engaged. Importantly, prior work has shown that these stimulation parameters over LIFC reliably induce speech errors. We reasoned that, if the LIFC-mediated language production system is involved in linguistic prediction, then LIFC disruption with rTMS during prediction should specifically impair the predictability benefit in memory. We found that, under RIFC stimulation (the control condition), predictable words were better recalled than unpredictable words, replicating the results from Exp 1. However, under LIFC stimulation, the predictability benefit was effectively eliminated. These results indicate that LIFC is recruited for prediction, and that disrupting LIFC-mediated predictive processes during presentation of the category eliminates the prediction-related memory benefit at the encoding of the target word. Disruption of neural predictive processes in the speech production network may have downstream effects on receptive language processes, disrupting high-level processes such as memory encoding.

Topic Areas: Reading, Methods

Effects of musical experience on processing speech envelope and temporal fine structure

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Numerous evidences have been provided that musical experience improves speech perception, especially in noisy environments. Such an experience-induced facilitation has been related with enhanced higher-level cognitive functions (e.g., auditory attention, auditory working memory, cross-modal integration) and strengthened processing of speech acoustic cues (e.g., pitch, harmonics). However, whether musical experience has an impact on speech perception at the sentence level and above is still under debate. Yet no study has investigated how musicianship affects the processing of speech temporal cues including the slowly varying envelope (ENV) which represents the fluctuation of speech energy and the rapidly varying temporal fine structure (TFS) which contains speech spectral texture. Combining psychophysics and EEG technique, the current study investigated the effects of musical experience on the processing of speech envelope and TFS in three experiments. In Experiment 1, cognitively matched young musicians (n = 24) and non-musicians (n = 24) were asked to hear and repeat mandarin HINT sentences containing either TFS only or envelope only information at various difficulty levels and signal-to-noise ratios. Results showed that musical expertise decreased the identification of envelope only sentences, but slightly increased the identification of TFS only

sentences. Experiment 2 investigated the effects of musical experience on brainstem frequency-following responses (FFRs) to the syllable /da/. Results showed that compared to non-musicians, musicians exhibited enhanced subcortical representation of the 1st harmonic (FFR-H1) of speech. And the FFR-H1 tracking strength had a positive correlation with subject's musical ability. Experiment 3 used cortical EEG to explore the influence of musicianship on envelope tracking responses induced by continuous natural speech, TFS speech and envelope speech in both quiet and noisy conditions. Results of inter-trial correlation (ITC), neural temporal response function (TRF) and envelope reconstruction accuracy consistently found a stronger entrainment to speech envelope in non-musicians compared to musicians at delta and theta frequencies, indicating decreased attention to speech envelope in musicians. In contrast, compared to non-musicians, musicians had a higher cross-frequency coupling between delta phase and theta amplitude when processing natural speech in noise and TFS speech in quiet, suggesting experience-induced enhancement of speech integration cross different time scales. Besides, the cross-frequency coupling in processing TFS speech in quiet was significantly correlated with subject's rhythm-specific musical ability. Our findings suggested that musicians may reduce resource allocation to speech envelope but have advantage for processing the dynamic feature of speech TFS to predict, chunk and integrate hierarchical speech units in a top-down manner, while non-musicians may rely more on the bottom-up tracking of speech envelope in comprehending speech. The present study thus shed light on the influence of musical experience on the hierarchical and dynamic processing of continuous speech and its temporal cues in the brain.

Topic Areas: Speech Perception, Perception: Speech Perception and Audiovisual Integration

MMN may not reflect lexical tone as phonemic categories: the involvement of multiple processing mechanisms

Poster F43 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session F.

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Perceiving speech involves multiple levels of representation. While evidence for the brain's access to phonological categories in consonants is relatively well-established, the same cannot be said for lexical tone categories. Following Phillips et al. (2000), this study used an adapted oddball paradigm (multiple acoustically varying tokens within standards and deviants) to evaluate the brain's access to lexical tone categories during speech perception. Two EEG experiments (acoustically matched) were conducted on 31 native speakers of Mandarin Chinese: a Phonological Contrast experiment (standards and deviants contrasting at the lexical tone level; Level vs. Falling), and an Acoustic Contrast experiment (two lexical tones are placed in the same group; standards and deviants not contrasting at the lexical tone level). Our design offers the possibility to examine three potential mismatch negativity (MMN) generating mechanisms: (1) a linguistic mechanism, which processes lexical tone as linguistic events in an all-or-none fashion; (2) an auditory mechanism, where MMN amplitude increases as physical distance increases; (3) an abstract-rule formation mechanism, which groups ad hoc clouds of stimuli together: under this mechanism, two contrastive lexical tones can be treated as if they are identical. Our results revealed that the biggest factor that modulates MMN is the direction of change. MMN is markedly reduced when the deviants are relatively flatter than the standards (standards vs. deviants: falling vs. level), while MMN is greater in the opposite configuration (level vs. falling). Though seemingly compatible with an underspecified lexicon, given the lexical tone categories we chose, this MMN asymmetry is more likely due to the acoustic properties of the stimuli. Strikingly, the Acoustic Contrast experiment yields MMN of comparable size to that of the Phonological Contrast experiment: the brain can form groups composed of phonologically heterogeneous lexical tone tokens to generate robust MMN, which is not the case for consonants as previously reported. This finding casts doubt on previous lexical tone MMN studies that interpret MMN behaviors as linguistic effects. We only found limited evidence supporting the linguistic processing of lexical tone categories. The MMN size is not linearly modulated by acoustic distance within each experimental block, as the auditory mechanism would predict. Crucially, when the acoustic distance between the standards and the deviants is matched, the modulation within the Phonological Contrast experiment and the Acoustic Contrast experiment is non-identical (non-monotonic vs. flat MMN amplitude responses to changes in acoustic distance, respectively). We interpret our findings as a synergy of the three potential MMN generating mechanisms (linguistic, auditory, abstract-rule formation). When perceiving lexical tone, all three mechanisms should be active. Whether the three mechanisms converge or compete, and their relative contribution to MMN are determined by the specific experimental configuration involved. Unlike consonants, the influence of acoustic properties is greater than phonemic inventory; abstract-rule formation can also override the linguistic processing of lexical tone. Due to the potential activation of the three MMN generating mechanisms when lexical tone stimuli are perceived, in the future, appropriate caution should be exercised before one claims the found effect is indeed attributed to phonemic processing.

Topic Areas: Speech Perception, Methods

Facilitation of syntactic processing by anodal tDCS over the left inferior frontal gyrus

Poster F44 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session F.

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Previous neuroimaging studies have demonstrated that the left inferior frontal gyrus (IFG) is critical for syntactic processing. To test the causal relationship between the left IFG activation and syntactic processing, we examined whether anodal (i.e. excitatory) transcranial direct current stimulation (tDCS) over the left IFG facilitates syntactic processing. We hypothesize that behavioral performance of sentences with additional syntactic loads (e.g., passive sentences) is improved by the anodal tDCS. We recruited 20 right-handed native speakers of Japanese (10 males, 22.5±0.8 years), who had no history of neurological or psychiatric diseases. We used 30 Japanese sentences for each of active intransitive (e.g., Taro-to Hanako-ga aruita, Taro and Hanako walked), active transitive (Taro-ga Hanako-o tataita, Taro hit Hanako), passive intransitive (Hanako-ga Taro-ni arukareta, Hanako was adversely affected by Taro's walking), and passive transitive sentences (Hanako-ga Taro-ni tatakareta, Hanako was hit by Taro) (total 120 stimuli). Note that the passive intransitive sentences, the so-called indirect passive, are grammatical in Japanese. Each sentence consisted of two noun phrases and one verb, immediately followed by a question (e.g., Taro-ga aruita?, Did Taro walk?). In the present experiment, we used a sentence comprehension task, in which the participants were instructed to judge whether the meaning of the sentence matched with the question by pressing one of two buttons. We used a single-blinded sham-controlled design. Stimulation was delivered using DC-Stimulator Plus (NeuroConn GmbH, Germany). The anode and cathode electrodes were placed over F5 and F6 according to the International 10-20 EEG system, which were right above the left and right IFG, respectively. For anodal tDCS, stimulation was given for 20 minutes (1 mA, 5 cm * 7 cm saline-soaked sponge electrodes). Sham stimulation ramped up to 1 mA over 10 s, remained at that level for 30 s, ramped back down over 10 s. Before and after the anodal and sham stimulations, the participants performed the sentence comprehension task (Pre and Post task). A three-way repeated-measures analysis of variance (rANOVA) (Stimulation*Condition*Pre/Post) for the accuracies showed significant main effects of Condition and Pre/Post ($p<.01$), while the main effect of Stimulation and interactions were not significant ($p>.18$). The rANOVA for the reaction times (RTs) also showed significant main effects of Condition and Pre/Post ($p<.001$), as well as the interaction of these factors ($p<.05$). To consider the random variabilities of participants and stimuli, we further analyzed the RTs by using a linear mixed-effect model (lme4 and lmerTest packages on R). We found that the model with the effect of Stimulation was significantly better than the simpler model without such effect ($\chi 2=38$, $p<.0001$), suggesting the effect of anodal tDCS. Moreover, the interaction between anodal stimulation and passive sentences was significant ($p=.002$), indicating that the anodal stimulation over the left IFG significantly decreased the RTs of the passive sentences. In the present tDCS study, we demonstrated that the anodal tDCS over the left IFG facilitated the processing of syntactically more demanding passive sentences, suggesting the causal relationship between left IFG activation and syntactic processing.

Topic Areas: Syntax, Reading

Syntactic representations in the human brain: beyond effort-based metrics

Poster F45 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session F.

Presenter Note: Please refer to our preprint for more details: https://doi.org/10.1101/2020.06.16.155499

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Most studies that examine syntactic processing in the brain use metrics which capture the effort needed to integrate words into a sentence's syntactic structure. By construction, these metrics are not reflective of the entire syntactic information in play and can only partially reveal the brain representation of syntactic constructs and their complex hierarchical structure. To move beyond effort-based metrics, we built explicit word-level features that capture the syntactic structure that is incrementally built while reading a sentence. We built two embeddings that attempt to encode the structure of constituency trees. First, we built embeddings using the largest subtree that is completed upon incorporating a word into the sentence. This subtree is representative of the implicit syntactic information given by the word. Further, to test whether the brain predicts upcoming sentence structure while reading, we computed embeddings using incomplete subtrees constructed by retaining all the phrase structure grammar productions that are required to derive the words seen till now. This allowed us to capture higher-level sentence structure before the full sentence is read. Upon extracting these complete and incomplete subtrees for each word, we used a subgraph embedding approach (Adhikari et al. (2018)) to produce embeddings that preserve the neighbourhood properties of subgraphs and encode phrase and clause structures. We also built a simpler explicit syntactic feature consisting of a word's part-of-speech and dependency tags. Node Count is a popular unidimensional effort-based metric, computed as the number of subtrees that are completed by incorporating a word into its sentence. We use it as a representative effort-based metric. To test whether regions that are predicted by syntactic features are selective for syntax, and not predicted by semantics, we modelled the semantic properties of the text using contextual word embeddings (Devlin et al. (2018)). Upon building these word-level feature sets, we used them to predict fMRI data, recorded while subjects read a natural text, using voxelwise ridge regression. Words were presented one at a time at a rate of 0.5s each. After controlling for sentence boundaries, we noticed that node count barely increased prediction performance. However, using explicit syntactic features led to significant increases in performance across all language areas. The distinct information provided by the incomplete subtrees-based embeddings produced the largest gains. These results call for a shift away from effort-based metrics towards more meaningful explicit features. After analyzing the syntactic information captured by our features, we found that our constituency tree-based embeddings are predictive of higher-level tree ancestors of words, suggesting that information relevant to phrase and clause structures is represented in the areas that are predicted by these embeddings. The embeddings computed using incomplete subtrees were more predictive than those derived using complete subtrees, suggesting the brain anticipates future syntactic structure. Finally, we found a large overlap between areas predicted by semantic and syntactic features, with semantic features having higher prediction performance. Consistent with recent findings (Fedorenko et al. (2020)), our results indicate that syntactic and semantic information is processed in a distributed fashion across the language network.

Topic Areas: Syntax, Computational Approaches

Rational adaptation in language comprehension: Evidence from ERPs

Poster F46 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session F.

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Introduction: Recent studies of language comprehension reported that people rapidly adjust their expectation to probabilistic statistics during experiments. For example, Fine et al. (2013) conducted a self-paced reading experiment and found that a garden-path (GP) effect was lessened as their participants were repeatedly

presented with GP sentences (e.g., The experienced soldiers warned about the dangers conducted …). Nevertheless, it remains controversial as to the limit of adaptive behaviour and the underlying mechanism of adaptation. Concretely, it is unclear whether people adjust their expectation only to less frequent disambiguation patterns of grammatical sentences or even to ungrammatical sentences when they are repeatedly exposed to them. Methods: To address this issue, the present study conducted two ERP experiments that examined whether people adapt to morphosyntactically anomalous sentences (Experiment 1) and semantically anomalous sentences (Experiment 2). Since ERPs may change during experiments for several reasons other than adaptation, such as fatigue, we manipulated the probability of morphosyntactically/semantically grammatical and ungrammatical sentence occurrences through experiments and assessed whether ERP differences between ungrammatical and grammatical sentences decreased only when the participants were exposed to a large proportion of ungrammatical sentences. For the low probability block, morphosyntactically or semantically anomalous sentences were presented less frequently than natural sentences (the ratio of 1 to 4), while they were presented as frequently as natural sentences in the equal probability block. The ratio of the syntactically/semantically natural and unnatural sentences was manipulated by intermixing filler sentences to balance the number of trials of the target sentences. Forty native Japanese speakers were recruited and randomly assigned to either Experiment 1 or Experiment 2 (20 participants for each experiment). Results and Discussion: In Experiment 1, P600 effects for the ungrammatical sentences were significantly smaller in the equal probability block than the low probability block. The linear mixed-effects models that included trial order as a fixed factor revealed that the smaller P600 effect resulted from an amplitude's decrease in the ungrammatical sentences as the experiment went along. This result suggests that people can adapt to ungrammatical sentences and is compatible with the representation-based account of adaptation because native speakers have no licit representation of ungrammatical sentences, and therefore, the activation level of its syntactic representation cannot increase to facilitate the subsequent processing of them. In Experiment 2, the semantically anomalous sentences elicited a larger N400 effect than the semantically natural counterparts, regardless of the probability manipulation. The trial order analyses did not reveal any evidence of adaptation to semantic anomalies. We argue that differential adaptive behaviour results when participants consider how likely certain types of errors are to occur. In spontaneous speech, native Japanese speakers as well as Japanese-speaking children and non-native speakers sometimes produce morphosyntactic errors. In contrast, semantic errors are infrequent. The difference in adaptive behavior suggests that the language-processing system is easily familiarized with morphosyntactic violations whereas semantic knowledge is so fixed that that the language-processing system is immune to the repeated exposure to semantic anomalies.

Topic Areas: Syntax, Reading

Reading Intervention Duration and Brain Activation Changes Before and After Treatment: A meta-regression study

Poster F48 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session F.

Presenter Note: Questions or comments? Feel free to contact Kelly Mahaffy at kelly.mahaffy@uconn.edu. For more on our meta-analysis, please see poster A42, presenter Meaghan Perdue.

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Children with reading disability (RD) commonly receive remedial intervention to strengthen reading abilities. The potential positive outcomes of intervention programs have been well established in the literature (ex. Fuchs et al., 2008; Partanen & Siegel, 2014; Barquero et al., 2014) The specific features of an intervention program that lead to positive outcomes are not well understood, particularly for intensive intervention programs. Furthermore, the neural responses associated with specific intervention program features (e.g. duration or intensity of intervention) are similarly opaque. Increasing the duration of an intervention program remains one

recommendation for improving intervention efficacy (National Center for Intensive Intervention, 2012), but currently there is little evidence for differences in participant outcome based on intervention timing (Wanzek et al., 2018). Studies that utilize neuroimaging techniques (fMRI, MEG) to explore brain activation changes post-treatment have characterized intervention response in three main ways. Some intervention studies show "normalization" of brain responses in the canonical "reading network," including the left hemisphere temporo-parietal, occipito-temporal, and inferior frontal regions (ex. Davis et al., 2001; Shaywitz et al., 2004). Other studies find "compensatory" changes, often indicated by increased activation in regions involved in general cognitive processing and the right hemisphere homologues of the canonical reading network (ex. Odegard et al., 2008; Partanen et al., 2009). Additionally, some find a mixture of both normalization and compensatory effects after intervention (ex. Eden et al., 2004; Gebauer et al., 2012; Meyler et al., 2008). We examined brain activation differences pre-to-post-intervention in relation to intervention duration. Based on the results of a previous meta-analysis of reading interventions performed in educational settings, we considered intervention duration in weeks as the number of sessions, over a total number of hours, was an important factor in intervention efficacy (Wanzek et al., 2018). After preparing a meta-analysis which included 9 studies that had participants with or at-risk for RD who underwent both pre- and post-intervention fMRI imaging (Perdue et al., in prep), we completed an exploratory meta-regression in order to consider possible effects of intervention duration on brain activation changes. The results of this analysis indicated that shorter intervention duration was linked to a greater degree of increase in brain activation in the left fusiform gyrus ($p<0.025$, uncorrected). One possible interpretation of this result is that, early in intervention, this area experiences greater degrees of increased activation as it is trained to process text. Limitations of the current analysis include a sole focus on duration. We hope to explore some additional factors in future work, including intervention focus, style, and total number of hours. These results may help us gain some understanding of the relationship between intervention duration and resulting brain activation changes, which may inform the design of tailored intervention programs in the future.

Topic Areas: Reading, Development

Voice-specific auditory imagery during reading? A work in progress

Poster F49 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session F.

Presenter Note: Thanks for your interest! If you have any feedback or suggestions for us (especially since we are still waiting until it is safe or practical to do so to start fMRI data collection), we'd love to hear from you! You can talk to me at the poster session F on Friday evening (9pm Eastern), send me comments or questions via email (krevill@emory.edu), or we can set up a time to talk.

Kate Pirog Revill[1], Lynne Nygaard[1]; [1]Emory University

Previous behavioral studies have shown evidence for voice-specific auditory imagery during silent reading. Readers read a passage faster when it is 'written' by a recently-heard faster talker (Alexander & Nygaard, 2008), respond faster to a word spoken by the 'correct' talker while reading a previously heard dialog (Kurby et al., 2009), and show diminished P600 effects to grammatical errors when reading text 'written' by an accented and thus presumably non-native speaker of English (Zhou et al., 2019). Neuroimaging studies have also demonstrated activation in temporal voice areas during silent reading (Perrone-Bertolotti et al., 2012, Yao et al., 2011) but have not been designed to determine whether the content of the imagery is talker-specific or instead represents an abstract or generic internal voice. This study in progress seeks to extend previous work by investigating neural evidence for talker-specific auditory imagery. Participants will be exposed to two distinguishable male talkers reading text passages drawn from Life on the Mississippi by Mark Twain and The Autobiography of Benjamin Franklin by Benjamin Franklin. These two works were chosen because they contain first person narration, are written in complex language that requires reading effort, are engaging, and are in the public domain. Both text difficulty and the presence of direct speech have affected the likelihood of observing effects of auditory imagery in previous studies (Alexander & Nygaard, 2008; Yao et al., 2011). Following an initial pre-scan exposure to each talker, participants will be scanned while reading passages they are told were written by the two talkers, interspersed with additional listening passages from each talker. Separate functional localizer tasks will be used to identify areas involved in auditory language processing (Scott et al., 2016) and voice processing (Pernet et al., 2015). Activation patterns from these regions of interest will be extracted for both the spoken and read passages. A classifier will be trained to discriminate talker 1 and talker 2 using the patterns of brain activity observed during the presentation of the heard passages. The classifier will be tested on brain activity patterns observed while participants read the text passages 'written' by talker 1 and talker 2. If a classifier trained to distinguish talker-specific heard speech can also successfully classify silently read text associated with each talker, this suggests that auditory imagery evoked during silent reading is similar in nature to the perceptual processing of the voices during listening. We report a behavioral pilot study that seeks to replicate and extend Alexander and Nygaard's finding using the materials, voices, and experimental setup described above. This paradigm differs from the previous study in the amount and type of talker exposure (2 minutes of two-actor dialog and two reading passages vs 20 minutes of interspersed 'audiobook' passages and 12 reading passages), but is similar in that there is a speaking rate difference between the two talkers. We predict that participants will read passages 'written' by the fast speaker more quickly than those 'written' by the slow speaker, suggesting auditory imagery for the speaking rate of each talker's voice.

Topic Areas: Reading, Speech Perception

Insights from a podcast: Neural modulation by phonetic competition in natural speech

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Presenter Note: Thank you for visiting my poster! Please feel free to contact me at hannah.mechtenberg@uconn.edu if you have questions or would like to talk further.

Hannah Mechtenberg[1], Christopher Heffner[2], Emily Myers[1]; [1]University of Connecticut, [2]University at Buffalo

INTRODUCTION Within the speech stream, there are local ambiguities in speech sound identity because phonetic tokens often fall near the boundaries between speech categories. The listener must resolve this phonetic uncertainty to accurately select the correct word, a process that continues for the duration of the incoming speech signal. For example, in the sentence "He picked up the b ? t" there are many possible completions of the final word (beet, bit, bait)—final selection of which relies on resolving the identity of the vowel. Of interest is how phonetic competition interacts with constraint at higher levels of processing (lexical, semantic, pragmatic) during continuous speech perception. Using isolated sentences, Xie and Myers (2018) and Mechtenberg, Xie and Myers (under review) found that the degree of phonetic ambiguity within a sentence modulated activation in left inferior frontal gyrus and left inferior parietal regions. However, there were different patterns of activation depending on the amount of semantic information present in a given sentence (i.e., nonsensical, non-predictive, or highly predictive). Of interest is how the availability of top-down information, such as in conversational discourse, interacts with phonetic ambiguity resolution during continuous speech perception. It may be that the rich semantic and narrative information inherent in discourse may decrease the burden on resolving phonetic competition and thus shift neural resources away from perceptual processing mechanisms and towards higher-level semantic networks. METHODS Seventy-nine participants passively listened to a 10-minute section of a podcast during fMRI. We extracted phonetic competition values for all stressed vowels in the input with both talkers (host and interviewee) collapsed into a single acoustic space. The timecourse of phonetic competition was estimated by convolving these values with a stereotypic HRF and regressing it against the observed hemodynamic response. Further analyses will also model predictability at lexical, semantic, and discourse levels to examine the interaction between top-down constraint and bottom-up ambiguity. RESULTS Preliminary whole-brain results for global phonetic competition show a negatively-graded activation pattern in bilateral superior temporal gyrus and a positively-graded pattern in bilateral inferior parietal lobule ($p < 0.01$, cluster size 200 voxels, uncorrected). Of interest is how the neural response to phonetic competition changes when phonetically ambiguous tokens happen to fall in predictable vs. unpredictable moments during the podcast. PRELIMINARY DISCUSSION Early analyses reveal a network that is differentially sensitive to phonetic competition in discourse, highlighting the flexibility of the speech perception neural system. An important question at this stage is how ambiguity at multiple levels (phonetic, lexical, semantic) can be modeled accurately during continuous fMRI. If this technique proves successful, it instantiates a promising method for estimating fluctuations in a listener's reliance on top-down and bottom-up information during the unfolding speech stream—providing valuable insight into the variable demands of natural speech perception.

Topic Areas: Speech Perception, Meaning: Lexical Semantics

Word-level rhythmic cue-weighting in Mandarin infants and adults – the effects of ITL and language-specific influence

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Infants use acoustic cues, such as pitch, intensity, and duration, to segment speech during language acquisition (Bion, Benavides-Varela, & Nespor, 2011; Bull, Eilers, & Oller, 1984). Iambic-trochaic law (ITL) (Hayes, 1995) - domain-general law of sound grouping, posits that sounds varying in pitch or intensity are grouped trochaically, while those varying in duration are grouped iambically (see Bhatara et al., 2013). It has also been documented that these cues are weighted differently across languages depending (largely) on the rhythmic categorization of the native language(s) (e.g., stress-timed and syllable-timed) (Höhle et al., 2009). Here, we examine ITL vs language-specific influence in speech and music cue-weighting in Mandarin infants and adults' weighting of pitch, intensity and duration cues at the first and second syllabic positions of a bisyllabic word/two-tone sequence. Mandarin speakers uses pitch contour but not intensity or duration change lexically. Because Mandarin participants were perceiving foreign prosodic cues, we predicted that greater discrimination (at one of the two syllable/tone positions) indicates a greater novelty effect. EEG signals from Mandarin-learning infants aged 7-8 months (N = 16, Mage = 7.31 months) and adult native speakers of Taiwanese Mandarin (N = 21, Mage = 23.3 years) were recorded in a Mismatch Negativity (MMN; an event-related potential component indexing sound discrimination) multi-feature paradigm (Näätänen et al., 2004). A bisyllabic non-word /dede/ (380ms) for speech and a musical stimulus of electric guitar timbre were used as the standards (or frequently repeating stimulus) to which listeners formed a memory trace. Pitch, intensity and duration cues at the first or second syllable position of the standard were manipulated to produce six deviants for each session. Twelve data points method (Guthrie & Buchwald, 1991) was used for statistical analysis of fronto-central MMN/Rs. When significant MMN/Rs were found for both syllable positions of the same cue, amplitudes were compared using t-tests to determine greater sensitivity to a certain syllabic position. For infants, speech deviants elicited significant MMRs but music deviants elicited MMNs: we found significant MMRs for the speech intensity deviant only at the second syllable (I2), significant MMRs for the speech duration cue only at the first syllable (D1) in infants, but similar MMN amplitudes for speech pitch at the first syllable (P1) and the second syllable (P2) (p = .961), and music duration change at the first (D1) and the second syllable (D2) (p = .116). For adults, all deviants elicited significant MMNs: for both speech and music domains, greater sensitivity was found to P2 (speech p <.0001; music p <.0001) but similar sensitivity was found to I1 and I2 (speech p = .073; music p = .224), D1 and D2 (speech p = .302; music p = .150). Thus, while there was discrimination of pitch and intensity at the second syllable and duration at the first syllable which is characterised of ITL, participants weighted both syllables similarly for some of the cues, driven by the language-specific influence of Mandarin.

Topic Areas: Speech Perception, Perception: Auditory

The timing of semantic interpretation in processing long-distance dependencies

Poster F52 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session F.

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[INTRODUCTION] Processing sentences with filler-gap dependencies (which cookie did Sniffle eat __ ?) requires relating the filler's meaning (which cookie) with the verb (eat). Processing models disagree on when the semantic relation between filler and verb is constructed: comprehenders may relate the filler as the verb's object before or after processing the verb. To test this, we conducted an MEG study to determine when neural activity distinguished plausible vs. implausible object fillers that were otherwise matched in lexical semantic association with the verb. Preliminary results show an effect of the filler-gap dependency shortly after verb onset (250–500ms), but sensitivity to the plausibility of the filler as the verb's object is observable in other ROIs at longer latencies (650–800ms), suggesting that the relation between filler and verb is not built until after the verb is processed. This study is ongoing; data collection is paused because of COVID-19. [METHODS] Brain activity from 5 English-speaking adults was recorded using magnetoencephalography (MEG) in a 2×3 within-subjects design of Question Type (Wh-Subject, Wh-Object, Yes/No) and Plausibility (Plausible, Implausible). In Wh-Object and Wh-Subject sentences, there was a filler-gap dependency. In Plausible sentences, the verb's thematic roles assigned to the filler or subject were plausible, and implausible for Implausible sentences. Sentences (49 sets) were displayed in randomized order, word-by-word, with each word displayed 300ms on/300ms off. After each sentence, participants registered one of two responses or "N/A" for uninterpretable stimuli. Wh-Object, {Plausible/Implausible} Which {cocktails/glasses} do wild partygoers drink excessively? Wh-Subject, {Plausible/Implausible} Which {partygoers/glasses} in fancy clubs drink excessively? Yes/No, {Plausible/Implausible} Do you think {wild partygoers/cocktail glasses} drink excessively? [PRELIMINARY RESULTS] We conducted cluster-based permutation tests over time windows within the presentation of the verb (drink) and subsequent adverb (excessively) in ten (left/right) ROIs implicated in processing filler-gap dependencies, lexical prediction, and semantics: inferior frontal gyrus (IFG; BA 44+45), visual word form area (VWFA; BA 37), anterior temporal lobe (ATL; BA 38), ventromedial prefrontal cortex (vmPFC; BA 12), and superior temporal gyrus (STG; BA 22). [QUESTION TYPE]. There was a cluster showing an effect of Question Type in LIFG from 234–522ms, in which Wh-Object and Wh-Subject diverged from Yes/No ($p = 0.01$), and similarly in LvmPFC (283–555ms, $p = 0.02$) and RVWFA (100ms–386ms, $p = 0.01$). These early main effects of Question Type show sensitivity to building a dependency between filler and verb. [PLAUSIBILITY]. Sensitivity to plausibility was reflected in neural activity at later latencies. There was a cluster showing divergence between Plausible and Implausible sentences in LVWFA at 667–777ms ($p = 0.04$). Two marginally significant differences showing the same profile were found in LSTG (638–829ms, $p = 0.08$) and LvmPFC (692–810ms, $p = 0.07$). [CONCLUSION] Processing filler-gap dependencies involves relating the meaning of the filler and verb. We found that sensitivity to plausibility of the filler as the verb's object was reflected in neural responses at longer latencies, suggesting that the semantic relation between filler and verb was not built until after the verb is processed.

Topic Areas: Syntax, Meaning: Combinatorial Semantics

ERP index of temporally delayed intrusive binding

Poster F53 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session F.

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INTRODUCTION: (Sturt, 2003) observed delayed effects of intrusive binding using eye-tracking measures of the ongoing parsing process. Other studies however predicted and observed simultaneous effects of grammatical antecedents and intruders (Patil et al., 2016). We used ERPs to differentiate between these two hypotheses. Defining terms, the 'antecedent' is a grammatical NP that c-commands and can bind a reflexive in its local binding domain; the 'intruder' is a non-c-commanding NP that might opportunistically try to bind a reflexive; and 'congruency' is defined by gender agreement between the putative binder (whether grammatical or intrusive) and the reflexive. These terms are exemplified by below, where the relation <1,1> is a grammatical antecedent with incongruent agreement, and <2,2> is an intrusive binding relation with congruent gender agreement: [The female soldier]1 that [Fred]2 treated in the hospital introduced himself1/2 to the surgeon Our goal was to ask if intrusion effects are facilitated by antecedent congruency violations, and to measure whether the intrusive binding has a separate time course compared to grammatical binding. METHOD: We modified a previous one-factor, 3-level ERP design (Xiang et al., 2009) into a 2x2 design. The independent variables were antecedent-congruency (a BT-grammatical antecedent agreed or not in gender with a reflexive), and intruder-congruency (a non-c-commanding NP agreed in gender or not with the reflexive). ERPs were analyzed with temporo-spatial PCA/ICA (Dien, 2012) to obtain the distinct temporal and spatial ERP components to the experimental manipulations. Experiment 1 (N=24) was conducted to obtain a baseline ERP response to observe the ERP response to a BT-grammatical antecedent congruency violation. Participants read 45x4 sentences like "The male/tough soldier that the team treated…introduced himself/herself…", in a word-by-word presentation, with ERPs time-locked to the reflexive. The plural 'The team' was not a candidate for intrusive binding. Experiment 2 (N=20) only used explicit gender for the BT-grammatical antecedent and manipulated the gender of the intruder, as in "The male soldier that Fred/Katie treated…introduced himself/herself…"). RESULTS: Data were signal processed with sequential temporo-spatial PCA/ICA (Dien, 2012). Experiment 1 and 2 was pooled to obtain the time course of the ERP response to antecedent-incongruency. The antecedent congruency violation resulted in two effects: A modulation of the visual N170 response (176ms peak latency), and N400 response (552ms peak latency). The N170 modulation shows that the structural antecedent congruency violation is detected very early (Dikker et al., 2009), followed by the N400 like response. In Experiment 2 we examoned the effects of intruder incongruency at each level of antecedent congruency. An interaction was observed such that the intruder congruency violation only showed up as an anterior negativity when the BT-grammatical antecedent was incongruent. There were two temporal portions of anterior negativity, one peaking at 388ms, and a later effect at 500ms. CONCLUSION: Intrusive binding only takes place if "regular" syntactically governed binding fails, contra the predictions of the cue-based approach and in support of Sturt. Furthermore, regular binding is checked by the parser in an early stage, prior to a second stage where intrusive binding can opportunistically apply.

Topic Areas: Syntax, Meaning: Combinatorial Semantics

Poster Session G

Processing different levels of argument structure complexity: A behavioral study in balanced Basque-Spanish bilinguals

Poster G1 [Poster PDF] [Poster Tour] Visit me at [Gather.Town] in the Broca room during Poster Session G.

Pavlina Heinzova[1], Manuel Carreiras[1], Simona Mancini[1]; [1]Basque Center on Cognition, Brain and Language

Verbs carry argument structure (AS) information, encoding who performs and who undergoes an event (i.e., agents and patients). Research in agrammatic and unimpaired populations shows that processing demands increase with AS complexity, e.g., with the number of arguments (i.e., transitives [he ate a cake(DO)] > intransitives [he smiled(-)]) or, in the case of intransitives, as a result of subject-agent non-correspondence (i.e., unaccusatives, where the subject is not an agent [he(patient) fell-] > unergatives [he(agent) smiled]). [1] However, it is unclear how verbs with different AS complexity are processed i) in languages like Basque, which differ in their AS realization and ii) by bilinguals of two languages with different AS realizations. Basque verb phrases consist of a lexical verb (e.g., erori[to fall]) and a transitive or intransitive auxiliary (ukan[to have] and izan[to be], respectively) assigned to the lexical verb depending on its type. Unaccusatives select the intransitive auxiliary, while unergatives (together with transitives) select the transitive auxiliary despite being intransitive, hence showing a conflicting feature. Spanish verbs do not select auxiliaries based on transitivity; haber[to have] is used in compound tenses and ser[to be] in passives. We hypothesize that in Basque, the verb's processing cost depends on its auxiliary selection, rather than on transitivity or subject-agent correspondence. Unaccusatives (i.e., intransitives accompanied by intransitive auxiliary) should be less costly compared to unergatives, which are also intransitive but select a transitive auxiliary. The "auxiliary mismatch" may render unergatives as demanding to process as transitives, which require an additional argument. In Spanish, unaccusatives and/or transitives are expected to elicit higher processing costs compared to unergatives, replicating previous studies. We selected 19 verbs from each type (unergatives, unaccusatives, and transitives) in both Spanish and Basque (controlled for length, frequency, orthographic neighborhood, and cognates). Reaction times (RTs) and accuracy were obtained from balanced, simultaneous Basque-Spanish bilinguals (n=71) in a lexical decision task (LDT) and speech onset times (SOTs) and accuracy in a production task (PT) where participants produced sentences after visual presentation of verbs with auxiliaries. We fitted generalized (for accuracy) and linear mixed effect models (for log-transformed SOTs and RTs) with verb type as a predictor (contrast-coded, lme4 package in R) and used likelihood ratio tests to compare models with increasingly complex fixed- and random-effect structure. Verb type was not a significant predictor in LDT in either language (all zs/ts<1.56; all ps>0.11). In the Spanish PT, verb type predicted SOTs with increased cost for unaccusatives vs. unergatives (unerg-unacc:t=2.43, p=.02; unerg-trans:t=-1.60, p<.12; trans-unacc:t<0.85, p<.40). In the Basque PT, verb type predicted accuracy; specifically, unergatives elicited more ungrammatical sentences (unerg-unacc:z=2.81, p<.01; unerg-trans:z=3.17, p<.01; trans-unacc:z=-1.10., p=.27). Our results suggest that AS complexity influences production more prominently than comprehension. The increased cost for Spanish unaccusatives aligns with previous findings. The increased cost for Basque unergatives partially supports our hypothesis and indicates that not all languages follow the same patterns of AS processing, calling for further investigation and extension of these findings to Basque-Spanish agrammatic speakers. [1]Thompson & Meltzer-Asscher (2014), In Bachrach, Roy & Stockall (Eds.), John Benjamins.

Topic Areas: Syntax, Multilingualism

Neuroanatomical dissociations of syntax and semantics revealed by lesion-symptom mapping

Poster G2 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session G.

William Matchin[1], Alexandra Basilakos[1], Dirk-Bart den Ouden[1], Brielle C. Stark[2], Gregory Hickok[3], Julius Fridriksson[1]; [1]University of South Carolina, [2]Indiana University Bloomington, [3]University of California, Irvine

In the 1800s, scientists debated whether the human brain was functionally differentiated with respect to cognition. The issue was largely resolved when specific language impairments were identified following focal patterns of brain damage. However, neuroimaging has revived this discussion, as many studies find similar syntactic and semantic effects across the set of brain regions implicated in language (see Matchin & Hickok, 2020 for a review). Some researchers have thus suggested that linguistic processing is distributed, and that regions are not differentiated with respect to syntactic and semantic function (e.g. Fedorenko et al., 2020). However, while syntax and semantics are two separate aspects of language, they are systematically connected, posing an obstacle to identifying their neural correlates through neuroimaging experiments. Here we address this modern debate using lesion- symptom mapping in two large, partially-overlapping groups of people with left hemisphere brain damage due to stroke (N=121, N=92). Each subject's lesion was manually drawn and the subject's brain and lesion mask were warped to MNI space. We assessed three distinct high-level linguistic measures: (i) syntactic comprehension (N=121), consisting of complex non-canonical sentence structures with simple, active sentences as a covariate to control for lexical processing and task confounds, (ii) expressive agrammatism (N=92), consisting of perceptual ratings of morphosyntactic reduction/simplifications deficits (den Ouden et al., 2019; Matchin et al., 2020) with a speech rate covariate to account for overall speech production ability, and (iii) semantic category word fluency (N=92), in which subjects much name as many animals as possible within one minute, with the same speech rate covariate to account for executive function and general speech articulation ability. Using a set of functionally defined set of regions of interest from healthy subjects (real sentences > jabberwocky sentences; Matchin et al., 2017), we performed lesion-symptom mapping analyses in NiiStat, correcting for family-wise error for each measure separately using permutation tests (10,000 permutations). Lesion volume was included as a covariate both for behavioral scores and lesion data (DeMarco & Turkeltaub, 2018). Damage to the posterior middle temporal gyrus (pMTG) and anterior superior temporal sulcus (aSTS) were significantly associated with syntactic comprehension deficits, damage to the anterior and posterior inferior frontal gyrus (aIFG and pIFG) was associated with expressive agrammatism, and damage to the inferior angular gyrus (iAG) was associated with semantic category word fluency deficits. In addition, we performed three hypothesis-driven interaction analyses using linear regression, finding that damage to pMTG was significantly more associated with syntactic comprehension deficits relative to damage to pIFG ($p = 0.003$), damage to iAG was significantly more associated with semantic category word fluency deficits relative to damage to aSTS ($p = 0.013$), and damage to pIFG was nearly significantly more associated with expressive agrammatism relative to damage to pMTG ($p = 0.075$). Our results support the neurobiological model of syntax and semantics presented by Matchin & Hickok (2020), and present a strong challenge to recent hypotheses that regions of the language network play similar roles in high-level linguistic processing.

Topic Areas: Syntax, Meaning: Lexical Semantics

Minimal syntactic composition in electrocorticography

Poster G3 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session G.

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The ability to construct meaningful phrase structures is an essential component of language. Some have argued that it is a species-defining trait, yet its neurobiological basis remains relatively obscure. MEG and fMRI studies of syntactic and semantic combinatorics have settled on a general consensus of left superior temporal regions for initial combinatorial processing (in particular, posterior middle temporal gyrus; pMTG), and left anterior temporal lobe (LATL) for aspects of semantic processing. Here we evaluate a minimal compositional scheme – the “red-boat” paradigm – using intracranial recordings to isolate the mapping of meaningful semantic representations. Patients (n=18) implanted with depth or subdural electrodes (n=3250) for the evaluation of medically refractory epilepsy were presented with auditory recordings of adjective-noun (“red boat”), pseudoword-noun (“zuik boat”) and adjective-pseudoword (“red neub”) phrases before being presented with a colored drawing (e.g. a red boat) and being asked to judge whether the phrase matched the object presented. We analyzed gamma (70-150Hz), beta (15-30Hz) and low frequency (2-15Hz) activity to index and contrast the engagement of cortical substrates. Significantly greater gamma activation occurred in temporo-parieto-occipital junction (TPO) and pMTG for pseudowords over words (300-700ms post-onset) in both first- and second-word positions. During the same temporal window exclusively after the second word, greater gamma activity was seen for pseudowords in pars triangularis, likely indexing a working memory buffer. We also found greater inter-trial phase coherence (8-12Hz) for real words than for pseudowords. Isolating phrase structure sensitivity, we identified a portion of TPO that showed increased gamma activity for phrases than for non-phrases. We found no portions of LATL that showed increased activity for meaningful phrases, in marked contrast to previous “red-boat” studies. Left superior temporal gyrus also did not show greater activity for meaningful phrases. However, lateral LATL displayed greater low frequency activity for phrases. Area 8aV, previously implicated in working memory, displayed greater low frequency activity for non-phrases. Lastly, previous work using scalp EEG has implicated the beta band in syntactic prediction, but little is known about the generation of this effect. According to a range of parsing models, adjective-noun syntax is constructed predictively. During the anticipatory window (-150–100ms at the second word after the presentation of a real word), ventral and mid-LATL display beta increases in preparation for generating syntactic or lexical content. As such, our intracranial data do not invoke involvement of superior temporal regions in phrasal sensitivity, only (pseudo-)lexical processing. Meanwhile, the LATL’s role seems restricted to lower frequency activity, likely coordinating distributed semantic representations cross-cortically. TPO (located slightly posterior to pMTG) appears to be a hub for minimal phrasal processing. Lastly, lexical information appeared to be encoded in alpha phase, with real words displaying greater inter-trial phase coherence than pseudowords.

Topic Areas: Syntax, Meaning: Combinatorial Semantics

Testing the automaticity of syntax using subliminal priming: A behavioral assessment in German language

Poster G4 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session G.

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INTRODUCTION. Previous research on the automaticity of initial syntactic structure building during sentence comprehension employed paradigms involving conscious processing (Friederici, 2011; Hahne & Friederici, 1999). In order to better understand the rapid nature of early phrase structure building, in the present behavioral study we addressed syntactic processing in the absence of conscious awareness. It has been argued that the automatic nature of early syntactic processes might be strongly connected to humans' predictive capacity to generate syntactic expectations upon the upcoming material (Lau et al., 2006). Following a recent study by Berkovitch and Dehaene (2019), we employed subliminal syntactic priming to test the connection between our predictive syntactic capacity and the automaticity of syntactic analysis. METHODS. We run three behavioral experiments — one pilot (N = 19) determining the adequate effect size, followed by two main experiments (N = 43, N = 40) — to explore the early influence of congruent primes (er "he", ein "a") on the processing of German verbs and nouns. Conscious perception of the primes was induced using unmasked syntactic priming, while unconscious perception was induced using subliminally presented masked primes. The first main experiment included nouns and verbs with the ending -t, which is part of the stem for nouns but an inflectional suffix for verbs. Given that numerous studies reported a rapid decomposition of morphologically complex words into the stem and affixes (Beyersmann et al., 2011; Beyersmann et al., 2016), to exclude a possible influence of the suffix "-t" on grammatical categorization, in the second experiment we only included nouns and verbs with various endings and eliminated overt inflectional morphology by using irregular past tense verbs. The (un)awareness of the primes was controlled in a prime visibility task in both studies. RESULTS. In the first main experiment, we found a strong prime × category interaction, which was independent of masking ($p < 0.001$), and which was further confirmed by a congruency effect in both masked and unmasked conditions. Thus, the pronoun facilitated the processing of verbs, whereas the determiner facilitated the processing of nouns even when syntactic context was not consciously perceived. The second main experiment confirmed the prime × category interaction, together with a main effect of category — pointing towards late processing mechanisms at work by irregular verbal forms without overt inflectional morphology. CONCLUSION. Overall, both experiments suggest that the pronoun and the determiner pre-activate an appropriate abstract syntactic category, facilitating the processing of upcoming nouns and verbs. The results indicate that abstract syntactic representations might be accessed unconsciously in an automatic fashion, thus providing empirical basis for future imaging studies focusing on the neural behavior of early structure building processing in the human brain. REFERENCES: Berkovitch & Dehaene, Cogn Psychol, 2019; Beyersmann et al., Psychon Bull Rev, 2011; Beyersmann et al., Psychon Bull Rev, 2016; Friederici, Physiol Rev, 2011; Hahne & Friederici, Journal of Cogn Neurosc, 1999; Lau et al., Brain and Language, 2006.

Topic Areas: Syntax, Reading

Bilateral neural representations underlie normal categorical speech perception in adults with dyslexia

Poster G5 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session G.

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Abnormal categorical perception of speech is one plausible explanation for the phonological deficit that often precedes and accompanies dyslexia. Abnormal categorical perception itself could be due to low-level auditory

processing deficits or to the cognitive demands of the tasks used to measure it, both of which have also been implicated in dyslexia. In this study, we aimed to control these factors by decoding the neural representation of a speech-sound continuum from patterns of brain activity evoked by passive listening and active categorization. We recorded magnetoencephalography (MEG) from adults with (n = 24) or without (n = 24) dyslexia who were exposed to 40 tokens each of 10 steps of an acoustic continuum ranging from ba to da, presented in pseudorandom order under two conditions. During the passive condition, participants performed a visual target detection task to maintain arousal but were told they could ignore the sounds. During the active condition, participants labeled each stimulus as either ba or da via counterbalanced and delayed button-press. We performed time-resolved and cross-validated classification of the MEG data using linear support vector machines. Classifiers were trained to distinguish both stimulus identity (pairwise) and stimulus label as applied by the participant (binary). Several findings favor the interpretation that categorical perception of a stop-consonant continuum is normal in adults with dyslexia. First, there were no significant behavioral differences in how the two groups categorized the stimuli. Second, the effect of condition on neural representations was similar and significant in both groups, with more sustained representation of stimulus identity in the active condition. Third, cluster analysis of neural dissimilarities in both conditions and in both groups revealed early representation of phoneme category followed by the emergence of higher-order “prototypical” and “ambiguous” categories. Fourth, the subjective ba vs. da labels were reliably decoded in both groups and with similar latencies, inconsistent with an account of bottlenecked access to phoneme representations in dyslexia. However, the control and dyslexia groups did differ in hemispheric contributions to perception: in the dyslexia group alone, the right hemisphere provided sufficient information to decode ba from da. Together, these results are consistent with prior work that identified intact and bilateral speech representations in adults with dyslexia. We extend that work to show that timely activation of bilateral representations supports normal performance on a ba-da categorization task.

Topic Areas: Speech Perception, Disorders: Developmental

Non-invasive peripheral nerve stimulation paired with speech sounds modulates pupillary responses and selectively enhances learning

Poster G6 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session G.

Jacie R. McHaney[1], William L. Schuerman[2], Matthew K. Leonard[2], Bharath Chandrasekaran[1]; [1]University of Pittsburgh, [2]University of California, San Francisco

Adults struggle when learning to categorize speech sounds that do not exist in their native language, but with sufficient training, listeners can learn to successfully categorize non-native speech sounds. Non-native speech category learning requires explicit attention to subtle acoustic cues. Mandarin Chinese tones contain syllable-level pitch contrasts not used in English and differ primarily along two acoustic dimensions: relative pitch and pitch change, where tones that primarily differ along the pitch change dimension tend to be more difficult for native English speakers to learn. Recent application of transcutaneous vagus nerve stimulation (tVNS) in humans enhanced Mandarin tone learning in native English speakers compared to those who did not receive tVNS (Llanos et al., in press). However, the exact mechanism for tVNS enhancement remains unclear. tVNS enhancement may occur through activation of the locus-coeruleus (LC) norepinephrine system, and pupillary responses have been shown to be an indirect index of LC system activation (Aston-Jones & Cohen, 2005). Thus, it is hypothesized that tVNS enhancement and pupillary responses share a common, underlying neural pathway (Joshi & Gold, 2020; Badran et al., 2018), which makes pupillometry an ideal metric for better understanding tVNS enhancement during non-native speech category learning. Forty-two native-English speakers with no prior tonal-language experience were randomly assigned to one of two tVNS conditions (n=21 per condition) in a pre-registered (osf.io/zw9m7) double-blind randomized control trial that paired sub-threshold tVNS with either easier- (tVNS-easy) or harder-to-learn (tVNS-hard) tone categories. Participants learned to categorize Mandarin tones over five blocks of training that consisted of 40 trials per block while pupillary responses to the speech stimuli were recorded. Behaviorally, the tVNS-hard condition had a greater trial-by-trial increase in accuracy

compared to the tVNS-easy condition (p=0.016), although overall average accuracy did not significantly differ between conditions (p=0.135). Changes in pupil diameter in response to the onset of Mandarin tone stimuli were modeled using a fourth-order polynomial mixed-effects growth curve analysis, which modeled the rate of pupil dilation (linear term) and distinct, functional forms of the change-in-rate of pupil dilation (quadratic, cubic, quartic terms) over-time. The growth curve analysis included fixed effects of tVNS condition (easy vs. hard) and training stage (early vs. late). Pupillary responses between early and late training were significantly different for both conditions (ps<0.001), however, the tVNS-hard condition demonstrated a larger decrease on the cubic (p=0.030) and quartic (p=0.032) terms from early to late training than the tVNS-easy condition. These results suggest that changes in speech-evoked pupillary dilation differed between early and late training and that this difference was greater in the tVNS-hard condition. In conclusion, the results from this study demonstrate that tVNS may selectively enhance the rate of learning, and decreases in pupillary responses to speech stimuli across training may reflect the ease of learning non-native speech categories when tVNS is paired with harder-to-learn categories.

Topic Areas: Speech Perception, Perception: Auditory

New Insights into Sentence Comprehension from a Condition-and-perturb TMS-EEG Study

Poster G7 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session G.

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Introduction: A large-scale network including the posterior inferior frontal gyrus (pIFG) and posterior superior temporal gyrus/sulcus (pSTG/STS) supports speech comprehension, a process that unfolds rapidly over time. Therefore, previous context information is used to make predictions about upcoming input. The event-related potential that is sensitive to fulfilled semantic predictions is the N400. Words that follow a less predictive (e.g. He sees the beer) relative to a highly predictive (e.g. He drinks the beer) context elicit a larger N400. Kroczek et al. (2019) recently combined electroencephalography (EEG) with transcranial magnetic stimulation (TMS) to investigate the role of the left pIFG and pSTG/STS in sentence comprehension. TMS applied at verb onset had short-lasting effects on the N400. The sentence final noun, however, showed no effect. The authors suggested that other areas of the semantic network might have compensated for the perturbation, in particular by the left angular gyrus (AG). The present study used a condition-and-perturb TMS-EEG approach to probe the contributions of the left pIFG and pSTG/STS after excitability in the left AG was temporarily reduced using continuous theta-burst stimulation (cTBS). We expected that the combined disruption of two semantic key nodes would significantly disrupt sentence comprehension. Methods: Healthy, native German speakers (n = 24) listened to short sentences (i.e., pronoun-verb-article-noun) that varied in their predictability of the final sentence noun (i.e. high vs low). Participants were instructed to perform a lexical decision task (i.e, word vs pseudoword). We applied cTBS at the left AG and triple-pulse TMS (10 Hz) at verb onset over either left pIFG, pSTG/STS, or sham. While participants listened to the sentences, EEG was measured. We were interested in two time-windows : one time-locked to the noun, another time-locked to the verb. Results: The effect of pSTG/STS TMS outlasted the stimulation duration at the verb and affected processing of highly predictable nouns, as indexed by changes in the N400 amplitude when compared to sham. We infer that conditioning AG with cTBS caused a dysfunction in this area, which increased the functional relevance of the left pSTG/STS for sentence-based semantic processing and sensitized the semantic network to the disruptive TMS effects. Despite these effects on electrophysiological level, however, stimulation did not impact behavioural measures. The ERP data of pIFG TMS is still under analysis. Conclusion: The functional significance of the left pSTG/STS within the semantic network depends on the functional integrity of the left AG. References: Kroczek, L. O., Gunter, T. C., Rysop, A. U., Friederici, A. D., & Hartwigsen, G. (2019). Contributions of left frontal and temporal cortex to sentence comprehension: Evidence from simultaneous TMS-EEG. Cortex, 115, 86-98.

Topic Areas: Speech Perception, Meaning: Lexical Semantics

Effects of acoustic similarity in the MMN response during L2 speech perception

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Second language (L2) phoneme perception initially takes place within the first language (L1) perceptual and acoustic frameworks (Best & Tyler, 2007; van Leussen & Escudero, 2015). The comparison between languages is usually defined as 'similarity' between the L1 and L2 sounds and is operationalized by measuring the phonetic or acoustic distance between the sounds of each language, often tested with discrimination tasks. This study focuses on the acoustic distance between Australian-English and Dutch vowels to examine how the perceptibility of non-native phonemes changes after a discrimination task aimed at highlighting easy (dissimilar) versus difficult (similar) contrasts. Monolingual Australian-English (AusE) speakers (N = 26) completed an experimental session consisting of (1) a pre-task EEG recording, (2) a discrimination task using a 4-interval forced choice (4IAX) paradigm, and (3) a post-task EEG recording. We measured the mismatch negativity (MMN) event-related potential response, which indexes sound discrimination during auditory stimuli presentation without requiring conscious attention, and has been used extensively for L2 perception (e.g., Diaz et al., 2016). The 4IAX discrimination task is thought to impose fewer demands on short-term memory and potentially leads to more continuous perception (as opposed to categorical) (Pisoni & Lazarus, 1974). Stimuli were four naturally-produced Dutch vowels from the Adank et al. (2004) corpus: /a/, /ɪ/, /i/, and /ɛ/, chosen for their degree of similarity to AusE vowels (Alispahic et al., 2017). The vowel /i/ was set as the 'standard' (or repeating) stimulus, whereas the other three vowels were 'deviant' (or infrequent) stimuli. The contrasts between the standard and each of the three deviants were classified as 'perceptually easy' (/i/-/ɛ/), 'perceptually difficult' (/i/-/ɪ/), or as a 'control' contrast (/i/-/a/) (see Tuninetti et al. 2019 for more details). We expected increased sensitivity (larger MMN amplitude) to the more difficult contrasts after the discrimination task, which required participants to pay attention to fine-grained acoustic details. Results showed that there were significant MMN responses to all stimuli before and after the 4IAX task (all p's < .001). There was also a significant main effect of time, $F(1, 25) = 11.03$, $p = .003$, $\eta p2 = .306$, with MMN amplitudes significantly less negative post-task (M = -2.72mV) compared to pre-task (M = -3.99mV). Importantly, there was an interaction between deviant and time, $F(2,50) = 5.77$, $p = .006$, $\eta p2 = .19$, with no difference in MMN amplitude between pre (-2.68mV) and post-task (-2.94mV) for the 'easy' deviant, while both the 'difficult' and the 'control' deviants had less negative MMN amplitudes post-task (Difficult-Pre: -4.76mV, Difficult-Post: -2.83mV; Control-Pre: -4.52mV, Control-Post: -2.38mV). Contrary to our prediction, MMN amplitudes were less negative after the discrimination task for the 'perceptually difficult' and the 'control' vowel contrasts, suggesting decreased sensitivity to the phonetic-acoustic information. The observed MMN amplitude reduction may be due to phonetic-acoustic properties specific to our stimuli as well as properties of the discrimination task itself, where the lack of feedback perhaps reinforced 'miscategorization' and/or the 4IAX design inhibited categorical perception. Further details will be discussed with the results' implications for current L2 speech learning models.

Topic Areas: Speech Perception, Multilingualism

Drifting pitch awareness after exposure to pitch-shifted auditory feedback

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Various studies have claimed that the sense of agency is based on a comparison between an internal estimate of an action's outcome and sensory feedback. With respect to speech, this presumes that speakers have a stable

pre-verbal representation of their own speech. However, recent research suggests that the sense of agency is flexible and thus in some contexts we may feel like we produced speech that was not actually produced by us. In non-speech motor control, participants can be made to feel like a rubber hand is part of their body, when their hand and the rubber hand move synchronously. This illusion is associated with a drift in the perceived location of one's own hand towards the location of the rubber hand. Here, we describe an analogous phenomenon in speech production: a drift in the perceived pitch of one's own vocalization. The current study tested how the perceived pitch of one's articulation (termed 'pitch awareness') is affected by manipulated auditory feedback, and if such manipulations can cause a drift in the speaker's awareness of their own pitch production. If self-monitoring is based on a comparison of feedback with a stable representation of the intended speech sound, pitch awareness should not rely on sensory feedback. Alternatively, if pitch awareness is also in part based on sensory feedback, our representation of pitch can be influenced by exposure to altered auditory feedback. Thirty participants produced single vowels in a pre-test, a training, and a post-test block. In the pre-test, participants received auditory feedback that was pitch-shifted by -150, -100, -60, -30, 0, +30, +60, +100, or +150 cents. After every vocalization, participants were asked in a two-alternative forced choice task whether they thought the feedback was higher or lower than their actual production. Subsequently, in the training block, participants were exposed to auditory feedback that was consistently pitch-shifted by +500 or -500 cents (between subjects), without any questions about the pitch shift. Finally, the post-test was the same as the pre-test block. The participants were more likely to label auditory feedback as "lower than my actual production" immediately after the training block with a constant +500 cents shift, suggesting that prolonged exposure to high-pitched auditory feedback led to a drift in participants' pitch awareness. The opposite pattern was found after a training block with a constant -500 cents pitch shift. This suggests that pitch awareness is not solely based on a preverbal representation of intended speech or on a sensory prediction, but also on sensory feedback. We propose that, as in the rubber hand paradigm, this drift in pitch awareness may be indicative of a sense of agency over the pitch-shifted auditory feedback in the training block. If so, this suggests that the sense of agency over vocal output is flexible, in line with previous studies. The current experiment also showed that prolonged exposure to pitch-shifted feedback led participants to align their pitch with the auditory feedback. This pitch alignment has previously been associated with a sense of agency over the auditory input.

Topic Areas: Speech Motor Control, Multisensory or Sensorimotor Integration

The contribution of phonological information to visual word recognition: Evidence from Chinese Phonetic Radicals

Poster G10 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session G.

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Lateralization is a critical characteristic of language production and also plays a role in visual word recognition. However, the neural mechanisms underlying the interactions between visual input and spoken word representations are still unclear. We investigated the contribution of sub-lexical phonological information in visual word processing by exploiting the fact that Chinese characters can contain phonetic radicals in either the left or right half of the character. FMRI data were collected while 39 Chinese participants read words in search for target color words. On the basis of whole-brain analysis and three laterality analyses of regions of interest, we argue that visual information from centrally presented Chinese characters is split in the fovea and projected to the contralateral visual cortex, from which phonological information can be extracted rapidly if the character contains a phonetic radical. Extra activation, suggestive of more effortful processing, is observed when the phonetic radical is situated in the left half of the character and therefore initially sent to the visual cortex in the right hemisphere that is less specialized for language processing. Our results are in line with the proposal that phonological information helps written word processing by means of top-down feedback.

Topic Areas: Reading, Phonology and Phonological Working Memory

Lexical parafoveal processing in natural reading predicts reading speed

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Presenter Note: Yali Pan, Y.Pan.1@bham.ac.uk (it's the number one, not the letter L) Any questions or suggestions are more than welcome :-)

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Introduction: Reading is a unique skill that separates human beings from other species. In spite of the reduced visual acuity, information can still be extracted parafoveally (2 to 5 degrees from current fixation). However, whether parafoveal information is extracted at the lexical level is unclear. This is the key dispute for eye-movement control models, as lexical processing guides when to move the eyes. Evidence from both eye-movement and electrophysiological studies has been equivocal. Methods: Here we show that lexical information can be obtained parafoveally, by combining eye-tracking, magnetoencephalography (MEG), and 'rapid frequency tagging' (RFT). In a silent reading task, target words of either low or high word frequency were tagged (flickered) at 60 Hz. Response to the invisible tagging during pre-target fixations reflected parafoveal processing for the upcoming target. Results: We found stronger pre-target tagging responses prior to saccade to low- compared with high-frequency targets, already detectable no later than 100ms following the onset of the first fixation on the pre-target word. Furthermore, differences in the magnitude of parafoveal lexical processing predicted individual reading speed. Conclusion: Our findings demonstrate that human reading unfolds in the fovea and parafovea in parallel to support fluent and flexible reading.

Topic Areas: Reading, Methods

Differences in the Functional Profile of the Ventral Occipitotemporal Cortex in Congenitally Blind and Sighted Readers

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Literate individuals develop a visual word form area/system in the ventral occipitotemporal cortex (vOTC) (Dehaene, 2010, Science). This visual word form system is left-lateralized and functionally heterogeneous, with a progressively changing preference from simple visual features to larger orthographic structures from posterior to middle and anterior portions of vOTC (Vinckier, 2007, Neuron). The vOTC is also active when blind individuals read Braille by touch (Reich, 2011, Curr Bio). The functional profile of the vOTC in Braille reading blind individuals is not known. 19 congenitally blind individuals and 15 sighted controls participated in an fMRI experiment of written and spoken word recognition. Blind participants performed a memory probe task with three tactile conditions (Braille words/consonant strings/tactile shapes) and two auditory conditions (spoken words and backwards speech). Sighted participants performed an analogous task in which tactile conditions were replaced with visual reading (visual words, visual consonant strings and false fonts). The vOTC showed different response profiles across blind Braille readers and sighted readers of print. In the sighted group, the functional profile of left vOTC was heterogeneous along the anterior to posterior gradient, with increasingly abstract and amodal responses anteriorly. The most anterior portions of vOTC responded more to visual words and consonant strings than false fonts, the medial portions responded more to consonant strings than either visual words or false fonts and the posterior regions responded equally high to all written visual conditions. In blind participants, responses were homogenous along vOTC, always preferring words over lower-level stimuli (Braille words > consonant strings > tactile shapes). Additionally, sighted but not blind participants showed an anterior to posterior gradient in modality-specificity. In the sighted group, anterior vOTC responded equally to auditory and written words, medial vOTC responded more to visual than auditory stimuli but responded more to

auditory words than backwards speech. The most posterior portion of vOTC in the sighted was deactivated below rest for the auditory conditions and did not distinguish between spoken words and backwards speech. In the blind group, all of vOTC responded more to auditory words than backwards speech, but still more to tactile words than any auditory stimuli. Lastly, responses to visual words and consonant strings in vOTC of sighted participants were left-lateralized, while in blind participants, responses to Braille word were bilateral. The results suggest that there is more sub-specialization for written and spoken material within the vOTC of sighted than blind readers. Additionally, in the sighted group, a preference for consonant strings was observed in sub-regions of vOTC, inferior frontal and parietal cortices. By contrast, all parts of the reading network preferred words in the blind group. This pattern may reflect differences in the cognitive mechanisms involved in reading tactile Braille versus visual print. Together, this evidence suggests that sighted readers of print and blind readers of Braille develop partially distinct neural systems for reading.

Topic Areas: Reading, Multisensory or Sensorimotor Integration

Spatiotemporal dynamics of neural processing for reading aloud

Poster G13 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session G.

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Dual stream theories of reading are the most credible models of the neural architecture that enables mapping of word orthography to its pronunciation. These models, primarily derived from lesion data, propose a lexico-semantic stream for direct lexical access and a phonological stream for grapheme-to-phoneme conversion. Lesion studies reveal the crucial roles of each route independent of each other but it is unclear how they actually interact in the healthy brain. The lack of temporal resolution in functional imaging and lesional studies has led to an incomplete understanding of the dynamics and interactions of the phonological and lexical streams of reading. We used direct cortical recordings in 40 patients undergoing implantation of intracranial electrodes for epilepsy localization, to create a spatiotemporal map of reading aloud. Each patient read aloud (a) regular words, (b) exception words and (c) pseudowords. Broadband gamma activity (70-150Hz) from electrodes across the left hemisphere (n>3200) was used to index local neural processing. We found that: (i) Response times for regular and exception words were significantly modulated by word frequency, while pseudoword response times were most strongly modulated by orthographic neighbourhood. (ii) Direct contrasts of regular words vs. pseudowords revealed distinctions in mid-fusiform cortex (mFus), anterior inferior frontal gyrus (aIFG) and inferior parietal sulcus (IPS) prior to articulation. Consistent with our prior work, mFus was the earliest region to show sensitivity to lexicality. (iii) mFus and aIFG were both sensitive to frequency of real words and aIFG was also sensitive to the orthographic neighbourhood of pseudowords. IPS was sensitive to orthographic neighbourhood of pseudowords and also regular words with a longer response time. This sensitivity to orthographic neighbourhood was observed later than the lexicality distinction in mFus. (iv) Utilising logistic regression neural decoding, we attained high single trial decoding accuracy between words and pseudowords within the first 500 ms following stimulus presentation. Model coefficients highly weighted activity from mFus and aIFG. By contrast, the model was ineffective at decoding between regular and exception words. In conclusion, we find a strong, early lexicality distinction during reading between known and novel words, with this effect progressing from mFus to aIFG. Later, the phonological route, via IPS, demonstrates sensitivity to orthographic neighbourhood of novel words. The lack of distinction between regular and exception words in any of our analyses suggests that, in the healthy brain, known words are processed preferentially through the lexical route, with little distinction made based on atypical phonological mappings. Temporal neural decoding enables the tracking of task-relevant information across the cortex without imposing prior assumptions about the data and can give insight into features that distinguish linguistic classes.

Topic Areas: Reading, Phonology and Phonological Working Memory

Expressive prosody in the semantic variant of primary progressive aphasia: understanding the role of the anterior temporal lobes

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Introduction: Prosody has historically been associated with right hemisphere brain regions, but recent knowledge points to a bilateral fronto-temporal network with a relative right dominance. However, its inter- and intra-hemispheric brain correlates are still largely debated. Semantic variant of primary progressive aphasia (svPPA), a syndrome characterized by focal anterior temporal degeneration (which may have a left or right predominance), appears as an interesting model to better understand the neural underpinnings of expressive prosody. Therefore, the aims of this study were to compare expressive prosodic abilities in svPPA patients with left or right predominance (svPPA-l, svPPA-r) and to investigate the relationship between prosody and gray matter volume in the temporal lobes. Methods: 27 svPPA-l, 19 svPPA-r and 22 cognitively normal controls (matched on age, sex, education, disease severity, disease duration) participated in this study. The lateralization of svPPA patients was defined using the clinical diagnosis as well as an objective left and right anterior temporal lobe atrophy ratio criterion. All participants completed the description of the Picnic picture (Western Aphasia Battery). We automatically extracted fundamental frequency (f0, an acoustic feature that is closely related to perceived pitch) from their speech sample using Praat. Based on previous studies, we computed a measure of its variation across the speech sample (f0 range on a logarithmic scale (semitone; ST) that controls for individual and sex differences). We compared f0 range in the three groups using a Kruskal-Wallis test and investigated its correlation with brain gray matter volume using voxel-based morphometry on the MRI T1 images (controlling for age, sex, total intracranial volume, handedness and scanner type). Results: f0 range was significantly smaller in svPPA-r, in comparison to both svPPA-l and controls (f0 range = 5.1 ± 1.8 ST in svPPA-r vs. 7.0 ± 3.0 ST in svPPA-l and 6.7 ± 2.3 ST in controls; $p \leq 0.005$). There was no significant difference between svPPA-l and controls. The VBM analysis revealed that f0 range was significantly and positively correlated to gray matter volume in the right anterior middle temporal gyrus ($x = 54$; $y = -28$; $z = -10$; pFDR-corr ≤ 0.05). Conclusion: Our results show that while prosody production is preserved in svPPA-l patients, it is overall limited in svPPA-r patients. They also highlight the role of the right anterior middle temporal regions in expressive prosody. This study suggests that automatic measurement of prosody may be a useful clinical biomarker to distinguish these two variants of svPPA. Moreover, an impaired prosody may alter communication in svPPA-r and be associated with their socio-emotional and behavioral changes.

Topic Areas: Prosody, Disorders: Acquired

Instantaneous processing of speech prosody conveying different communicative actions: neurophysiological evidence

Poster G15 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session G.

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During conversations, the speaker’s communicative intentions are often understandable solely by the power of the voice, namely intonation. Rising vocal pitch tone at the end of a sentence typically acts as a cue for the recognition of question types, as opposed to falling pitch used for statements. Little is known about the brain correlates underlying such prosodic markers affecting the meaning of the speaker´s linguistic action. Here, we show that, already ~100 ms after the critical word differing in intonation brain responses diverged between question and statement functions expressed with the same spoken sentence. To control for the effect of acoustic features, we also presented low-pass filtered speech signals and non-linguistic sounds obtained by mimicking the F0 frequency contours of ‘question’ and ‘statement sentences’ by a single-pitch tone. These low-pass and sound control conditions did not show any neurophysiological dissociations comparable to the speech acts differing in prosody, thus arguing against an effect of the difference in physical intonation. The early enhancement of question-related brain activity relative to that produced by statements was due to sources in the articulatory motor and inferior frontal cortex, including Broca´s region, along with parietal activation. This motor system activation may carry information about action knowledge immanent to questions, in particular the commitment regarding expectations of the partner action of answering the question. As different types of directive speech acts are characterized by such motor system activation indicative of expectations of partner actions, these results appear consistent with a grouping of questions into the larger category of directives. The present findings demonstrate the crucial role of prosody for the rapid understanding of linguistic actions and their communicative roles.

Topic Areas: Prosody, Meaning: Discourse and Pragmatics

An investigation of Phonological Awareness Using Eye Tracking

Poster G16 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session G.

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Phonological Awareness skills are positively associated with reading and literacy skills in children (Holm, Farrier, & Dodd, 2008; Melby-Lervåg, Lyster, & Hulme, 2012). In a follow-up investigation to a behavioral study conducted on first grade Emirati children (Marquis, 2016-2018), three phonological conditions were explored experimentally on Emirati adults while their eye movements were tracked via a visual world paradigm adaptation of the same task. The phonological task conditions were 1. Onset Consonant Matching with explicit instructions (OCM) 2. Segmentation of Initial Consonant/Phoneme with implicit instructions (SIC) and 3. Rhyme Matching (RM). The stimuli used were images of familiar Emirati target nouns which were selected from the Emirati Arabic Language Acquisition Corpus (EMALAC, Ntelitheos & Idrissi, 2017). There were 4 target phonemes per phonological condition, and each phoneme appeared in three separate trials, resulting in a total of 12 experimental trials per condition; yielding 48 trials in total. In addition, four practice trials were included at the beginning of each task to familiarize participants with the experiment. Each trial consisted of a display containing the target noun image and three distractors, which was preceded by the introduction of character on the screen whose name served as a probe for the target phoneme. We hypothesized that eye movements reflect the different phonological conditions, where rhyme matching, a vowel-based manipulation, should show the least efficient fixation patterns. We also hypothesized that performance on the explicit task instructions would be superior to the implicit instructions task. Furthermore, half the participants received feedback on their responses during practice trials. Results showed that performance was significantly hindered in the rhyming task, where participants made more fixations towards the target of longer average durations as compared to the two consonant tasks. Accuracy on the task was also significantly reduced for the RM task. No further differences within the two consonant task conditions were found, and there was no overall effect of administering feedback. These results confirm that gaze patterns differ according to the different phonological conditions. Unlike children, adults do not experience detriment to performance when task instructions are implicit, and neither is performance affected by the absence of feedback.

Topic Areas: Phonology and Phonological Working Memory, Perception: Speech Perception and Audiovisual Integration

Sensitivity of high-level language processing brain regions to phonological information

Poster G17 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session G.

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A set of brain regions on the lateral surfaces of left frontal, temporal, and parietal cortices support high-level language processing. They show robust responses to the processing of individual word meanings, as well as to combinatorial semantic and syntactic processing. This 'core language network' has been argued to store our linguistic knowledge representations. However, aside from knowledge of words and how words combine to form phrases and sentences, our linguistic knowledge also includes information about sounds and how sounds combine to form syllables and words. Is this sub-lexical information also represented in these 'high-level' language regions? Indeed, according to usage-based accounts of language, no sharp boundary is drawn between sub-lexical, lexical, and supra-lexical representations and processes. Here, across 3 fMRI experiments, we investigated sensitivity of high-level language processing brain regions to sub-lexical phonological structure. In Experiment 1 (n=467), we establish strong responses to pseudowords relative to baseline, in a subset of the language regions. In Experiment 2 (n=16), we find robust sensitivity to phonotactic regularities with progressively stronger responses elicited by pseudowords that obey the sound-combinatorial constraints of English, in English speaking participants. Finally, in Experiment 3 (n=14), we rule out the possibility that the responses in Experiments 1 and 2 are due to the activation of real words that may share some phonology with the pseudowords, by showing similarly strong responses to pseudowords with low vs. high neighborhood densities. The results suggest that phonotactic knowledge is part of the linguistic knowledge that is stored within the fronto-temporal language network, and that the very same regions that are sensitive to lexical and combinatorial semantic/syntactic processes are also sensitive to sub-lexical-level information.

Topic Areas: Phonology and Phonological Working Memory, Meaning: Lexical Semantics

Neural correlates of embodied L2 learning

Poster G18 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session G.

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Within the framework of embodied semantics, the overlap between sensorimotor and language processes could have important implications for second language (L2) acquisition. Neurolinguistic studies have established motor-language interactions and behavioral studies have shown that coupling word encoding with corresponding, relevant gestures enhances linguistic retention and language learning. The present study explored these aspects of language processing and acquisition, using virtual reality (VR), to investigate how performing naturalistic actions during the learning of L2 action verbs may enhance mapping between word form and meaning. We examined whether "embodied learning", or learning that occurs using specific physical movements that are coherent with the meaning of new words, creates linguistic representations that produce greater motor resonance (activity in the motor cortex), due possibly to stronger and more specific motor traces, compared to a control condition. In addition, we investigated whether embodied learning leads to better retention; indeed the implication of both linguistic and motor areas should lead to a more complete semantic representation and increased learning. Training took place over two days using auditory verbs and a VR oculus headset and hand controller. Native French speakers learned the same set of 12 verbs in Serbian, in either the "embodied learning" or the control condition. Words were presented with the correct visual action three times during the first day of learning and twice during the second day. In both conditions, participants heard the verb,

repeated it, and then saw the corresponding action on a virtual CRT screen. The “embodied learning” group learned the action verbs using specific movements to manipulate objects for each verb; the control group simply pointed to the virtual objects. Both pre and post training, time-frequency analysis were carried out on the EEG data to measure mu and beta suppression, associated with motor activation, while participants passively listened to the new verbs. EEG and behavioral accuracy were also used to assess learning in an audio-visual match-mismatch task. Preliminary analysis on the “embodied learning” group showed no ERP differences between conditions in the match-mismatch task pre-training. Post-training, participants showed greater N400 amplitude for mismatch versus match trials. These results were corroborated by behavioral measures. Time-frequency analysis is expected to show greater motor resonance during passive listening of new verbs post-training compared to pre-training in both the “embodied learning” and the control group. Further analysis will be carried out to compare the two groups both as regards motor resonance during passive verb listening and the N400 effect for match versus mismatch trials post-training. Behavioral learning results will also be compared between the two groups. We expect that the “embodied learning” group will show greater motor activation during verb processing post-training compared to the control group, and that this will correlate with improved learning as indexed by a greater N400 effect and improved behavioral results compared to the control condition. This pattern would suggest that embodied learning adds a motor trace to lexical items, which would support theories of embodied semantics.

Topic Areas: Multisensory or Sensorimotor Integration, Meaning: Lexical Semantics

Sensitivity of elicited speech tasks to the cognitive side effects of immediate- vs extended-release tacrolimus (Envarsus® XR) -based immunosuppression regimens in kidney transplant recipients

Poster G19 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session G.

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Variants of the picture description task (Goodglass & Kaplan, 1983) have been used extensively in the literatures on aphasia (Basso et al., 1990), second language proficiency (Robinson et al., 1995), and the diagnosis and categorization of various disease states (Forbes-McKay et al., 2005). The goal of the current work was to determine whether elicited speech tasks such as picture description are sufficiently sensitive to distinguish between the side effects associated with different formulations of a (potentially) cognition-impairing drug. If so, this would suggest that elicited speech tasks would be of great utility both in the literature on drug-related cognitive side effects and in clinical settings. Six kidney transplant patients (between 4 and 38 months post-transplant), on immediate release (IR) tacrolimus regimens completed all sessions of the study protocol. Upon providing informed consent and enrolling in the study, a subset of patients remained on tacrolimus (IR group; n = 3) while the remaining patients were switched to Envarus XR® under doctor’s supervision (XR group, n = 3). Patients completed a total of 5 visits: a practice visit no earlier than 3 months post-transplant, a baseline visit at which randomization occurred no earlier than 4 months post-transplant, and at 6, 12, and 24 months post-baseline. At each visit, patients completed a neuropsychological battery containing tests of generative semantic/phonemic (COWA) fluency, psychomotor speed and visual information processing (Trails A; Lezak, 1985), cognitive control and task-set maintenance (Trails B; Lezak, 1985), motor control and sustained attention (SDMT; Smith, 1982), and maintenance and manipulation of information in working memory (forward and backward digit span; Wechsler, 2014). Manual and computerized psycholinguistic assessment including both simple word counts (total words minus repetitions and disfluencies) and lexical density (adjectives + nouns + adverbs + verbs/total words) measures were calculated on spontaneous speech samples recorded while subjects performed the Trier (Kirschbaum et al., 1993) and picture description (Goodglass and Kaplan, 1983) tasks. Though there were insufficient data to track changes in cognitive/linguistic function over time across visits, it was possible to conduct cross-group comparisons across XR and IR groups. Due to insufficient data points, missing data, and statistical outliers, constructing full linear mixed effects models was deemed inappropriate; non-parametric two-tailed t-tests on independent samples were instead conducted to compare the performance of IR and XR groups. Results revealed no significant differences between groups on traditional neuropsychological assessments. In contrast, analyses of both picture description and Trier task results showed XR over IR advantages: the XR group produced numerically more total words ($.05 < p < .10$) and the group's speech was overall significantly more lexically dense (both $p < .03$). Our results suggest that measures of elicited speech such as those employed here may be sufficiently sensitive to distinguish between the cognitive side effects associated with two formulations of the same drug. Moreover, this sensitivity seems to outstrip that of the traditional pencil-and-paper neuropsychological assessments often used to assess these effects. As such, these data suggest potential new applications for elicited speech tasks in both research and clinical settings.

Topic Areas: Methods, Disorders: Acquired

Functional and structural biomarkers of cognitive outcomes after brain tumor resection

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Presenter Note: For more information you can contact me in: me.garcia@bcbl.eu

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Diffuse low-grade glioma (DLGG) is a primary brain tumor that affects an individual's cognitive faculties. The slow growth of this type of lesion allows the brain to reorganize its structure and functions, delaying the onset of cognitive symptoms. Nevertheless, DLGG unavoidably evolves to become a more invasive type of tumor, at the expense of both survival and the prognosis for healthy cognitive function. Surgical resection of these tumors can unintentionally damage the neural substrates of critical cognitive functions, as DLGG frequently invades putative areas of language, motor, visuospatial, or memory functions. By applying machine learning algorithms to a compendium of clinical, behavioral, and neuro-anatomical feature sets from a sample of 17 individuals with DLGG, we aimed to identify behavioral and structural biomarkers that predict an individual patient's postsurgical cognitive outcomes (i.e., language, working memory, cognitive control, and overall cognitive status). Specifically, we contrasted the predictive performance of different models to classify cognitive outcomes when trained on one or more of the above mentioned feature sets. Our results indicated that a subset of features from clinical, behavioral and structural imaging measures better predicted patient's prognosis over features from each separate measure. Moreover, Logistic Regression classification yielded the highest performance when predicting overall cognitive status and working memory outcomes. This study provides a proof-of-concept for classifying patient's cognitive prognosis. Further development of these kinds of tools are essential for both clinicians and patients, as they can aid in planning surgeries and promote longer life expectancy and better quality of life for patients. Keywords: glioma, resection, postoperative outcome, prediction, neuropsychological test

Topic Areas: Methods, Development

Distinct neurocognitive effects of compositional vs. conceptual semantic violations

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Veena D. Dwivedi[1], Janahan Selvanayagam[2]; [1]Brock University, [2]Western University

We used event-related brain potentials (ERPs) in order to investigate the effects of 'double violations' (Hagoort, 2003) in single sentences. Specifically, we were interested in the modulation of the N400 ERP component when it was elicited by sentences exhibiting both compositional and conceptual semantic anomalies. That is, demonstrative determiners such as "that" were used with object nouns (which were either congruent or incongruent with sentence-internal context) in the absence of a previous context of utterance (i.e., resulting in

presuppositional violation). In this 2x2 study, 33 participants read sentences manipulated by object type (congruent vs. incongruent) and object determiner type (definite vs. demonstrative). Thus, sentences were of the following form (i) The connoisseur tasted the wine on the tour vs. (ii) The connoisseur tasted the #roof… and (iii) The connoisseur tasted *that wine … vs. (iv) The connoisseur tasted *that #roof… We expected that ERPs at incongruent (#roof) vs. congruent objects (wine) would elicit N400 effects. The 'double violation' condition (iv)… *that #roof , exhibiting both compositional and conceptual semantic violations, revealed an attenuated N400 effect (the opposite of a 'syntactic boost' as found in Hagoort, 2003). Interestingly, this attenuated component was preceded by a P200 effect, indicating that contextual information is processed at early stages post-stimulus onset. In addition, the P200 effect followed by the N400 effect is further empirical evidence of differential sensitivity to compositional vs. conceptual semantic (also known as algorithmic vs. heuristic) sentence anomaly (cf Dwivedi, 1996; Dwivedi et al., 2006; Dwivedi, 2013).

Topic Areas: Meaning: Combinatorial Semantics, Meaning: Lexical Semantics

Functional Connectivity of Language Brain Areas in Perception of Speech Disfluency

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Ekaterina Pechenkova[1], Roza Vlasova[2], Yana Panikratova[3], Alena Rumshiskaya[4], Irina Lebedeva[3], Katerina Smirnova[5], Nikolay Korotaev[6], Olga Fedorova[5], Valentin Sinitsyn[7]; [1]HSE University, [2]University of North Carolina at Chapel Hill, [3]Mental Health Research Center, [4]City Clinical Hospital named after I.V. Davydovsky, [5]Lomonosov Moscow State University, [6]Russian State University for the Humanities, [7]Medical Research and Education Center of Lomonosov Moscow State University

Speech disfluencies are an important part of natural discourse which plays a role in controlling communication flow, e.g., by mediating turn-taking decisions in the conversation. While neural underpininngs of the fluent speech are widely covered by neuroimaging research, only few attempts to describe the brain mechanisms of the speech disfluency production and comprehension have been made so far (Kircher et al., 2004; Eklund and Ingvar, 2016; Smirnova et al., 2020). The present fMRI study continues the previous work with a focus on functional connectivity when listeners encounter disfluencies compared to a fluent speech baseline. Imaging was performed with the 3T Philips Ingenia scanner. During the functional scanning, the right-handed native speakers of Russian were presented with the spoken fragments of the discussion of the "Pear Film" (The "Russian Pear Chats and Stories" corpus RUPEX; Kibrik and Fedorova, 2018) which contained 154 annotated speech disfluencies of several types (silent pauses, filled pauses, lengthenings, self-repairs, or breaks, and other), either isolated or clustered (i.e., several disfluencies in close temporal proximity). To distract participants' attention from the disfluencies, we asked them to perform a referential task (i.e., at the certain moments marked by a red frame appearing on the screen, the participants were to decide which film character was referred to by the pronoun 'he' just uttered by the speaker, and to respond by a button press). Three functional localizers for language areas were also administered (picture-aided verb generation, reading sentences and listening to speech vs. reversed speech). For a task-based functional connectivity analysis, each disfluency type as well as fluent speech was modelled as a condition in an event-related design. 21 language ROIs were constructed individually for each participant by including voxels activated by at least one functional localizer and falling within the scope of one of the anatomical labels from the Harvard-Oxford selected on the basis of the meta-analysis of the brain areas involved in sentence comprehension (Walenski et al., 2019). Data collection is in progress (with data of 30 out of 40 participants already acquired). The preliminary results (connection-level, $p < 0.005$ uncorrected) reveal connectivity alterations for disfluencies of different type which most frequently included the decreasing connectivity between the middle temporal gyrus and the posterior temporal fusiform cortex of the left hemisphere (for the filled pauses, miscellaneous isolated disfluencies and clusters combining filled pauses and lengthenings) and the increasing connectivity of the right posterior superior temporal gyrus (with the right posterior middle temporal gyrus for the silent pauses; with the left lateral occipital cortex for self-repairs; with the temporal pole for the clusters comprised by the filled pauses and self-repairs). Therefore we expect that the final dataset might dempnstrate that speech disfluencies (vs. fluent speech) are associated with weaker connectivity between the left-sided language areas and stronger connectivity of the right-sided language areas or language area homologues. This is consistent with the evidence that prosody and paralinguistics aspects of speech processing, of which speech disfluencies are the part, are more associated with right hemisphere (Lindell, 2006).

Topic Areas: Speech Perception, Perception: Auditory

Neural networks for attention to speech: Mapping distributed and selective attention onto the brain

Poster G23 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session G.

Galit Agmon[1], Paz Har-Shai Yahav[1], Michal Ben-Shachar[1], Elana Zion Golumbic[1]; [1]Bar Ilan University

Focusing on one speaker in a noisy environment and distributing attention among multiple speakers, are both critical abilities for successful daily communication. These two abilities presumably harness different cognitive mechanisms, although their precise neural nature is yet unknown. In this study we distinguish shared neural substrates from regions that are differentially involved in selective versus distributed attention to speech, using fMRI. 35 participants listened to continuous speech from several concurrent speakers while their brain was scanned, and had to respond to a target word that was spoken either by any of the speakers ("distributed attention"), or by a designated speaker ("selective attention"), in a block design setting (12s on, 10s off). We manipulated the acoustic and cognitive load of both tasks by using 1, 2 or 4 concurrent speakers in each experimental block. Results indicate that both types of attention largely activate a similar array of fronto-parietal-temporal brain regions. This network of auditory attention to speech included bilateral responses in sensory areas (STG and STS), the insulas, IFG and SMA, as well as the right MFG and right medial cingulate. A functional connectivity analysis complements this observation, as pairwise connectivity between regions within this network was similar for both Attention Types. Despite the high overlap in the brain regions activated by both Attention Types (vs. Baseline), the magnitude of the responses in several areas was nonetheless modulated by Attention Type (Selective vs. Distributed) and by the interaction between Attention×Number of Speakers. Responses in bilateral STS/STG were stronger in the Distributed condition whereas the right MFG and the left IPS showed enhanced responses during Selective Attention. The STG/STS, bilaterally, were also sensitive to the Number of Speakers regardless of the Attention Type required. Bilateral insulas, areas that are traditionally linked to language processing, showed an interaction between Attention Type and Number of Speakers, stemming from a stronger effect of Number of Speakers under the Distributed Attention condition. Overall, these results nicely demonstrate the relationship between sensory auditory regions and higher-order fronto-parietal regions involved in attentional control and language processing during attention to speech. Moreover, they shed light on the manner in which activity within these areas is affected by employing different listening strategies for prioritizing among concurrent speakers.

Topic Areas: Perception: Auditory, Speech Perception

An ERP Study on Picture Naming in Late Language Learners: The Role of Gender Congruency and Cognate Status

Poster G24 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session G.

Presenter Note: Thank you for your interest in this poster! For any comments or feedback, do not hesitate to contact me! My email address is: s.von.grebmer.zu.wolfsthurn@hum.leidenuniv.nl Hoping to hear from you!

Sarah von Grebmer zu Wolfsthurn[1,2], Leticia Pablos Robles[1,2], Niels O. Schiller[1,2]; [1]Leiden University, [2]Leiden Institute for Brain and Cognition

Cross-linguistic interference (CLI) represents a persistent struggle for bilingual speakers, but especially for late language learners in early acquisition stages. The focus of the current study is on CLI in German late learners of

Spanish. More specifically, we investigate CLI of the grammatical gender systems, which is reflected in the gender-congruency effect (Klassen, 2016). Further, we explore CLI of the phonological systems, reflected in the cognate facilitation effect (Costa, Caramazza & Sebastián-Gallés, 2000) in German-Spanish speakers. Previous research showed that congruent nouns are processed faster than incongruent nouns. For example, the noun "throne", el trono and der Thron is masculine in German and Spanish and is processed faster compared to the noun "duck", el pato and die Ente which has different gender values in German and Spanish. Likewise, cognates were shown to be subject to a similar processing advantage compared to non-cognates. However, it is unclear whether both the gender-congruency effect and the cognate facilitation effect exert a modulating influence in language production in late language learners. In addition, there is little research on CLI in late language learners, in particular on the neural correlates of CLI during picture naming. In the present study, we manipulated gender-congruency and cognate status in a picture naming task. We examined their modulating effects in a population of native German speakers with a B1/B2 level of Spanish and low previous exposure to Spanish. We conducted a picture naming paradigm in Spanish while participants' EEG was recorded. We were particularly interested in N200 amplitudes as an index for response inhibition (Rodriguez-Fornells et al., 2006, Zhang & Yang, 2007); especially during trials where we predicted a response conflict such as in incongruent trials and in non-cognate trials. Further, we measured picture naming accuracy rates and naming latencies. We predicted higher accuracy rates and shorter naming latencies for congruent and cognate nouns. This would reflect CLI at the level of the grammatical gender, but also at the phonological level. In addition, we expected an N200 effect for incongruent and non-cognate trials as a result of response interference from German with Spanish while naming the pictures in the non-native language Spanish. Preliminary behavioural results support our initial hypothesis. They support the notion of CLI in late language learners at the grammatical and phonological level. The EEG/ERP data are currently being analysed. These results are highly relevant not only for the conceptualisation of CLI in late language learners, but also for quantifying the respective influence of gender congruency and cognate status while naming objects in a foreign language. Finally, these results allow us to make inferences about the organisation of the languages at the neurocognitive level.

Topic Areas: Multilingualism, Language Production

Learning and consolidation of morphologically derived words in a novel language: Evidence from Hebrew speakers

Poster G25 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session G.

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Upasana Nathaniel[1], Stav Eidelsztein[2], Bracha Nir[2], Brianna L. Yamasaki[3], Vedran Dronjic[4], Marisa N. Lytle[3], James R. Booth[3], Tali Bitan[1,5]; [1]Department of Psychology, IIPDM, University of Haifa, [2]Department of Communication Sciences and Disorders, University of Haifa, [3]Department of Psychology and Human Development, Vanderbilt University, [4]Department of English, Northern Arizona University, [5]Department of Speech Pathology, University of Toronto

Previous studies on second language learning have pointed to the active role of morphological decomposition (the ability to decompose complex words into their constituent morphemes, e.g., un-learn-able) to flexibly use and efficiently understand a language. An adaptation of the Complementary Learning Systems theory (McClelland et al., 1995) to language (Davis & Gaskell, 2009), suggests that novel words are initially encoded within the hippocampal system (as episodic memories), and are later consolidated and supported by neocortical structures (forming semantic memories). During memory consolidation repeated aspects of discrete events, are extracted to form regularities and induce generalization (Lewis & Durrant, 2011). The current study examines the role of decomposition in the early stages of learning and consolidation of morphologically derived words in a novel language. We predict that morphologically complex words, which can be decomposed and generalized, will be learned and consolidated faster than morphologically simple words, and will show more reliance on neocortical regions, and independence from hippocampal areas, in earlier stages of acquisition. We also examine the role of prior knowledge on learning and consolidation of morphologically complex words. Our participants' native language, Hebrew, is morphologically rich with prominent nonlinear derivations (consonantal root interleaved with a vowel pattern), alongside linear derivations. By comparing results of Hebrew speakers to a sample of English speakers (presented as a separate abstract), we will examine the hypothesis that Hebrew speakers' experience with nonlinear morphology will facilitate their learning and consolidation of nonlinear words as compared to English speakers. Finally, we will also examine whether individual differences in morphological and phonological abilities in Hebrew predict better learning and consolidation of novel words. 25 native Hebrew speakers (20-35 years) are being recruited and trained across 4 sessions on an artificial language, which includes 72 nouns from three morphological conditions: Complex-nonlinear (e.g., gulbaki = "fisherman"; g-l-b-k = "fish"), Complex-linear (e.g., zomgine = "birdwatcher"; zomg = "bird"), and a Simple condition related semantically but not morphologically (bunkut = "shoemaker" & gosdif = "sole"). In the first and last sessions, training is followed by testing in an MRI scanner. In the last session, participants are also tested on their ability to generalize learning. Preliminary behavioural results (n = 7) show better overall learning in the complex-linear condition, with a faster learning rate and greater generalization. Offline consolidation was only evident for the complex-nonlinear condition (2.4% reduction in reaction time). Neuroimaging results (n = 5) show activations in the fronto-temporal language areas. Morphologically complex words activated semantic middle temporal areas more than simple words. In summary, preliminary results are consistent with our first prediction, that morphologically complex words are better learnt and generalized. Predictions regarding the effects of prior knowledge can only be tested with collection of more data from the two samples, as well as examining correlations with screening measures within the Hebrew speakers.

Topic Areas: Morphology, Multilingualism

Learning and consolidation of morphologically derived words in a novel language: Evidence from English speakers

Poster G26 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session G.

Presenter Note: Thank you for your interest in our work, if you have any questions or comments about the research please feel free to reach out: brianna.l.yamasaki@vanderbilt.edu.

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According to the Complementary Learning Systems (CLS) theory (McClelland et al., 1995), new knowledge is initially encoded within the hippocampal system and then, over time, consolidated into long-term memory within neocortical structures. Information that is novel or inconsistent with prior knowledge is slowly integrated into long-term memory, whereas information that is consistent with prior knowledge is rapidly consolidated (McClelland, 2013; McClelland et al., 2020). Recently, this domain-general model of learning was extended to word learning contexts (Davis & Gaskell, 2009). While previous research has provided general support for the CLS model of word learning, relatively little work has explored the role of prior knowledge. The aim of the current study is to investigate whether prior knowledge, in the form of known morphological structures, contributes to word learning. It is predicted that, consistent with the CLS theory, English speakers will more rapidly learn and consolidate words composed of morphological structures present in English. Twenty-five native English speakers (18-35 years old) will be recruited for this study. Across four days, participants will be trained and tested on an artificial language comprised of 72 words from three conditions: (1) complex-linear, composed of words with a continuous morphological structure (similar to English morphology), (2) complex-nonlinear, composed of words with a discontinuous morphological structure (dissimilar to English morphology), and (3) simple, composed of words with a morphologically simple structure. Participants will be auditorily presented with each word and trained and tested through a translation task in which they are asked to select the correct English translation from four alternatives. At the end of training, participants will be tested on a set of untrained words. Additionally, following the first and last training sessions, participants will complete testing

in an MRI scanner. Preliminary behavioral results (n = 7) show better overall learning, a faster learning rate, and greater generalization for the complex-linear condition. Offline consolidation was similar across both morphologically complex conditions (3.2% vs. 3.7% reduction in reaction time) but numerically greatest for the complex-nonlinear condition. Neuroimaging results (n = 2) revealed recruitment of a distributed network of regions including the left inferior frontal gyrus, which has been shown to be particularly important for morphological decomposition. In summary, preliminary results are in line with the CLS theory and, more specifically, the prediction that prior knowledge will facilitate learning. Future work will explore whether the observed pattern of results is maintained with the full sample as well as extend this work by exploring whether native Hebrew speakers, who have experience with both linear and nonlinear morphological structures, show facilitated learning for both morphologically complex conditions.

Topic Areas: Morphology, Meaning: Lexical Semantics

The neural correlates of schema-dependent representational geometries during naturalistic discourse: text-based and experiential approaches

Poster G27 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session G.

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Discourse comprehension requires formation of a coherent situation model, i.e., a mental representation of the situation denoted in a text (Zwaan & Radvansky, 1998; Zwaan & Singer, 2003), which, in turn, guides integration of information over extended time periods. However, when the discourse is semantically unspecific, such as in the ambiguous text paradigm (Bransford & Johnson, 1972), a coherent situation model can only be created when the context (e.g., title, picture) provides information in the form of a cognitive schema. The schema guides the interpretation of the incoming information and allows the listener or reader to construct a coherent situation model. On the neural level, the vmPFC has been shown to play a critical role related to the activation of cognitive schemas and the schema-guided adaptation of information processing in posterior neocortical regions (e.g., anterior and middle temporal cortex, angular gyrus, medial parietal cortex). Here, we aim to investigate whether the availability of a schema (=title) influences the way that “idea units” (IUs: sentences or sentence fragments), are represented during discourse. In the current paradigm, semantically ambiguous expository texts (c.f. Dooling & Lachman, 1971; Bransford & Johnson, 1972) were presented to 27 participants with varying degree of preceding information in the title that in some cases did and in others did not facilitate the formation of a coherent situation model by providing a cognitive schema: either a highly informative, intermediately informative (highly/intermediately informative title condition) or no title at all (absent title condition). We use fMRI and representational similarity analysis (RSA) to probe representational geometries (Kriegeskorte & Kievit, 2013) on the neural level - characterized as representational distances between across-voxel activity patterns - to IUs during the ambiguous-text listening task. The representational geometries on the neural level will be compared with predicted representational geometries based on two semantic modelling approaches: a text-based and an experiential approach. In the text-based approach, the representational structure between IUs is assessed using word2vec (Continuous bag of words model, COBW: Mikolov et al., 2013). Individual IUs are represented as 200-dimensional vectors (point-wise sum of content words) that are based on COBW model pretrained on SONAR-500 and subtitle corpus in Dutch (Mandera, Keuleers & Brysbaert, 2017). Influence of the schema is modelled as cumulative distance (cosine angle) between pairs of IUs and the schema representation. In the experiential approach, an independent group of participants is asked to arrange IUs according to their perceived semantic distance using a spatial arrangement task (Kriegeskorte & Mur, 2012). In both semantic modelling approaches, the IU representational geometry is expected to be modulated by the availability of a cognitive schema, which will be assessed by comparing the three conditions of title informativeness. Preliminary data will provide first insight into the shaping of brain activation patterns as a function of schema availability during naturalistic discourse. The results are discussed in terms of neural mechanisms underlying the influence of a schema-guided interpretative framework on the neurocognitive representation of discourse.

Topic Areas: Meaning: Discourse and Pragmatics, Methods

Multilevel representations of semantics

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To derive a meaningful sentence-level interpretation from serial linguistic input, word semantics need not only to be retrieved but also integrated into a broader event representation. Two current computational models of sentence processing provide contrasting predictions about the timing of integration: Brouwer et al. (Cognitive Science, 2017) model integration as a late process that occurs after activation of meaning specific to the currently perceived word (around 600 ms). On the other hand, Rabovsky et al. (Nature H Behaviour, 2018) propose that a probabilistic event representations is immediately updated within the first 400 ms after onset of an incoming word. In support of the early integration account, a recent MEG study on semantic composition showed evidence for integration as early as 250 ms after hearing a noun (Lyu et al, PNAS, 2019). Importantly, that study relied on the target words inflicting strong semantic constraints on each other (running a program / running a race), leaving open the question of whether early integration also happens in sentences containing more arbitrary combinations of word meanings. To address this question, we created sentences with arbitrary conceptual pairings (electrician cheering / surgeon cheering), pairing nouns with different actions in either agent or patient role without imposing strong semantic constraints. We will record brain activity from 16 native German speakers using magnetoencephalography (MEG) during passive reading of 384 German sentences for a total of 2 hours. Each sentence will be followed by a comprehension question. Since data acquisition is delayed due to COVID-19, we will present preliminary findings based on pilot data. Results will be based on source reconstructed neural activity (LCMV beamforming), evoked by the final noun of each sentence. Multivariate representational similarity analysis allows us to track neural patterns encoding semantics on different levels of representation: Using a spatial searchlight, we will extract activity for each brain region, each stimulus and time point and compute the Euclidean distance between those neural activity vectors for all stimulus pairings. We will correlate (Spearman's rank) the resulting trial-by-trial neural dissimilarity matrix with different models of our stimuli. Specifically, we will correlate with an event-representation model and a word-representation model. We expect the word-representation model to correlate early after onset up until 400 ms. The temporal dynamics of the comparison with the event-representation model will allow us to test the two predictions with respect to the timing of integration. Statistical inference will be based on nonparametric permutation tests. We base our models for word- and event similarity on behavioural similarity judgments from 200 subjects, which were acquired online using a spatial multi-arrangement task (Kriegeskorte & Mur, Front in Psychology, 2012). By tracking neural representation at different levels of integration, our study will inform our understanding of compositional processing. The temporal dynamics of encoded event representations will provide evidence for or against alternative computational hypotheses of sentence processing, which can in turn inform the interpretation of the N400 and P600 ERP components, which are widely used to study language comprehension in the brain.

Topic Areas: Meaning: Combinatorial Semantics, Syntax

Programming in the Brain: Syntactic and Semantic Processing of Language vs. Source Code

Poster G29 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session G.

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Although at first glance source code lines and sentences have little in common, there are some similarities between programming and language. For example, both are rule-based systems of communication in which symbols are combined to convey meaningful messages. Are similar neurocognitive mechanisms responsible for processing source codes and language? Recent fMRI studies of neurocognitive mechanisms supporting programming provide contradicting evidence. Whereas some researchers find evidence for neural overlap (e.g., Siegmund et al., 2014), others report that the language network in the brain is not involved in source code processing (Ivanova et al., 2020). In an ongoing project, we explore neurocognitive mechanisms supporting language and source code comprehension using the method of electroencephalography (EEG). Specifically, we are obtaining EEG and event-related potentials (ERPs) responses from individuals with extensive programming expertise while they process sentences or source codes with vs. without violations. Processing of semantic and syntactic violations in programming vs. natural language are compared. The project includes four experiments. Across all 4 experiments, participants process language or source code while their EEG/ERP responses are recorded. In Experiment 1, participants read semantically plausible or implausible sentences (e.g., The shark swam in the sea/garden to find its prey.). In Experiment 2, participants process correct source codes or source-codes that contain semantic errors (e.g., x = 10; y = x + x/z). In Experiment 3, participants read syntactically legal or illegal sentences (e.g., The man admired Don's sketch of/of sketch the landscape). Finally, in Experiment 4, participants process correct source codes or source codes with syntactic errors (e.g., var_1 = "John"; var_2 = "Bill"/"Bill" = var_2). ERP components associated with processing linguistic violations have been well examined (Kutas & Federmeier, 2011; Gouvea et al., 2010). We expect that semantic linguistic violations will lead to increases in the N400 component. For syntactic linguistic violations, increases in magnitudes of ERPs are expected in the P600 component. Our main aim is to uncover if similar ERP effects are obtained when programmers process semantically or syntactically incorrect source code lines. This result would be suggestive of partially overlapping neurocognitive mechanisms supporting language and programming. Alternatively, if semantic and/or syntactic violations in source code evoke patterns of responses that are substantially different from the ones evoked by semantic and/or syntactic violations in language, evidence for neurocognitive dissociation for language and programming will be provided. Kutas, M., & Federmeier, K. D.(2011). Thirty years and counting: finding meaning in the N400 component of the event related brain potential (ERP). Annual Reviews in Psychology,62, 621-647. Siegmund, J., Kästner, C., Apel, S., Parnin, C., Bethmann, A., Leich, T., Saake, G. & Brechmann, A.(2014). Understanding understanding source code with functional magnetic resonance imaging. Proceedings of the 36th International Conference on Software Engineering, 378-389. Gouvea, A., C., Phillips, C., Kazanina, N. & Poeppel, D.(2010). The linguistic processes underlying the P600. Language and Cognitive Processes,25(2), 149-188. Ivanova, A., A., Srikant, S., Sueokal, Y., Kean, H., H., Dhamala, R., O'Reilly, U., Bers, M., U., Fedorenko, E.(2020). Comprehension of computer code relies primarily on domain-general executive resources. bioRxiv.

Topic Areas: Meaning: Combinatorial Semantics, Syntax

Neural correlates of postlexical retrospective strategies in an indirect semantic priming task

Poster G31 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session G.

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Neural correlates of semantic priming have been centered in networks of spreading activation for automatic prelexical processes typical of direct priming or indirect priming with a short stimulus onset asynchrony (SOA). In the latter, widespread recruitment of left and right hemispheric regions such as rSMG, rMFG, lMTG, rINS and lSFG, involved in semantic and attentional components has suggested rINS as part of an amodal semantic system and the precuneus having an important role in automatic semantic processing (Sass et al., 2009).

Meanwhile postlexical retrospective strategies such as semantic matching, compound cue or episodic retrieval, controlled process contributing to priming, has been neglected even though there is plenty of evidence of its contribution to short SOA direct/indirect priming (Jones & Estes, 2012). Trying to map brain regions participating in semantic priming during postlexical retrospective strategies we used a lexical decision task (LDT). To enhance the effect of controlled processing we used a long SOA (800 ms). To minimise the effects of expectancy (another strategy) we increased the related-unrelated ratio to 1:2 (20 related, 40 unrelated, 20 non-words) and employed indirect priming. 16 right-handed Spanish speakers' volunteers (ages 20-40, 50% male) were given a visual LDT in a Signa 1.5 T scanner with a TR of 3.5 s to obtain BOLD activation. Pairs of words were obtained from Barrón-Martínez & Arias-Trejo (2014). Each 3500 ms trial consisted on a fixation screen for 1000 ms followed by a 100 ms black screen, then the prime word for 600 ms, another black screen for 200 ms, the target word for 600 ms and finally a response screen for 1000 ms. We found differences in RT ($F=304.65$, $p=.0001$) in non-words ($M=1025.4$, $DE=181.6$; $p=.015$) compared to related-words ($M=917.4$, $DE=187.1$) and unrelated-words ($M=919.4$, $DE=165.8$). An increased activity was found in pars orbitalis of LIFG for related and unrelated versus non-words. Furthermore, we found cluster of more activation in lSTMp and lITG for non-words versus related and un-related conditions. These data suggest differential circuits in controlled postlexical retrospective strategies for words and non-words involving IFG in prime-target relation searching and ITG for processing lexicality of stimuli.

Topic Areas: Meaning: Lexical Semantics, Control, Selection, and Executive Processes

A diffusion tractography investigation of the shared and distinct white matter tracts of language and theory of mind

Poster G32 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session G.

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Successful communication depends not only on the ability to interpret words but also the ability to understand emotional states. Often described as components of language and theory of mind (ToM), these lifelong skills develop simultaneously during childhood, pointing to their shared roots. However, functional MRI research demonstrates that language and ToM are part of two functionally distinct networks that lateralize to opposite hemispheres in healthy adults. To further understand their distinction and interrelation, we examine how language and ToM relate to diffusion MRI data collected from 965 healthy young adults aged 22 - 35 years in the Human Connectome Project. Respectively capturing language comprehension and ToM, the NIH Toolbox Picture Vocabulary Test (TPVT) and the Penn Emotion Recognition Test (PERT) are investigated. To consistently parcellate the white matter (WM), we apply a neuroanatomically curated WM atlas that leverages machine learning to identify the WM tracts in each participant's brain (Zhang et al. 2018). In both the left and right hemispheres, we examine the microstructure of 12 major WM association tracts: the arcuate fasciculus (AF), uncinate fasciculus (UF), cingulum bundle (CB), external capsule (EC), extreme capsule (EmC), posterior limb of internal capsule (PLIC), inferior occipito-frontal fasciculus (IoFF), inferior longitudinal fasciculus (ILF), middle longitudinal fasciculus (MdLF), and superior longitudinal fasciculi (SLF I,II, and III). In each hemisphere, and in each association tract, mean fractional anisotropy (FA) is separately measured. Using Spearman's correlation and correcting for multiple comparisons using FDR, performance on PERT is found to be most strongly and significantly correlated with the mean FA of the right SLF III ($rho = 0.112$, $p < 0.005$). Performance on TPVT is most strongly and significantly correlated with the mean FA of the left ILF ($rho = 0.183$, $p < 0.001$). The measure most strongly and significantly correlated with both the TPVT ($rho = 0.133$, $p < 0.001$) and PERT ($rho = 0.105$, $p < 0.01$) is the mean FA of the left AF. Our results bolster the understanding that ToM and language are not only functionally separate but are also supported by structurally separate WM tracts. Additionally, the results suggest that the left AF may be a common tract of both ToM and language, perhaps pointing to the AF's involvement in their synchronous but lateralized development. However, laterality indices calculated using the mean FA of the left and right AF do not demonstrate a significant relationship ($p > .05$) with either assessment, suggesting the degree of AF lateralization is not related to performance on these ToM or language assessments in healthy young adults. This work is the first to examine the relationship of ToM and language assessments with a total of 12 white matter association tracts in separate hemispheres using a large dataset of healthy adults. Future work will investigate how the mean FA of the left ILF, right SLF III, and left AF in temporal lobe epilepsy patients may relate to language and ToM deficits, inform functional lateralization, and be used to plan neurosurgical operations.

Topic Areas: Meaning: Lexical Semantics, Meaning: Discourse and Pragmatics

Bridging concepts in different modalities: the N400 of verbal and multimodal metaphor processing

Poster G33 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session G.

Presenter Note: For further information, comments, and remarks, please email luca.bischetti@iusspavia.it and paolo.canal@iusspavia.it

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There is increasing interest in cognitive sciences over multimodal metaphors and their creative and communicative power (1,2), but little is known about the brain processes supporting their comprehension. We aimed to fill this gap, using the Event-Related-Potentials technique and mainly focusing on the N400 component. In the multimodal metaphors we investigated the topic was expressed in the verbal modality and the vehicle in the visual modality. We asked whether the N400 effect usually observed for verbal metaphors compared to literal counterparts (3) is affected by modality. Verbal and multimodal metaphors may elicit similar N400 effects, but with different scalp distributions (4). Alternatively the visual modality does not simply come with a shift in distribution, but also enhances the metaphor-related N400 effect, due to increased costs in establishing the link between topic and vehicle (5). Such costs may further be balanced by some kind of cognitive benefit, as for instance in terms of memory persistence (6), as suggested by the use of visual metaphors in persuasive communication (1). Participants (N=29) were presented with 256 concept pairs (in 4 blocks) employing a S1-S2 paradigm. Within each pair, Figurativity was manipulated on S1 making the relationship between concepts literal (river-bridge) or metaphorical (language-bridge). Modality (Verbal or Multimodal) was manipulated by changing the presentation modality of S2, making the item purely verbal or verbo-pictorial (i.e., bridge was either a word or a picture). After each block, participants were asked to recall the second member of each pair (cued-memory-recall). Results showed that metaphors elicited more negative ERPs compared to the literal condition: this was true for both modalities during the N400 time window, as attested by the main effect of Figurativity [-1.12μ, $t = -5.05$, $p < 0.001$]; in the following time window, only multimodal metaphors were associated with more negative effects compared to the literal condition, as attested by the significant interaction between Figurativity and Modality [-1.94μ, $t = -5.65$, $p < 0.001$]. Results suggest that across modalities, and consistently with the bulk of ERP evidence on verbal materials, more effort is needed to retrieve the metaphor-relevant properties of the vehicle. Crucially, the effort is extended in time when the target is presented in the visual domain. In this kind of multimodal metaphors the interpretation may hinge on the prolonged recruitment and evaluation of visual information, which may be due to the more open-ended meaning of multimodal materials (7,8). 1- Forceville (1996). Pictorial metaphor in advertising. Routledge. 2- Bolognesi & Aina (2019). CORPUS LINGUIST LING, 15(1), 101-138. 3- Bambini et al. (2016). FRONT PSYCHOL, 7, 559. 4- Ganis et al. (1996). J COGNITIVE NEUROSCI, 8(2), 89-106. 5- Coulson & Van Petten (2002).MEM COGNITION, 30(6), 958-968. 6- Marschark & Hunt (1985). MEM COGNITION, 13(5), 413-424. 7- Sadoski & Paivio (2013). Imagery and text: A dual coding theory of reading and writing. Routledge. 8- Carston (2018). METAPHOR SYMBOL, 33(3), 198-217.

Topic Areas: Meaning: Discourse and Pragmatics, Multisensory or Sensorimotor Integration

Out of the ordinary: the neural correlates of engaging with literary stories

Poster G34 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session G.

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Engagement with narratives and literature is an important application of language abilities in naturalistic language use that is poorly understood. While reading literature, readers often experience emotions related to aesthetics through empathy with characters, suspense, and even physical sensations like chills because of the use of words. Eye-tracking data shows that infrequent readers are slower and make more regressions toward passages rated as highly literary, indicating a disruption of the reading flow. Are these disruptions due to higher attentional load or aesthetic processes? To better understand what brain systems support aesthetic experiences during reading, we parametrically modeled literariness and emotional intensity in an existing fMRI dataset of people listening to literary stories. The goal of this exploratory study was to test the hypothesis that different aesthetic experiences (here literary style and emotional intensity) are neurally dissociable and to develop new hypotheses for future research. We collected word by word ratings from two independent groups of raters of literariness (N=27) and emotional intensity (N=27) of two literary stories. These ratings were used as predictors to parametrically model blood oxygen-level-dependent signal changes in 52 participants listening to the same two stories from a prior dataset. In addition, brain activation percent signal change from regions of interest (ROIs) was extracted and correlated with behavioral measures linked to aesthetic experiences and individual differences in reading behavior, social cognition, and subjective reward. ROIs were selected based on anatomical and functional approximations of the results of the whole brain analysis through meta-analysis on neurosynth.org. The results confirm that literariness and emotional intensity when engaging with literary fiction are supported by different brain networks. High degree of literariness was associated with increased activation in brain areas linked to semantic and situation model integration (left angular gyrus, left supramarginal gyrus, and precuneus), and decreased activation in bilateral middle temporal cortices, associated with semantic representations and word memory. This pattern suggests that literary language requires deeper semantic and contextual integration and possible inhibition of a default lexical memory. Correlating behavioral measures with activation in ROIs revealed that activation in several of these regions was linked to individual differences in reading behavior such as how much people care about style or how literate they are (Author Recognition Test). This finding suggests that efficient processing of literary language might be a training effect. The predictor for emotional intensity correlated with decreased activation in a bilateral fronto-parietal network that is often associated with controlled attention. Network ROIs of the frontal control network and fronto-parietal attention network revealed that (de-)activation of these networks correlated with how interesting participants found a story and individual differences in experienced reward to social and emotional engagement with others (Need for Affect). These results suggest a link between disengagement of controlled attention with narrative engagement. Our results confirm a neural dissociation in processing the form of literary language and the emotional content in stories. We generate new questions about the function of and interaction between attention, social cognition, and semantic systems during literary engagement and aesthetic experiences.

Topic Areas: Meaning: Discourse and Pragmatics, Reading

Speech-gesture integration in patients with schizophrenia – a first fMRI measurement as the base for evaluating a multimodal speech-gesture training intervention

Poster G35 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session G.

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Dysfunctional social communication is one of the most stable characteristics in patients with schizophrenia that also affects quality of life. Interpreting abstract speech and integrating nonverbal modalities is particularly affected. According to former studies (e.g., Straube et al. 2013), aberrant neural activation in left inferior frontal gyrus (IFG) and superior/middle temporal regions (STS, MTG) as well as their disconnection (e.g., Straube et al. 2014) could account to those dysfunctions. These findings are in line with the dysconnectivity hypothesis (Friston & Frith 1995). Considering the impact of communication on social life but failure to treat communication dysfunctions with usual treatment, we investigate the possibility to improve verbal and non-verbal communication in schizophrenia by applying a multimodal speech-gesture training (MSG training). Outcomes are measured through pre-post-fMRI and standardized psychological questionnaires. Here we describe first results from n=23 patients with schizophrenia from the pre-fMRI measurement. Based on these first results we will be able to evaluate the MSG training paradigm, comparing the these results from pre-fMRI with the outcomes in post-fMRI measurements. During the fMRI measurements, videos of an actor are presented in a passive viewing task in 2x3 conditions: 1) abstract sentences (ABS) or 2) concrete sentences (CON) and a) unimodal: speech only (S), b) unimodal: gesture only (G) and c) multimodal: speech accompanied by gesture (SG). Neural data were preprocessed with the robust and reproducible preprocessing pipeline fMRIPrep [RRID:SCR_016216]. Contrast images for each condition (SG_ABS, SG_CON, S_ABS, S_CON, G_ABS and G_CON) were calculated during a first-level analysis and implemented in a 2 × 3 second-level random effects analysis (flexible factorial design) with SPM12 [RRID: SCR_007037]. The inner-session contrast of interest focussed on the conjunction of two interactions: ([SG_ABS – S_ABS] – [SG_CON - S_CON]) ∩ ([SG_ABS – G_ABS] – [SG_CON – G_CON]). Whole-brain results were corrected for multiple comparisons on clusters covering at least 162 voxels, with a corrected threshold for rejection of the null hypothesis of $P < .01$ (thresholds were identified on the basis of a Monte Carlo simulation and applied to all functional analyses). First results show increased activity in two clusters, including left IFG (MNI x,y,z = [−44, 24, 8], $t = 3.36$, number of voxels = 512) with highest activation for the SG_ABS condition. Strikingly, despite our small sample, we were able to find activation in predicted brain regions in a whole brain analysis, indicating higher processing costs for integration of gestures in an abstract sentence context. This is in line with findings from former studies as well as the dysconnectivity hypothesis. Due to our promising preliminary results, we expect to be able to demonstrate the beneficial effect of a speech-gesture training intervention on neural levels (focusing on left IFG and temporal regions) with the described paradigm. For further information about the study design and the MSG training, please feel free to visit our public project repository on OSF (https://osf.io/uh4f9/).

Topic Areas: Language Therapy, Perception: Speech Perception and Audiovisual Integration

Monolingual and bilingual abstract semantic associative network training (AbSANT/BAbSANT): theoretically-based anomia therapy that promotes within- and cross-language generalization

Poster G36 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session G.

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Chaleece W. Sandberg[1], Teresa Gray[2]; [1]Penn State, [2]San Francisco State University

Generalization to untrained items is one measure of therapeutic success in aphasia treatment research. Protocols that capitalize on theorized relationships within the semantic system are more likely to promote generalization. Previous work based on the complexity account of treatment efficacy (CATE; Thompson et al., 2003) and leveraging the unique relationship between abstract and concrete words has shown that when abstract words are trained, concrete words also improve, but not vice-versa (e.g., Kiran et al., 2009). Additionally, previous work based on the revised hierarchical model (RHM; Kroll & Stewart, 1994) has shown that training in the non-dominant language promotes cross-language generalization in bilingual persons with aphasia (PWA; e.g., Edmonds & Kiran, 2006). However, it is unclear if training abstract words in the non-dominant language will have an additive benefit in bilingual PWA. This work aims to a) replicate previous work showing the generalization benefit of training abstract words in monolingual PWA, and b) extend this abstract word training protocol to bilingual PWA. We hypothesize that training abstract words in the non-dominant language will result in generalization to concrete words in the trained language as well as abstract and concrete words in the dominant language. Thirteen monolingual and nine bilingual PWA participated in the study. Each participant completed an assessment battery and was trained on ten abstract words in a category for ten weeks, two sessions per week, two hours per session. Bilingual PWA were trained in their non-dominant language. For bilingual PWA, we obtained culturally and linguistically appropriate stimuli by norming category generation on fifteen native speakers. Words produced consistently across norming respondents were selected as targets. The therapy protocol was identical to that in Sandberg and Gray (2020). Effect sizes (ES) were calculated based on Beeson and Robey (2008). Additionally, Pearson correlations were used to examine possible associations between treatment ES and selected standardized tests (Boston Naming Test – English only, Pyramids and Palm Trees Test – nonlinguistic, and the Cognitive Linguistic Quick Test – English or Spanish). On average, monolingual PWA showed a small direct training effect (6.77) and a small generalization effect (2.32), replicating previous work. Bilingual PWA showed an average medium direct training effect for the trained abstract words in the non-dominant language (8.19), a within-language generalization effect that was nearing the small threshold for untrained concrete words in the non-dominant language (1.85), and a small cross-language generalization effect for abstract words in the dominant language (2.15). Thus, we successfully extended this therapy protocol to bilingual PWA, and partly confirmed our second hypothesis. No correlations with standardized test results were significant, except that pre-treatment English picture naming scores for bilingual PWA positively correlated with non-dominant abstract ES (direct training) ($r = 0.856$, $p < 0.05$) and dominant abstract ES (cross-language generalization) ($r = 0.938$, $p < 0.01$). These results support the use of the CATE and RHM in guiding therapy, show the benefit of training abstract words in both monolingual and bilingual PWA, and show the additive benefit of training in the non-dominant language in bilingual PWA.

Topic Areas: Language Therapy, Meaning: Lexical Semantics

Semantic Processing in Young Children with Autism: Abnormalities in Neural Strength and Timing

Poster G37 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session G.

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BACKGROUND: Deficits in semantic processing has been shown in many individuals with autism spectrum disorder (ASD).1,2 Neural mechanisms underlying semantic processing have been investigated using event related potentials (ERPs), which have a known component associated with semantic processing, called the N400.3,4 It is a negative deflection in the ERP whereby semantic incongruencies generate a larger deflection than semantic congruencies. This difference in amplitude, called the N400 effect, is typically examined as a measure of semantic processing.3 In adults, it peaks at 400 ms in the central electrodes whereas in children, it is seen broadly across frontal central areas, occurring at a later latency with longer duration.3–5 However, in children with ASD, it remains unclear as to whether the N400 effect is delayed, diminished or absent. Furthermore, most N400 studies rely on visual stimulation and reading ability, precluding investigation in young children.5 Investigating semantic processing of spoken words in young children with ASD as well as exploring the developmental differences with adults and control children would address a gap in the literature. We aimed to examine the N400 effect underlying semantic processing of auditory language as a surrogate of verbal comprehension abilities in children with ASD compared to control children and adults. METHODS: We used a 64-channel electroencephalogram cap to investigate the N400 during semantic categorization of auditory stimuli in 15 control Adults (mean age: 22.9 years; 6 females), 21 control Children (mean age: 6.3; 11 females) and 15 children with ASD (mean age: 6.4 years; 2 females; ranging in language function). Participants listened to a list of words (n=96), and determined after every word, if it was ‘in’ (semantically congruent) or ’out’ of category (semantically incongruent). Brain data were recorded continuously and preprocessed (artifact rejection; epoched -500 to 2000 ms; lowpass filtered at 30 Hz), averaged by condition for each participant and then grand-averaged. ANOVAS were used to analyze behavioural data and cluster-based permutations tests (p <.05, 1000 permutations, two-time windows: 300-700, 700-1100 ms) were performed for ERPs. RESULTS: Results revealed significant between groups differences in accuracy (Adults (95.8%±2.6) > Children (86.5%±9.6) > ASD (72.9%±16.6); p=0.001). For reaction time, Adults were faster (1.1 sec ±0.7; p<0.05), but there were no significant differences between child cohorts (1.9 sec±0.99; p=0.5). Cluster-based permutations revealed a N400 effect for Adults in the central-frontal region, as expected. An N400 effect was not seen in children, although the N400 component for each condition was significantly larger and prolonged in children, extending from 300-1100 ms. In the ASD group, the N400 was not seen until 700 ms, with a lower amplitude for both conditions. DISCUSSION: Behavioural results and the brain data imply that children process semantic aspects of auditory stimuli, but the absence of the N400 effect suggest that children may not have developed semantic expectancy. Furthermore, the delayed and lower amplitude N400 component in both conditions in ASD suggest that verbal information processing is slower and more restricted. This could affect comprehension abilities in ASD by impacting the ability to track and categorize continuous incoming speech.

Topic Areas: Disorders: Developmental, Meaning: Lexical Semantics

Lower cortical thickness in contralesional language network in acute aphasia and the role of lesion site

Poster G38 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session G.

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Background. Post-stroke aphasia (PSA) is generally caused by left hemisphere ischemic stroke. Neuroplastic changes in the contralesional uninjured hemisphere have been reported at early stages of the disease. Within 3-4 days post-stroke, PSA patients present with reduced activation of the right hemisphere during language tasks and decreased interhemispheric functional connectivity between regions of the language network [1,2]. These functional changes seem to be influenced by lesion site [3]. Studies investigating structural cortical characteristics in stroke patients (i.e. not only PSA patients) have found gray matter atrophy in lesion homologues in the uninjured hemisphere around 10 days post-stroke [4,5]. However, structural changes in the acute stage of PSA and their relationship with the main lesion site have yet to be documented. Objectives. We aimed to determine whether acute PSA patients (within 1-3 days post-stroke) following middle cerebral artery stroke of the left hemisphere presented with differences in cortical thickness of right hemisphere areas of the language network when compared to healthy controls. Our second objective was to determine whether the pattern of right hemisphere cortical thickness in acute PSA patients was related to the main lesion site (frontal vs. temporo-parietal). Methods. We recruited 26 acute PSA patients (10 women; mean age = 70.9 ± 12.8; days post-stroke = 2.4 ± 1.2) with a first left hemisphere stroke. Lesion sites were as follows: mainly frontal (n=10), mainly temporo-parietal (n=10), both frontal and temporo-parietal (n =6). We also recruited 22 healthy controls (11 women; mean age = 64.5 ± 7.8). Surface-based morphometry (i.e. Freesurfer) was used to pre-process structural magnetic resonance imaging data and obtain cortical thickness for nine regions of interest within the right hemisphere language network with previous evidence of functional connectivity changes in PSA patients [6]. Results. Acute PSA patients presented with thinner gray matter in right pars opercularis, pars orbitalis (ParsOrb), supramarginal gyrus (SMG) and superior temporal gyrus (STG). Compared to controls, gray matter was thinner in right ParsOrb, SMG and STG for patients with a frontal lesion, while gray matter was thinner in

right STG only for patients with a temporo-parietal lesion. In addition, patients with a frontal lesion presented with thinner gray matter in ParsOrb than patients with a temporo-parietal lesion. Conclusion. Our results indicate that remote cortical abnormalities can be observed in PSA patients as early as 1-3 days post-stroke in right hemisphere lesion homologues that are structurally related to the lesion site. Cortical abnormalities appear to be more extended across the right hemisphere in the case of frontal lesions, while they appear to be restricted to the STG in the case of temporo-parietal lesions. A better understanding of right hemisphere cortical characteristics early-on post-stroke is necessary to provide the neurobiological rationale for developing more timely and efficient interventions for PSA language recovery. [1] Saur et al. (2006) Brain. [2] Nair et al. (2015) Ann Clin Transl Neur. [3] Saur et al. (2020). [4] Wu et al. (2017) Biomed Res Int. [5] Wu et al. (2016) Neural Regen Res.

Topic Areas: Disorders: Acquired, Meaning: Lexical Semantics

Discourse comprehension deficits in non-fluent variant Primary Progressive Aphasia

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Theoretical background. Damage to the left inferior frontal gyrus in individuals with non-fluent variant primary progressive aphasia (nfvPPA) has been associated with syntactic comprehension impairment (Mesulam, 2016) and deficient formulation of predictions about upcoming words in speech perception (Cope et al., 2017). However, no study to date has investigated nfvPPA patients' discourse comprehension skills. Discourse comprehension requires the integration of syntactic information with contextual and background world knowledge to enable the comprehender to inferentially derive a coherent interpretation of the input (Rohde & Kurumada, 2018). The current study aims to: (a) determine the discourse comprehension deficits of nfvPPA patients compared to controls on a listening comprehension task targeting textually explicit and implicit comprehension skills, and (b) identify the relation between discourse comprehension, syntactic comprehension and verbal working memory skills. Method. Fourteen Greek-speaking participants with nfvPPA (age range 53-73; mean age: 64 yrs., SD: 5.1) along with eighteen age- and education-matched language-unimpaired adults performed a listening comprehension test (Cain & Oakhill, 1999) that included 4 passages of ascending lexical and morphosyntactic difficulty and measured four skills: 1) inferencing of implicit information; 2) comprehension monitoring for inconsistencies; 3) recall of explicit facts; and 4) simile interpretation. Dependent measures included the sum of the above 4 measures in the 4 passages, and accuracy in each of the four skills collapsed across the 4 passages. Participants were also assessed on syntactic comprehension (Peristeri & Tsimpli, 2010), and forward and backward digit span tests. These were entered as predictors into a stepwise regression model, with comprehension accuracy in each of the four skills as the dependent variables. Results. The nfvPPA patients performed lower than controls in overall discourse comprehension accuracy (mean nfvPPA=54.5% vs. mean controls=84.8%; $p<.001$). There was a significant interaction between story complexity and group ($p=.04$), since nfvPPA patients scored significantly lower than controls in the stories with the highest degree of complexity. In the specific discourse comprehension measures, the nfvPPA group performed lower than controls in: (1) inferencing of implicit information and, (2) comprehension monitoring for inconsistencies ($p < .001$ for both differences; Bonferroni corrected). In contrast, the nfvPPA group performed similar to controls in: (1) recall of explicit facts and, (2) simile comprehension ($p > .420$). Syntactic comprehension was the strongest predictor of nfvPPA patients' performance in implicit inferencing (adjusted $R2 = 51.7$, $p < .001$), followed by digit forward span (adjusted $R2 = 23.9$, $p = .008$). On the other hand, syntactic comprehension emerged as a significant predictor of nfvPPA patients' monitoring of inconsistencies (adjusted $R2 = 38.3$, $p = .001$), followed by digit forward span (adjusted $R2 = 36.9$, $p = .001$). Conclusions. Patients with nfvPPA were impaired in discourse comprehension and, in particular, in drawing implicit inferences and monitoring inconsistencies. Deficits in these skills were strongly associated with their syntactic capacity and verbal working memory skills. The overall results are consistent with emerging perspectives of the language deficit in nfvPPA as the outcome of impairments in language-specific (syntax), verbal working memory and domain-general deficits (inferencing, monitoring). References Cain, K., & Oakhill, J. V. (1999). Inference making ability and its relation to comprehension failure in young children. Reading and Writing, 11, 489-503. Cope, T.E., Sohoglu, E., Sedley, W., Patterson, K., Jones, P. S., Wiggins, J., Dawson, C., Grube, M., Carlyon, R. P., Griffiths, T. D., Davis, M. H., & Rowe, J. B. (2017). Evidence for causal top-down frontal contributions to predictive processes in speech perception. Nature Communications, 8, 2154. Mesulam, M. M. (2016). Primary Progressive Aphasia and the Left Hemisphere Language Network. Dementia and Neurocognitive Disorders, 15(4), 93-102. Peristeri, E., & Tsimpli, I. M. (2010). An Interference Method to Investigate Working Memory in Greek-Speaking Patients with Broca's Aphasia. Procedia-Social and Behavioral Sciences, 6, 66-67. Rohde, H., & Kurumada, C. (2018). Alternatives and Inferences in the Communication of Meaning. Psychology of Learning and Motivation, 68, 215-261.

Topic Areas: Disorders: Acquired, Meaning: Discourse and Pragmatics

The role of statistical learning and the hippocampus in the recovery of aphasia

Poster G40 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session G.

Presenter Note: Feel free to contact me for questions, discussions, or just a chat via email (klara.schevenels@kuleuven.be) or other social media (twitter: @KSchevenels or LinkedIn: Klara Schevenels).

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Aphasia is an acquired language disorder most commonly caused by a left-hemispheric stroke. In the first months post-stroke, there is often some spontaneous and intervention-induced recovery, but for most patients a chronic deficit remains (Maas et al., 2012). Information on the lesion and the initial severity of the aphasia are the most robust predictors of recovery (Plowman et al., 2012; Watila & Balarabe, 2015), yet there remains a large proportion of unpredicted variance (Hope et al., 2013). One promising direction is to look beyond the traditional language and lesion-related variables and to include patients' ability to learn. In this regard, (intact) cognitive abilities and brain structures that assist in (re)learning of language are important. Given the importance of statistical learning (SL) in the acquisition of the mother tongue in infants (Kuhl, 2004), as well as in adult second language learning (Frost et al., 2013), SL shows great potential to explain variability in relearning language in aphasia. At the neural level, the hippocampus (HC) is well-known for its involvement in SL (Covington et al., 2018), though this has not yet been tested with regard to language recovery in aphasia. Therefore, our first aim was to test whether the HC volume is associated with SL skills in persons with aphasia. Second, we investigated whether binary (hippocampal) lesion information and behavioral (SL tasks) or neural (HC) correlates of SL improve the prediction of functional verbal communication post-stroke, above and beyond a formal language screening test. We consecutively recruited 52 stroke patients (31 males, 21 females, mean = 70.6 y.o., SD = 9.9 years) from the stroke unit at the University hospital of Leuven, with a left or bilateral lesion and language impairment. In the acute phase, patients were screened for language disorders with a formal aphasia screening test 'ScreeLing' (on average 4.8 days post-stroke, SD = 5.5 days) and underwent a T1-weighted MRI-scan (on average 6.3 days post- stroke, SD = 5.1 days). Hippocampal volumes were derived through FreeSurfer's HippocampalSubfields module (Iglesias et al., 2015). In the subacute phase (on average 4.0 months post-stroke, SD = 1.1 months), a functional verbal communication test 'ANELT' was administered in a subset of patients (n = 23), as well as three SL tasks (i.e. auditory conditional, visual conditional and visuomotor) each assumed to tap on different aspects of SL. The results indicated a significant positive correlation between the visuomotor SL task and the volumes of the left ($r_p(29) = .441$, $p = .013$) and right ($r_\tau(29) = .265$, $p = .037$) hippocampi. A Bayesian linear regression model was used to predict the language outcome on the ANELT in the subacute phase based on the acute language scores on the ScreeLing (n = 23, BF10 = 25.275). Adding the volumes of the hippocampi and/or the behavioral SL results did not improve the likelihood of the model. As data collection is still ongoing, we plan to integrate new data from the subacute phase, as well as expand the prediction to the chronic phase (> 9 months) post-stroke.

Topic Areas: Disorders: Acquired, Language Production

Different patterns of functional network re-organization across the variants of primary progressive aphasia: A graph-theoretic analysis

Poster G41 [Poster PDF] [Poster Tour] Visit me at [Gather.Town] in the Wernicke room during Poster Session G.

Presenter Note: Article DOI: https://doi.org/10.1016/j.neurobiolaging.2020.09.007 Drop me an email if you have any questions or would like to get a copy of the poster! yuan.tao@jhu.edu

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Primary progressive aphasia (PPA) is a neurodegenerative syndrome with three main variants (non-fluent, logopenic, semantic). Recently, analyses of resting-state functional connectivity (RSFC) have furthered our understanding of the network disruptions underlying the different variants (e.g., Battistella et al., 2019). In this study we applied graph-theoretic methods to study the RSFC network organization in the three PPA variants. Network changes measured with graph-theoretic metrics have been reported in many brain disorders, yet in PPA there have been only two published studies, each examining one variant (Agosta et al., 2014; Mandelli et al., 2018). We extended this previous work to identify and compare functional network changes across the three PPA variants. Furthermore, we aimed to understand the relationship between functional network changes and structural changes (atrophy). Methods: MRI data were collected from 42 individuals with PPA (18 non-fluent (nfvPPA), 15 logopenic (lvPPA), 9 semantic (svPPA)) and 17 age-matched healthy controls (HC). For each participant, we computed a whole-brain functional connectome with 76 gray matter regions-of-interest (ROIs). First, we calculated 8 global graph-theoretic metrics that have been previously reported in PPA and which serve to characterize global topological structure. Second, to examine regional effects, we identified the “connector hubs” within each variant using the centrality measure participation coefficient (PC). For regions that differed between HC and PPA, we further examined the relationship between PC and gray matter volume to investigate the mechanisms underlying changes in hub distributions. Results: PPA (all variants combined) were significantly higher than HC for three global metrics (characteristic path length, clustering coefficient, modularity, corrected $p<0.05$), all indicating higher levels of network segregation in PPA. No variant differences were found across the global metrics. Regarding hub distribution, all variants lost hubs in the left superior frontal and superior parietal gyri, while each variant recruited different “new hubs”. Specifically, nfvPPA recruited new hubs in the anterior frontal and ventral temporal areas bilaterally, consistent with a previous report (Mandelli et al., 2018). Meanwhile, lvPPA and svPPA showed a similar right-lateralized distribution of new hubs. Regarding the “lost hubs”, PPA also showed lower PC values ($p=0.03$) than HC; conversely for the “new hubs”, all variants had significantly (or numerically) higher PC (nfvPPA $p=0.24$; lvPPA $p=0.03$; svPPA $p=0.03$; Bonferroni corrected), consistent with the hub status changes. Regarding volume, no significant differences were found between PPA and HC except a marginal effect for the lost hubs (lost: $p=0.06$; new: all corrected $p>0.1$). Importantly, no significant correlations were found between PC and volume (lost: $r=0.22$, $p=0.08$; new: $r=-0.07$, $p=0.6$). In sum, there was no clear correspondence between the functional property (PC) and volume. Summary: All PPA variants showed greater global segregation along with global connectivity reduction of the left frontal and parietal regions, while the three variants exhibited different patterns of new hub recruitment. Importantly, these functional changes could not be fully explained by volume loss. This study suggests that functional changes can serve as independent biomarkers for distinguishing the PPA variants and highlights the utility of graph-theoretic approaches in understanding functional re-organization in neurodegenerative diseases.

Topic Areas: Disorders: Acquired, Computational Approaches

Premorbid brain health negatively impacts residual language function in subacute aphasia

Poster G42 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session G.

Veronika Vadinova[1], David A. Copland[1], Katie L. McMahon[2], Tracy Roxbury[1], Katherine O'Brien[1], Jennifer Lee[1], Kimberley Garden[1], Laura Ziraldo[1], Sonia L. E. Brownsett[1]; [1]University of Queensland, [2]Queensland University of Technology

Introduction: Cerebral white matter hyperintensities (WMH) are a pathological radiological marker typically associated with ageing and vascular risk factors. Increases in WMH are thought to be an indicator of deteriorating global brain health (Cannistraro et al., 2019). Research has demonstrated that when stroke is accompanied by premorbid WMH, poorer cognitive and linguistic outcomes are likely (Georgakis et al., 2019; Vadinova et al., in preparation). Two previous studies showed that high WMH correlated with an increase in language impairment in chronic aphasia, specifically in naming (Basilakos et al., 2019; Wright et al., 2018). Importantly, the influence of premorbid WMH on language functions in subacute aphasia remains unexplored. The first weeks after stroke onset represent the most dynamic and spontaneous recovery period, potentially driven by innate brain recovery processes and the upregulation of the unlesioned brain regions (Hartwigsen & Saur, 2019). We hypothesized that when the integrity of the unlesioned brain regions is compromised by pre-existing WMH, recovery processes are suboptimal, leading to poorer language function in the subacute stage of recovery. Research Question: Does premorbid severity of WMH, a measure of premorbid brain health, negatively impact residual language function in subacute aphasia? Methods: 37 patients with single left-hemisphere stroke and subsequent aphasia participated in a structural MRI scan at 2- 6 weeks post-stroke. WMH were assessed on FLAIR sequences and scored using the six-point Fazekas scale (0-6) (Fazekas et al., 2002). Language assessment, performed within one week of scanning session, included the subtests from the Comprehensive aphasia test (CAT). Here we report on language production skills previously investigated in chronic cohorts (naming), and, for the first time, on receptive language skills (spoken word & sentence comprehension). Linear regression models were built to evaluate the relationship between each standardized outcome measure and severity of premorbid WMH, controlling for percentage lesion volume (lesion volume/intracranial volume*100). Results: The model with sentence comprehension was significant (R2=0.316, p=0.0016). Mean performance on sentence comprehension task was 69.6 points (95% CI [61.109… 78.112]) and patients' scores were significantly impacted by severity of premorbid WMH (effect size Δz = -3.417, 95% CI [-5.400… -1.433]) and by percentage lesion volume (effect size Δz = -0.313, 95% CI [-0.526… -0.099]). The model with word comprehension and naming were significant (R2=0.171, p=0.015 and R2=0.123, p=0.018). However, there is no evidence of impact of premorbid WMH on these two language functions. These two functions were significantly impacted by percentage lesion volume (word comprehension: Δz = -0.288, 95% CI -0.489… -0.086]; naming Δz = -0.367, 95% CI -0.613… -0.120]). Conclusion: Our first preliminary finding suggests that premorbid brain health, assessed by the total WMH burden, negatively impacts residual language function in subacute aphasia. This is complemented by our second finding that whilst some language skills are more susceptible to disruption with premorbid WMH burden, other language functions appear unaffected. Future research should investigate whether complex language tasks, that rely on more extensive neural networks, are particularly vulnerable to the diffuse nature of WMH burden.

Topic Areas: Disorders: Acquired, Language Production

Neuromodulation of the dLPFC during cursing in American English

Poster G43 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session G.

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Neurogenic cursing, the non-volitional or uncontrolled production of taboo words, is a hallmark of several neurological disorders such as stroke aphasia, Tourette syndrome, traumatic brain injury and the behavioral variant of frontotemporal degeneration (bvFTD). Neurogenic cursing poses significant negative societal consequences often leading to the feeling of isolation for the patient and caregiver. There is no known intervention for this communication disorder. A review of the etiology of neurogenic cursing, including the disorders listed previously as well as right hemisphere frontal lobe damage, often associated with diminished cursing, suggests there is a neuroanatomical dissociation between the left and right hemisphere in relation to taboo word production. Here we investigate the hemispheric lateralization of cursing by examining the effects of transcranial direct current stimulation (tDCS) to the left or right prefrontal cortex on behavior (reading latency) and physiological (pupillary) response during taboo word production. We hypothesized that that the upregulation of the right prefrontal cortex and downregulation of the left prefrontal context would impact taboo word production, specifically resulting in slowed reaction time to taboo words relative to non-taboo word as well as increased dispersion between peak pupillary amplitudes. 32 neurotypical native English speakers took part in the study. Taboo and non-taboo word production was tested using a go-no-go read-aloud task prior to and following 20 minutes of off-line neurostimulation. Participants where split into two groups each receiving opposite polarity stimulation with one electrode placed over the right dorsolateral prefrontal cortex and the other placed over the left dorsolateral prefrontal cortex. Behavioral effects were evaluated using reading latency and the physiological response was evaluated using the sustained peak pupillary amplitude and maximum peak pupillary amplitude. Although we found no effect of tDCS on reading latencies, there was a cross over effect of tDCS on the pupillary response. Participants who received anodal stimulation to the right dorsolateral prefrontal cortex showed elevated pupil response for taboo words post-stimulation. Those that received cathodal stimulation to the right dorsolateral prefrontal cortex showed dampened response to taboo words post tDCS. Modulation of the dorsolateral prefrontal cortex impacts the production of taboo words. Elevated pupil response following the upregulation of the right prefrontal cortex suggests that taboo words are imbued with more affective salience. Our results support the continued research into the application of tDCS as a treatment for neurogenic cursing.

Topic Areas: Disorders: Acquired, Methods

Effects of early language exposure on grey matter plasticity

Poster G44 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session G.

Stephanie Deschamps[1,3], Jen-Kai Chen[1,3], Lara Pierce[2,4], Fred Genesee[1,3], Shari Baum[1,3], Denise Klein[1,3]; [1]McGill University, [2]Harvard Medical School, [3]Centre for Research on Brain Language and Music, [4]Boston Children's Hospital

It is well known that learning a new language can modulate the brain over time, as language development is accompanied by the formation of novel neural representations. However, the exact underlying neural mechanisms of such neuroplasticity, as well as its robustness over time, are still not well understood. Previous work by Pierce et al. (2014) has attempted to shed light on these questions by studying Internationally Adopted (IA) children from China. IA children have a unique language background, as they were exposed to their original birth language (Mandarin) for the first 1 to 2 years of their life, subsequently discontinuing their birth language for the new language of their adopted family (in this case, Quebecois French). The unique linguistic circumstances of IA children permit the opportunity to observe the longevity of the early neural representations of the birth language that were established during infancy, but which were not maintained into adulthood. Using a task-based functional MRI approach, Pierce et al. compared three groups of age-matched speakers in a Chinese lexical tone discrimination task: 1) IA children originally born in China and adopted into French-speaking families (mean age of adoption, 12.8 mo), 2) highly-proficient simultaneous bilingual Chinese-French speakers, and 3) monolingual French speakers. Results of the study revealed that the patterns of brain activation of IA, who have no functional knowledge of their birth language (Chinese), are similar to those of proficient Chinese-French bilinguals when processing Chinese lexical tones (2014). Both groups processed these tones as linguistically relevant, whereas the French monolingual speakers processed these tones as acoustically, but not linguistically, relevant. In the current study we performed a manual Region of Interest (ROI) grey matter segmentation analysis with the T1-weighted MRI images of the same three groups of speakers previously

reported by Pierce et al. (2014). The objective of our study was to determine if the differences in neural activation patterns observed between groups by Pierce et al. (2014) were accompanied by anatomical grey matter changes. We selected an ROI in the left superior temporal gyrus (STG), planum temporale (PT) that was found to reveal a peak activation during the lexical tone discrimination task in Pierce et al.'s findings (2014). Results of our study revealed a significant difference in grey matter volume between the bilingual and the monolingual groups in the left PT ROI (p = 0.02), with the bilinguals having greater volume compared to the monolinguals. Notably, the left PT grey matter volume of the IA children group was found to be between those of the monolinguals and the bilinguals. This suggests that early but discontinued exposure to a language during infancy modulates brain structures well into adulthood, although to a lesser degree than does maintained exposure to the language. Our finding provides additional evidence of the deep-rooted effects of early language exposure on the brain, not only at the neural connectivity level, but also at the anatomical level. This aligns with an optimal period framework for language, specifically regarding phonology.

Topic Areas: Development, Multilingualism

Individual variability in infants' cortical tracking of speech rhythm relates to their word segmentation performance

Poster G45 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session G.

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Young infants are very sensitive to the rhythm of speech (Nazzi et al., 1998). Rhythmic cues help infants to identify words and phrases in continuous speech, necessary to start building a lexicon (Cutler, 1994). Neural oscillations in the adult brain track the rhythm of speech, synchronising with the incoming speech envelope to focus on salient aspects of the input (Lakatos et al., 2008, Giraud & Poeppel, 2012). This cortical tracking of speech might be a possible neural mechanism through which infants can effectively use rhythmic cues for early language learning. In the current study we related infants' cortical tracking of rhythm to their later word segmentation performance. We measured EEG in 7.5-month-old Dutch-learning infants (N=108) while they listened to stretches of speech (nursery rhymes), as well as to rhythmically regular (2.5 Hz) and irregular trains of complex tones (beeps). At 9 months the same infants took part in a headturn-preference task assessing their word segmentation ability. Here infants were familiarised with passages containing a reoccurring bisyllabic trochaic pseudoword, and tested on listening times for familiar and novel word-lists. At 7.5 months the infant brains entrained to the rhythm of the regular beeps, as evidenced by a larger 2.5 Hz power over bilateral frontotemporal electrodes for regular compared to irregular beep trains (cluster p<.001; N=51 datasets with enough trials after artifact rejection). Speech-brain coherence (SBC) to the nursery rhymes was assessed by looking at the consistency of the phase difference between the EEG signal and the speech amplitude envelope, for frequencies from 1-7 Hz (encompassing frequencies of occurrence for stress, words and syllables). We compared the observed SBC to SBC of randomised data (with shuffled speech envelope), and used cluster randomisation to assess all electrodes and frequencies in one test. The infants showed significant SBC over all electrodes from 1-7 Hz (N=58; cluster p<.001). In a next step, both the entrainment to the 2.5 Hz beeps and the SBC were related to the infants' familiarity effect in the word segmentation experiment. While there was no relation for the non-linguistic beep entrainment, there was a correlation between the nursery-rhyme SBC and the familiarity effect. Again cluster-randomization was used to assess the correlation for all electrodes and frequencies in one test. A left-lateralised cluster was identified showing a negative correlation between the nursery-rhyme SBC at 1.5-1.75 Hz and the familiarity effect (cluster p=.033; N=39 included in both experiments). Infants with larger SBC at 1.5-1.75 Hz more often had a novelty effect in the word segmentation task, listening longer to novel compared to familiar word-lists. To conclude, infant brains synchronise to the rhythm of both simple beeps and speech. The current study gives evidence for the functional relevance of neural tracking of speech. Specifically for 1.5-1.75 Hz, which corresponds to the stress rate in our stimuli, SBC was related to the outcome of the word segmentation task. Around 7-8 months of age for Dutch infants the cortical tracking of stress rhythm might be particularly important for starting to identify words in continuous speech.

Topic Areas: Development, Prosody

The neural correlates of semantic control revisited

Poster G46 [Poster PDF] Visit me at [Gather.Town] in the Wernicke room during Poster Session G.

Presenter Note: Accepted manuscript available at https://www.sciencedirect.com/science/article/pii/S1053811920309290.

Rebecca Jackson[1]; [1]University of Cambridge

Semantic cognition is comprised of two distinct, yet interacting elements; semantic representation and semantic control, a distinction that forms the basis of the Controlled Semantic Cognition framework. Whilst semantic representation (the extraction and storage of the underlying structure within the environment) is relatively well studied, fewer research focuses upon semantic control; the ability to selectively access and manipulate meaningful information based on context demands. Although neuropsychological and neuroimaging results have provided some understanding of the regions involved in semantic control, the precise neural correlates are disputed. Particular debate surrounds three puzzles; (1) parietal involvement, (2) the spatial extent of the posterior temporal contribution, and (3) network lateralisation. Here semantic control was revisited, utilising improved analysis techniques and a decade of additional data to refine our understanding of the network topography. An ALE meta-analysis of 876 peaks over 121 contrasts illuminated a left-focused network consisting of inferior frontal gyrus, posterior middle temporal gyrus, posterior inferior temporal gyrus and dorsomedial prefrontal cortex. Compared to previous assessments, the current work extended the temporal region implicated into inferior temporal cortex, and found no parietal involvement. Although left-lateralised overall, relative lateralisation varied across the implicated regions with bilateral dorsomedial prefrontal cortex, left-dominant inferior frontal gyrus and posterior temporal cortex recruited exclusively on the left. Independent analyses of experiments employing visual and auditory stimuli identified highly consistent networks, and conjunction analyses were able to confirm the multimodal nature of the core network for semantic control, a key assumption of the Controlled Semantic Cognition framework. A supporting analysis situated the semantic control within the wider set of regions implicated in semantic cognition. Implications for the role of each semantic control region, the interaction semantic representations regions, and the relation to domain-general control will be considered.

Topic Areas: Control, Selection, and Executive Processes, Meaning: Lexical Semantics

Recruitment of auditory regions for visual executive processing in deaf individuals

Poster G47 [Poster PDF] [Poster Tour] Visit me at [Gather.Town] in the Wernicke room during Poster Session G.

Presenter Note: Please, if you have any question or comment on the poster, contact me at b.manini@ucl.ac.uk. If after reading my poster or attending the poster video tour, you want to understand how language influences executive function in deaf individuals, please visit poster G48 in the Wernicke Room by my co-author Valeria Vinogradova.

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Executive functions (EF) are a set of cognitive mechanisms responsible for flexible and goal-directed behaviours in complex and mutating environments (Diamond, 2013). Among other cognitive processes, EF include working memory, planning, task switching and inhibition. EF tasks typically activate frontoparietal brain regions (D'Esposito and Grossman, 1996). Recent research found evidence for functional reorganisation toward visual working memory (WM) in the superior temporal cortex (STC) of deaf individuals (Cardin et al., 2018; Ding et al., 2015), a region involved in auditory processing in hearing individuals (Kaas et al., 1999). Here we ask whether, as a consequence of deafness, auditory regions can also take over EF. If such reorganisation occurs, will it involve cognitive control as a whole, or will it only affect more specific processes within the EF tasks? Methods: Deaf (N=25) and hearing (N=20) adults took part in an fMRI scan while performing cognitive tasks tapping into four executive functions. Each task was designed to have a High Executive Function task/condition (HEF) and a Low Executive Function task/condition (LEF). The EF investigated were: WM (HEF task: WM, LEF task: colour detection task), planning (HEF task: Tower of London, LEF task: arithmetic sum), task switching (TS, HEF condition: switch, LEF condition: stay) and response inhibition (Simon task, HEF condition: incongruent, LEF condition: congruent). Analysis fMRI scans were realigned, co-registered, slice-time corrected, normalised, and smoothed (8mm FWHM Gaussian kernel) in SPM12. The data were then entered in a GLM and Region of Interest (ROIs) analysis. The ROIs analysis targeted three subregions of the auditory cortex: the planum temporale (PT), Heschl's gyrus (HG) and the posterior STC. Results: Significant differences were found in the neural response profile between the groups in two tasks: 1- WM engaged the left PT in the deaf, but not in the hearing individuals. During the WM (vs control) condition, only the hearing group showed suppression of activity in the posterior cingulate gyrus and the inferior parietal lobule (part of the default mode network, DMN). 2- TS recruited deaf individuals' temporal areas. The neural response was positively correlated with the behavioural switching cost in both the right STC and the left HG. The postcentral gyrus (PoG) and the occipital portion of the calcarine sulcus (right hemisphere) also displayed increased activity in the deaf group during this task. Discussion Functional reorganisation towards specific aspects of visual executive functions tasks was observed in auditory regions of deaf individuals. This suggests that sub-regions of the auditory cortex may take over specific processes of EF, but they do not have a general role in cognitive control. We found that WM and TS recruit temporal regions in deaf individuals. Different profiles of activity between groups were also found in brain regions beyond the auditory cortex (i.g., DMN, PoG, calcarine sulcus), suggesting that the neural reorganisation observed as a consequence of deafness is not limited to regions involved in auditory sensory processing.

Topic Areas: Control, Selection, and Executive Processes, Signed Language and Gesture

Language experience in deaf individuals is linked to behavioural performance and neural reorganisation in the auditory cortices during planning and switching tasks

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Introduction: Executive functions (EFs), such as inhibition and working memory, are crucial for navigating everyday life and carrying out higher order cognitive processes (e.g., Best & Miller, 2010). The connection between EFs and language has been documented in studies of typically developing and special populations, especially in those with developmental language disorders (e.g., Marini et al., 2020). In deaf individuals, language acquisition experience and subsequent proficiency varies greatly. We aim to investigate how language proficiency in deaf individuals is related to EF processing and neural reorganisation in the brain. Methods: 25 deaf participants took part in the study. They had different language backgrounds, reflecting the heterogeneity observed in deaf communities, with varied proficiency and age of language acquisition in signed and spoken language. To measure language proficiency, we used grammaticality judgement tests in both BSL (BSLGJ) and English (EGJ). Our aim was to represent the language ability of each participant in their most proficient language. Z-scores were obtained from performance in the BSLGJ and EGJ tests separately, and, for each participant, the higher z-score was combined into a single measure of language proficiency independently of modality. The fMRI neuroimaging session consisted of 4 tasks tapping into different EFs – working memory (WM), planning (Tower of London), switching (Switching), and inhibition (Simon) – with each task having a HEF (higher executive function) and a LEF (lower executive function) condition (HEF: working memory, LEF: colour detection; HEF: planning; LEF: simple mental arithmetic; HEF: switch, LEF: stay; HEF: incongruent, LEF: congruent). The neuroimaging data were realigned, co-registered, slice-time corrected, normalised, and smoothed using SPM12, and then entered into a 1st-level GLM. An ROI analysis was conducted on temporal (planum temporale – PT, Heschl's gyrus, and superior temporal cortex – STC) and fronto-parietal regions. Results: The deaf group had significantly slower RTs in all tasks and less accurate performance in the switching task. In the planning task, the RT in the LEF condition (simple mental arithmetic task) negatively correlated with language z-score, and in the switching task, there was a significant positive correlation between accuracy in the HEF condition (switch) and language z-score. Language z-scores were positively correlated with neural activity in the PT and in the STC in both conditions of the planning task. Conclusion: Our study revealed a link between language proficiency and performance during a switching task and during solving basic mental arithmetic problems. There was also a correlation between language proficiency and recruitment of temporal regions associated with language for planning. Our results demonstrate that early language experiences could affect the development of EFs, with better language skills supporting better EF skills, and that this is also reflected in the level of brain reorganisation in the deaf group.

Topic Areas: Control, Selection, and Executive Processes, Signed Language and Gesture

Investigating different alignment methods between natural and artificial neural networks for language processing

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Presenter Note: Contact Anand Bollu (abollu@andrew.cmu.edu) with any questions.

Anand Bollu[1], Mariya Toneva[1], Leila Wehbe[1]; [1]Carnegie Mellon University

Aligning the internal representational spaces of state-of-the-art natural language processing (NLP) models with those of the brain has revealed a great deal of overlap in what both systems capture about their language input. Prior work investigated this alignment using linear encoding models that predict each fMRI voxel as an independent linear combination of the NLP representations[1]. However, a linear mapping may fail to align nonlinearly encoded information within the NLP and fMRI representations, and is not well equipped to benefit from information shared among groups of voxels. Here, we investigate the effect of varying encoding model complexity on alignment performance. We align fMRI recordings of 8 participants reading naturalistic text word-by-word with intermediate representations from BERT[2], a state-of-the-art NLP model, that correspond to the stimulus text[3]. We investigate three encoding models that predict the fMRI voxels as a function of the BERT representations: LinearAnalytical - linear model where weights were estimated using a closed-form solution; LinearGD - linear model trained using gradient descent (GD); MLPGD - multilayer perceptron (MLP) with one hidden layer trained using Batch GD. Two key features separate MLPGD from the linear models: (1) a nonlinear activation layer and (2) predicting all voxels jointly using a shared hidden layer. We include LinearGD to identify whether any performance differences can be attributed to the training method. We evaluate alignment performance by computing the mean Pearson correlations[4] between predicted and true voxel activities within regions of interest (ROIs) known to be consistently activated during language processing[5,6]. We additionally evaluate each encoding model against a noise ceiling[7], computed based on pairwise correlations between participants' fMRI recordings. We use paired t-tests to test for significant differences between model performance across subjects and pycortex[8] to visualize voxel correlations on a 3D brain surface. We find no significant difference between LinearAnalytical and LinearGD ($p>0.05$ for all ROIs). LinearGD performs on par with the noise ceiling in 5 ROIs ($p>0.2$), and worse in the dorsomedial prefrontal cortex (dmPFC, $p=0.009$), inferior frontal gyrus pars orbitalis (IFGorb, $p=0.05$) and posterior cingulate (pCingulate, $p=0.06$), revealing room for improvement in those regions. Differences between LinearGD and MLPGD evaluated based on the whole ROIs are not significant ($p>0.05$), but qualitative analysis reveals smaller clusters within the dmPFC, IFGorb and pCingulate where MLPGD outperforms LinearGD. We further observe that the encoding models sometimes outperform the estimated noise ceiling, especially within the posterior temporal lobe, angular gyrus and middle frontal gyrus. Interestingly, our qualitative analysis of voxel correlations reveals clusters within the dmPFC, IFGorb and pCingulate that are better predicted by the MLP architecture. One interpretation of this finding is that these clusters may process different information from the rest of the region -- information that only a

nonlinear alignment can reveal -- but further investigation is necessary. We also find that the noise ceiling computation provides suboptimal estimates. A better noise ceiling may provide stronger evidence for our observations and highlight other areas where the encoding model can be improved upon as a guide to future research. References: https://tinyurl.com/y2v23rd2

Topic Areas: Computational Approaches, Reading

Reccurrent Neural Networks Models for Developmental Language Acquisition: Reservoirs Outperform LSTMs

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We previously developed cortico-striatal models for sentence comprehension (Hinaut & Dominey 2013) and sentence production (Hinaut et al. 2015). The sentence comprehension model is based on the reservoir computing principle: a random recurrent neural network (a reservoir) provides a rich recombination of sequential word inputs (e.g. a piece of prefrontal cortex), and an output layer (e.g. striatum) learns to "reads-out" the roles of words in the sentence from the internal recurrent dynamics. The model has several interesting properties, like the ability to predict the semantic roles of words during online processing. Additionally, we demonstrated its robustness to various corpus complexities, in different languages, and even its ability to work with bilingual inputs. In this study, we propose to (1) use the model in a new task related to a developmental language acquisition (i.e. Cross-Situational Learning), (2) provide a quantitative comparison with one of the best performing neural networks for sequential tasks (a LSTM), and (3) provide a qualitative analysis on the way reservoirs and LSTMs solve the task. This new Cross-Situational Task is as follows: for a given sentence, the target output provided often contains more detailed features than what is available in the sentence. Thus, the models have not only to learn how to parse sentences to extract useful information, but also to statistically infer which word is associated with which feature. While reservoir units are modelled as leaky average firing rate neurons, LSTM units are engineered to gate information using a costly and biologically implausible learning algorithm (Back-Propagation Through Time). We found that both models were able to successfully learn the task: the LSTM reached slightly better performance for the basic corpus, but the reservoir was able to significantly outperform LSTMs on more challenging corpora with increasing vocabulary sizes (for a given set of hyperparameters). We analyzed the hidden activations of internal units of both models. Despite the deep differences between both models (trained or fixed internal weights), we were able to uncover similar inner dynamics: the most useful units (with strongest weights to the output layer) seemed tuned to keep track of several specific words in the sentence. Because of its learning algorithm, it is predictable to see such behavior in a LTSM but not in a reservoir; in fact, the LSTM contained more tuned-like units than the reservoir. These differences between LSTMs and reservoirs highlights differences between classical Deep Learning approaches (based on back-propagation algorithm) and more plausible brain learning mechanisms. First, the reservoir is more efficient in terms of training time and cost (the LSTM needs several passes on the training data, while the reservoir uses it only one). Secondly, only the reservoir model seems to scale to larger corpora without the need to adapt specifically the hyperparameters of the model. Finally, the presence of more tuned units in the LSTM compared to the reservoir might be an explanation of why the LSTM seems to overfit too much to training data and have limited generalization capabilities when the learning data available becomes limited.

Topic Areas: Computational Approaches, Development

A minimal reduction of dendritic structure and its functional implication for sequence processing in biological neurons

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Biological neurons integrate synaptic input within a rich morphological structure called the dendritic tree. Previous work has shown that dendritic structure provides powerful computational primitives (Koch, 1999; London & Häusser, 2005) and supports cognitive functions such as the maintenance of associative memories (Kastellakis et al., 2016) and single-trial learning (Haga & Fukai, 2018). Here, we explore the possible functional contribution of dendrites to sequence processing. We developed a reduced model of a biological neuron, called the tripod model, and investigated the function of dendritic structure through computer simulations. The neuron model had three segregated compartments, two dendrites and the soma. The dendrites were passive membrane patches (Koch, 1999), and the soma had adaptive exponential dynamics (Brette & Gerstner, 2005). Synapses were conductance-based, and those located in the dendrites had non-linear voltage-gated channels that mimic NMDA receptor dynamics (Antic et al., 2010). Soma and dendrites were regulated by feedback and feed-forward inhibition with different timescales (Tremblay et al., 2016). The tripod neuron implements the simplest structural reduction of the dendritic tree. First, we compared two sets of biological parameters obtained from physiological measures in mice and modelling in humans. We show that NMDA dynamics translates synaptic efficacy into the duration of the memory trace for afferent input. Our simulations indicate that human-like dendrites favor non-linear dynamics and retain information over longer timescales. Next, we varied the electrical coupling between compartments and this produced distinct computational functions. When the two dendrites had similar geometries, the neuron operated as an AND or OR gate. With different geometries, the dendrites had two integration timescales. The shorter one governed the spike times whereas the longer one modulated somatic activity. Segregated compartments showed a local balance of excitation and inhibition and targeted inhibitory connections could selectively switch off one of the two dendritic pathways, with minimal effect on the other passive compartment. We then used these dendritic mechanisms in a language-like task where simple sequences had to be recognized by a single neuron (e.g., AB versus BA). We found that the tripod model was sensitive to changes in the spatial location of synaptic activity and could track variations in the stimulus. When endowed with spatially-asymmetric feedback, it could distinguish the order of elements in the sequence, purely based on the dendritic location of the input, and without learning. These findings suggest that the spatial segregation of synaptic activity in the dendritic tree supports the processing of information with temporal structure. Feedback afferents from higher cortical areas target different dendritic locations than feed-forward inputs from lower areas. The tripod model shows how these asymmetries lead to a differential spike-response, and that single-compartment kernels may not account for the integration between sensory and conceptual information. Eventually, this approach might also shed light on the role of NMDA receptors in working memory (Wang, 1999) and event-related potentials (Baggio & Hagoort, 2011). Overall, this work suggests that language models that are based on highly simplified neurons without dendritic structure might miss important functional features of cortical computation.

Topic Areas: Computational Approaches, Speech Perception

What counts? A comparison of aphasia treatment outcome measures in single-case experimental designs.

Poster G52 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session G.

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A major challenge for aphasia research is determining the magnitude of change secondary to intervention and qualifying the impact of that change, particularly in single case experimental design, which represents the majority of experimental research in aphasia. One commonly used method involves calculating effect sizes (ES) based on performance across repeated pre- and post-treatment assessments (Beeson & Robey, 2006). Recently, Howard et al. (2015) proposed an alternative approach (WEighted STatistics [WEST]), arguing that ES calculations do not account for random variation in item-level performance. It is not clear if these two approaches yield consistent results or if one approach is superior in capturing meaningful change. Thus, the goal of the current study was to directly compare ES with WEST calculations to determine if the two approaches yield different results. Here, we present data from two individuals with chronic post-stroke aphasia who participated in an ongoing clinical trial assessing the efficacy of repetitive transcranial magnetic stimulation (rTMS) to enhance aphasia recovery when paired with a behavioral intervention. Patient 1 (P1) was 55 years old, 98 months post-stroke onset (MPO), with a left perisylvian frontotemporal infarct. Patient 2 (P2) was 58 years old, 15 MPO, with a left perisylvian frontotemporal, inferior parietal, and occipital infarct. Both participants received 10 semi-consecutive sessions of 1 Hz inhibitory rTMS to Broca's area homologue immediately followed by 60 minutes of constraint induced language therapy (CILT). Seventy-two action images designed to elicit sentences comprised of an agent noun, verb, and patient/place were used for a modified CILT (mCILT) behavioral treatment protocol. We obtained two full-set, pre-treatment baseline measures of sentence production. Baseline performance informed the selection of treated and untreated items, which were matched for noun lexical frequency and noun response accuracy consistency, i.e. equal proportion of high vs. low frequency agent nouns that were inconsistently or never accurate. All stimuli were probed within 10 days following treatment (T0) and at 3- (T3) and 6-months (T6) post-treatment. ES were computed for each follow-up time point to assess treatment gains, maintenance (small=3.88; medium=6.56; large=11.14) and generalization (small=3.29; medium=5.52; large=9.53), and compared with the WEST COmpare Level of performance (WEST-COL). P1's ES revealed treatment-induced improvements for nouns with maintenance through T6 (ES's>13.43), verbs at T0 (ES=8.25), and sentences at T0 and T3 (ES's>3.54); however, there was no evidence of treatment generalization (ES's<1.41). WEST-COL yielded similar results for nouns and sentences (p's<.04), but verbs were not significant (p's>.13). For P2, ES revealed treatment-induced improvements for nouns with maintenance through T6 (ES's>10.61) and generalization at T0 (ES=4.24), and generalization maintenance for verbs and sentences through T6 (ES's>6.35). WEST-COL was mostly consistent with ES except for nouns, which indicated generalization and maintenance through T6 (p's<.001). While preliminary, these findings suggest that inferences regarding treatment effectiveness may differ depending on the outcome measure. Although, the two measures were relatively consistent, the control of item-level variability using the WEST procedure may be advantageous particularly when there are limited baseline observations. Further research is needed to guide clinicians and researchers to the best approach.

Topic Areas: Language Therapy, Disorders: Acquired

Morpho-Phonologically Based Treatment for Hebrew Speaking Individuals with Aphasia: An Intervention Study

Poster G53 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session G.

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Introduction: Anomia is a common characteristic in all types of aphasia. Despite the extensive knowledge that has been accumulated on aphasia therapy, there are no naming treatment studies in Hebrew - a Semitic language with rich morphology. All verbs and the majority of nouns and adjectives in Hebrew are composed of a three consonant root embedded in a phonological pattern. Roots and patterns are intertwined together in a non-concatenative way, to form words. Words sharing the same root are often semantically related. Studies have shown the prominent role of the root morpheme in access to Hebrew words. The aim of our study is to examine the effects of a new root-based treatment on naming abilities and the rearrangement of their neural circuits among Hebrew speaking individuals with aphasia. Methods: Participants: fourteen adults with chronic post-stroke aphasia and significant anomia. Till now, four patients were recruited for the behavioral part as a pilot: two of them had anomia resulting from a phonological output lexicon deficit, and two had anomia resulting from semantic and phonological output lexicon deficits. Morphology-based treatment: The treatment includes three pre-treatment language assessments. Based on each participants' naming performance of our morphological naming test, 30 treated words, and 30 untreated (control) words are chosen. Each participant receives twenty bi-weekly frontal treatment sessions, followed by three post-treatment language assessments, and another follow-up assessment 10 weeks after the final treatment session. The treatment is composed of three steps: 1) Increasing morpho-phonological awareness to the semantic-morpho-phonological relations between words sharing a root. E.g., “miʃkefet” (binoculars) and “maʃkifim” (overlook), which share the root: ʃ.k.f.; 2) Morpho-phonological recognition of words sharing a root, out of three additional distractors; 3) Naming a picture of the target word, in a sentence completion task, where the sentence contains a verb with the same root, e.g ., The clinician said, “Hu maʃkif be…” (he looks around with a….), and participants were requested to complete “miʃkefet” (binoculars). The other ten participants will undergo fMRI scans, before and after the morphological treatment, to explore changes in brain activity and effective connectivity. Preliminary behavioral results: When comparing pre- and post-treatment naming performances of the four patients: i) Treated Words: all four participants demonstrated a significant improvement in naming treated words, with greater effect sizes for participants with phonological anomia. For three of them, this improvement was preserved in the 10-week follow-up assessment; ii) Untreated Words: One participant with phonological anomia significantly improved in naming untreated words in the follow-up assessment. To conclude, following the morpho-phonologically based treatment all four patients improved in naming the treated words and one demonstrated generalization to untreated words. These preliminary results point to the potential effectiveness of the treatment for Hebrew speaking individuals with aphasia. We are now collecting data for a larger sample of patients, to test treatment generalizability, the effect of the type of deficit and the associated changes to neural mechanisms.

Topic Areas: Language Therapy, Morphology

Does the brain recruit the same word representations across language behaviours? A Registered Report MEG study of language production versus perception

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Presenter Note: This is a Registered Report under review, and so we do not yet have the data. We are especially interested in getting feedback on the study before it is run and welcome any and all comments and questions. If you can't find me at the conference/in Gather.Town, please email amie.fairs@univ-amu.fr. Thanks!

Amie Fairs[1], Xenia Dmitrieva[1], Valerie Chanoine[1], Benjamin Morillon[1], Amandine Michelas[1], Sophie Dufour[1], Friedemann Pulvermuller[2], Kristof Strijkers[1]; [1]Aix-Marseille Universite, [2]Freie Universitat Berlin

Traditionally, language production and perception have been studied in isolation, but investigating both behaviours jointly is needed to understand language use in its default context: conversation. Presently, however, the overlap between the modalities of production and comprehension for the basic building blocks of language, words, is unclear. We aim to fill this gap by comparing the spatiotemporal dynamics of word activation between production and perception using MRI-constrained magnetoencephalography (MEG). According to (partial) Separation Models (pSM), words are activated in a behaviour-specific manner: temporally, meaning-related information is accessed before sound-related information in production, and vice versa in perception; and spatially: both temporal and frontal brain regions play a role in production, whereas only temporal regions are involved in perception. In contrast to these models, Integration Models (IM) predict similar brain dynamics in the temporal and spatial domains in production and perception. In both behaviours, the same meaning- and sound-related information is accessed early and in parallel over distributed fronto-temporal circuits. To contrast these hypotheses, 40 participants (as established with power analyses using minimal detectable effect sizes) will carry out an MEG experiment containing a production task (picture naming) and a perception task (passive listening). The same stimuli will be presented in both tasks, with two linguistic manipulations testing meaning and sound: whether the stimuli are animals or tools (the Meaning manipulation), and whether the stimuli are bilabial- or alveolar-initial words (the Sound manipulation). Both manipulations have established cortical dissociations, thus showing spatially different activation networks. We will rely on these cortical dissociations as markers for lexico-semantics (Meaning) and phonology (Sound), and (a) contrast their activation time-course between production and perception, and (b) assess whether activation in one behaviour predicts the other behaviour. Regions of interest (ROIs) will be defined individually for each participant using fMRI localizer tasks, with source-level MEG data used for analysis. To contrast the source-level activation time course per ROI between behaviours, data will be analysed in 25ms time bins using linear mixed effects models. The models will contain the predictors Behaviour (perception vs production), Meaning (animals vs tools) and Sound (bilabial vs alveolar). pSM predict that we should see interactions between Behaviour and Meaning/Sound in specific regions, such that Meaning effects are found prior to Sound effects in production, and vice versa in perception. Additionally, during perception, only ROIs in the temporal cortex should show Meaning and Sound effects. IM predict effects of Meaning and Sound in similar (early) time bins, in both behaviours, in frontal and temporal ROIs. To assess whether activation relating to the manipulations in one behaviour can predict the other behaviour, we will conduct temporally-generalised multivariate pattern analysis (i.e. decoding across time), where classifiers will be trained on the Meaning and Sound predictors in one behaviour and tested on the other behaviour at all possible time points. Overall, this study will allow us to address whether words are represented as the same functional units, or rather recruit interacting, but dissociable, processing pathways in each behaviour.

Topic Areas: Language Production, Speech Perception

A systematic investigation of oral and written language production in fMRI

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Neural substrates underlying language processing have been described using a combination of electrophysiological and neuroimaging methods. Focusing on single word production, separate studies have shown that speaking and writing are supported by similar brain regions, such as the inferior frontal gyrus, premotor and sensorimotor cortex, as well as parietal areas. Behavioral studies have also suggested that common cognitive mechanisms are shared between modalities (e.g., Pinet & Nozari, 2018). However, it is unclear whether differences in motor processes between the spoken and written modalities extend to upstream linguistic processes as well, beyond the differential retrieval of specific phonological/orthographic representations. Regardless of the output modality, words can be produced in a variety of contexts, stemming from different stimuli (e.g., reading a word, naming an object). Activation in some regions underlying lexical selection, for instance pre-SMA and SMA, is directly related to the generative nature of the task, such that internally generated language rely more on these areas than externally generated language (Alario et al., 2006; Tremblay & Gracco, 2005). Therefore it is necessary to take into account word elicitation context when examining word production. The aim of this functional Magnetic Resonance Imaging (fMRI) study is to systematically compare the similarities and differences between output modalities (speaking and writing) of language production. In order to give a full picture in several language production contexts, production will be elicited using various inputs (picture, written and auditory words), resulting in six distinct tasks: reading, spelling, repetition, copying, oral and typed picture naming. Thirty-five participants are currently being recruited for their ability to type well without looking at their hands. Participants will be presented 252 stimuli (pictures, written or auditory words), and will have to say them aloud or type them on a MR-compatible keyboard. A block design will be used in which activation and control blocks of 15s are intermixed with rest-fixation periods to allow the hemodynamic response function to return to baseline. Control conditions will account for the visual or acoustic sensory processes and motor processes specific to each task. Analysis will follow three main objectives: (1) performing two-by-two between-task comparisons (e.g., reading vs. spelling), (2) elucidating the role of specific regions of interest (e.g., ventral occipitotemporal cortex, superior temporal sulcus), and (3) uncovering the semantic, phonological and orthographic neural networks. A complementary objective is to determine to what extent the specific motor circuitry recruited by each production modality (i.e., speaking and typing) determines the upstream activation of the language production network, which will subsequently provide answers regarding the involvement of the motor network (e.g., cerebellum, basal ganglia) in language production. Such a systematic evaluation across several input and output modalities will give us unprecedented information on the organization of the language system. It holds the promise of updating current neuroanatomical models of language production by taking into account the differential implication of brain areas in various production contexts.

Topic Areas: Language Production, Writing and Spelling

Left-handedness, Male Sex, and Anomalous Language Lateralization in Adults with Reading Disability: A New Twist on an Old Observation.

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Anomalous language lateralization has been theorized as important to the pathogenesis of reading disability based on early observations of an increased amount of left-handedness, male sex, and epilepsy within dyslexia cohorts. Studies that have tested this hypothesis have found support for differences in language lateralization within dyslexia populations, but have focused on children or young adult populations and many employed methodologies that lack high spatial and temporal fidelity. Here, we utilized magnetoencephalography (MEG) imaging techniques to determine the pattern of language activation as well as measure the degree of atypical lateralization associated with reading disability (RD) in a group of adults with and without a history of RD. 282 healthy individuals who underwent a formal research neurology visit including structural brain imaging, and determined to possess normal cognition, filled out a structured questionnaire on past and current reading habits known as the adult reading history questionnaire (ARHQ). Based on the history obtained during their visit along with their ARHQ score, a subset of 14 RD (n=14; 6 left-handed; 9 male) and 18 nRD controls (n=18; 4 left-handed; 4 male) were recruited to undergo MEG imaging language lateralization testing. Across the heathy control cohort, linear modeling demonstrated that left-handedness and male sex each significantly predicted RD as measured by a higher AHRQ score (left-handedness, p=0.002; male sex; p=0.036). Within the subgroups recruited for neuroimaging studies, the RD cohort possessed a higher percentage of male sex (p=0.02) and performed worse on measures isolated to phonological processing (p<0.004 for both digits forwards and digits backwards). Voxel-based morphometry MRI analyses revealed no differences within left-sided language regions. In contrast, MEG functional imaging whole-brain analyses identified beta-band (12-30Hz) activity reductions in the left-hemisphere within the middle temporal gyrus (MTG) and visual word form area (VWFA) of the RD cohort (p<0.001). While standard laterality analyses for hemispheric dominance yielded no significant differences, analyses restricted to VWFA and MTG regions demonstrated a higher degree of anomalous language lateralization within the RD cohort (RD vs. nRD LI, p=0.03). Further, this pattern of anomalous language lateralization was the consequence of reduced left-sided VWFA and MTG activation (RD vs. nRD, p=0.006). Taking advantage of stable adult brain networks, we captured focal activity decreases within key occipito-temporal regions implicated in dyslexia. These regional hypoactivations resulted in an increased rate of anomalous language lateralization, which in turn was driven by selective left-hemisphere decreases in VWFA and MTG activity. Together these findings support the hypothesis that disconnection of the visual word system from reading and language networks is a common cause for RD.

Topic Areas: Disorders: Developmental, Multisensory or Sensorimotor Integration

Corpus callosum involvement in language ability after left-hemispheric stroke

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The left hemisphere (LH) is dominant for language in the majority of the healthy population. Patients with LH-damage may show global right-hemisphere (RH) activity for language. This makes interhemispheric transfer a good candidate for a brain plasticity mechanism through which speaking abilities may recover. However, the brain structures enabling this functional reorganization remain largely unknown. In this study, we investigate the involvement of the major white-matter commissural pathway, corpus callosum (CC), in language performance after stroke. The study sample consisted of 19 left-hemispheric stroke patients (mean age = 56, SD = 11) and 22 age, sex and education-matched healthy controls (mean age = 59, SD = 12). All participants were right-handed and underwent high resolution diffusion weighted imaging (DWI). Participants carried out a picture-word interference task (PWI) and the Amsterdam-Nijmegen Everyday Language Test (ANELT), which investigates functional communication. We focused on three portions of the CC: genu, anterior midbody and splenium. Anatomical definition of the three corresponding regions of interest (ROIs) was specified on the MNI brain template following the parcellation proposed by Hofer and Frahm (2006). Subsequently, these ROIs were transferred to each participant's native space DWI and their corresponding white-matter circuitry was obtained using probabilistic tractography implemented in FSL Probtrackx. The outputs were thresholded at 50% of the robust range and binarized, then used to extract microstructural (Fractional Anisotropy, FA) and macrostructural (Volume) properties of the three CC portions. Picture naming times were shorter for controls than for patients ($p = .021$). When naming pictures with a distractor word relative to a congruent distractor, there was a significant difference in the congruency effect between patients and controls ($p = .030$). Finally, patients scored lower on functional communication ($p = .013$). Significant differences were found between patients and controls' FA for genu ($p = .025$) and for anterior midbody ($p = .008$), but not for splenium. To summarise the location of the lesions across the entire sample, hierarchical clustering was used on the proportion of damage to major gray matter gyri. Preliminary results suggested two separate clusters: one with smaller lesions located mainly in the temporal lobe, the other one with bigger lesions encompassing both frontal and temporal lobes. For the genu, the mean FA value in controls was 0.461 (SD = 0.022), for patients in the small-lesions cluster 0.449 (SD = 0.022) and for patients in the big-lesions cluster 0.430 (SD = 0.030). For the anterior midbody, the mean FA in controls was 0.466 (SD = 0.026), for the small-lesions cluster 0.450 (SD = 0.031) and for the big-lesions cluster 0.407 (SD = 0.065). Finally, the mean FA of splenium for controls was 0.532 (SD = 0.032), for the small-lesions cluster 0.527 (SD = 0.024) and for the big-lesions cluster 0.520 (SD = 0.043). To check for possible relationships between the structural integrity of the CC portions and performance in the behavioral tests, we will adopt an exploratory approach, using a series of Spearman correlations.

Topic Areas: Disorders: Acquired, Language Production

Electrophysiological connectivity and network changes after high-definition transcranial direct current stimulation in post-stroke aphasia

Poster G58 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session G.

Presenter Note: Email prishah@mcw.edu for more details.

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Stroke recovery is thought to depend on neuroplastic changes within the preserved brain areas. In aphasia, language recovery relies on spared left-hemispheric areas, surrounding the stroke lesion (perilesional), and/or right-hemispheric contralateral areas. Evidence suggests however that the functional capacity of the perilesional areas is compromised due to the surrounding lesion. Using resting-state magnetoencephalography (rsMEG), we and others have shown that spontaneous neural activity in perilesional areas is abnormal, exhibiting shifts toward slower electrical activity and alterations in signal complexity. The observed slowing in relatively intact brain tissue can hinder recovery processes. Guided by these results, in a recent study, we investigated whether perilesional dysfunction can be temporarily remediated by high-definition transcranial direct current stimulation (HD-tDCS) in chronic aphasia. Improvements in sentence repetition accuracy were found after excitatory/anodal-tDCS, accompanied by decreases in slow activity, as indicated by reduced contralateral theta (4-7Hz) and coarse-scale multi-scale entropy (MSE), and increases in perilesional low-gamma (25-50Hz) and fine-scale MSE (fast activity), indicating reversal of abnormalities. Our goal moving forward is to expand our approach, focused on local abnormalities and changes thereof from tDCS, to evaluating global changes by examining functional connectivity (FC) and network properties, encompassing the perilesional and contralateral areas. We are developing rsMEG analysis pipelines for computing power/amplitude envelope correlations (AEC) and phase-based long-range synchronization measures to characterize electrophysiological FC and networks, and the effects of perilesional anodal-tDCS and contralateral cathodal-tDCS in post-stroke aphasia. Ten-minutes of rsMEG from 21 chronic aphasia survivors and 20 age-matched healthy controls will be analyzed. The current pipeline's capabilities are: source, grid-based MEG reconstruction using a scalar beamformer; parcellation and singular value decomposition to extract representative signals from atlas-defined nodes; for AEC, Morlet wavelet decomposition for time-frequency representations in log-frequencies from 2-128Hz, pairwise spatial leakage correction and power envelope correlation analysis between node pairs within frequency bands from theta to high-gamma (2-128Hz); computing phase-based measures (weighted phase-lag index and phase-locking value) in the same frequency bands. MEG collected pre- and post-20-minutes of anodal-, cathodal- and sham-tDCS will be analyzed in 12 aphasia survivors to evaluate post vs. pre differences in FC and network properties. Correlation analyses between FC differences and tDCS-related changes in language performance are planned. Aspects of pipeline under-development are whole-brain FC computations with stimulation sites as seed regions, and application of graph theory measures to evaluate global and local network efficiency. We expect frequency-specific differences in intra- and inter-hemispheric FC in aphasia survivors compared to controls among the language regions. FC changes in the theta and low-gamma bands are expected, indicating reduced theta but increased low-gamma connectivity after anodal-tDCS, which will be correlated with improved language performance. Network efficiency analysis will reveal reduced (abnormally high) global and increased perilesional, local efficiency after anodal-tDCS. Our study has important clinical implications to better understand the FC and network (re)configurations in aphasia, and alterations from tDCS that support language recovery.

Topic Areas: Disorders: Acquired, Methods

Maternal Stress, socioeconomic status, and auditory statistical learning in 24-month-olds: an event-related potential study

Poster G59 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session G.

Lara Pierce[1,2], Erin Carmody-Tague[1], Charles Nelson[1,2,3]; [1]Boston Childrens Hospital, [2]Harvard Medical School, [3]Harvard University

Children raised in low socioeconomic contexts have been found to underperform on language measures compared to their peers from higher-SES backgrounds. However considerable individual differences have been observed, and the extent to which socioeconomic variables influence the neurocognitive mechanisms underlying language acquisition are not well understood. Auditory statistical learning, or the ability to segment a continuous auditory stream based on its statistical properties, develops during early infancy and is one mechanism thought to underlie language learning. The present study used an event-related potential (ERP) paradigm to test whether socioeconomic variables (e.g., family income, maternal education, maternal stress) were associated with neurocognitive processes underlying statistical learning in a predominantly low- to middle-income sample of 24-month-old children (n = 19). Event-related potentials were recorded while children listened to a continuous stream of tri-tone pseudo "words" presented in random order, such that Tone 1 always predicted Tones 2 and 3, but Tone 1 could never be predicted. Maternal reports of stress at 6, 9, and 12 months were positively correlated with N1 amplitude to Tone 3 (6 months: r = 0.579, p = 0.03; 9 months: r = 0.633, p = 0.01; 12 months: r = 0.625, p = 0.01), as well as with the difference between Tone 1 and Tone 3 (6 months: r = 0.653, p = 0.01; 9 months: r = 0.714, p = 0.003; 12 months: r = 0.613, p = 0.01), such that children of mothers who reported higher levels of stress showed a larger difference between the predictable and unpredictable tones. Results suggest that maternal stress, within a low-SES context, is associated with the manner in which children encode statistical properties of auditory input. In addition to this finding, within session changes to N1 and P2 amplitude and latency will also be discussed, along with associations between these components and language and cognitive outcomes.

Topic Areas: Development, Perception: Auditory

Tracking complex rules in language: Electrophysiological data from preschoolers

Poster G60 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session G.

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Processing of complex relationships in the auditory input lies in the core of higher cognitive functions. Complex regularities can involve nested dependencies between linguistic elements, as an essential feature of human syntax. Recent electrophysiological evidence suggests that even preverbal infants can track nested dependencies in simple tone sequences, but this remains unexplored for the linguistic domain. For the processing of simpler dependencies, upon which nested dependencies are built, a developmental change across early childhood has been reported. This change showed a decline in dependency learning under passive listening conditions and was found to be modulated by individual differences in children's basic auditory processing. Whether a similar developmental pattern applies for the processing of nested linguistic dependencies across preschool years has not been examined so far. The current event-related potential (ERP) study examined nested dependencies during preschool age and studied the relation between children's dependency processing and their pitch discrimination abilities. Importantly, we here implemented nested dependencies in linguistic stimuli, as opposed to the non-linguistic stimuli used in previous infant studies. To this end, we employed a passive-listening oddball paradigm with 2- to 4-year-old children (N = 36). The stimuli comprised standard syllable sequences (83% of trials) that followed nested dependency rules of the form [A1 [A2 C B2] B1], such that the syllable in the A1 position predicted the syllable in the B1 position, the syllable in the A2 position the syllable in B2 position, while the syllable in the central position remained identical across trials. Deviant syllable sequences either violated the expected nested dependency (8.5% of trials), by reversing the position of the two final syllables, or the expectedly applied pitch on the fourth syllable (8.5% of trials). Differential ERP responses to both deviant types as compared to the standard stimuli would indicate successful processing of the linguistic nested rules and reveal whether rule processing is modulated by pitch discrimination abilities. ERP results showed children's differential brain responses to the syllables, where either the nested rule or the pitch was violated, compared to the standard sequences. While the rule effect in the ERP was not modulated by children's age, it was predicted by the pitch effect, with larger pitch discrimination predicting larger rule detection responses. Together these findings indicate that across preschool years, children are able to process nested relations in linguistic stimuli under passive listening, modulated by their basic auditory

discrimination. This implies that enhanced auditory abilities may provide children with an advantage in the encoding of complex linguistic structures during early language acquisition.

Topic Areas: Development, Syntax

Poster Session H

Individual differences in the processing of wh-dependencies: An ERP investigation

Poster H1 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session H.

Lauren Covey[1], Alison Gabriele[2], Robert Fiorentino[2]; [1]Montclair State University, [2]University of Kansas

This study tracks the dynamics of wh-dependency resolution, examining individual differences in two distinct processes: prediction, in which the parser searches for a potential gap site upon encountering the wh-element, and integration, which occurs when the dependency is successfully resolved. The ERP literature suggests that these qualitatively different processes may be linked to distinct components: N400 for prediction (Federmeier, 2007; Lau et al., 2013; Michel, 2014; Van Berkum et al., 2005), and P600 for syntactic integration (Gouvea et al., 2010; Kaan et al., 2000; Phillips et al., 2005). To test gap prediction, we examine filled-gap effects, which occur when the parser predicts a gap in a position that is already filled with lexical material (e.g., the editor 1b/1d vs. 1a/1c) (Clifton & Frazier, 1989; Hestvik et al., 2007, 2012; Lee, 2004; Stowe, 1986). This study also examines the extent to which gap prediction is grammatically constrained, investigating whether the parser avoids predicting a gap in positions that are not licensed by the grammar, called 'islands' (e.g., Dave Campbell in 1c vs. 1d) (Johnson et al. 2016; Stowe, 1986). ***(1a-b) Jamie wondered if/who the editor interviewed Dave Campbell with __ from the department. (1c-d) Jamie wondered if/who the editor [that interviewed Dave Campbell] kissed __ after the meeting.*** Native English speakers (N=79) read sentences such as (1a/b)/(1c/d). Effects of gap prediction were examined at the subject (the editor) and object positions (Dave Campbell), inside (1c/d) and outside (1a/b) an island. Dependency resolution was examined at the actual gap (with/kissed). Participants also completed tests of working memory (counting/reading span) and attentional control (Stroop). At the subject position (the editor), N400 emerged, suggesting that a gap was predicted, and processing was disrupted at the pre-verbal filled gap. Furthermore, increased working memory was associated with smaller N400s, suggesting that individuals with higher working memory may posit that a post-verbal potential gap site is forthcoming, thus reducing the processing disruption upon encountering the subject filled gap. At the object position (Dave Campbell), the critical Wh-Extraction×Island interaction was significant. Follow-up models revealed significant N400s in both non-island (1a/b) and island (1c/d) conditions. Crucially, the N400s in the island and non-island conditions were differentially modulated by attentional control, such that better performance on the Stroop task was related to larger N400s in the non-island condition, but smaller N400s inside the island. This pattern suggests that individuals with greater attentional control show an increased ability to engage in prediction in the grammatically licensed object position, and are better able to successfully inhibit gap prediction within the illicit island domain. At the actual gap (with/kissed), P600s emerged in both conditions, indicating the wh-element was successfully integrated at the gap site. Individuals with increased working memory and attentional control showed larger P600s at the actual gap site in non-island sentences (with). Overall, these results reveal that individual differences modulate wh-dependency resolution with respect to both prediction and integration and show that individuals with higher cognitive abilities are less likely to posit gaps in positions not licensed by the grammar.

Topic Areas: Syntax, Meaning: Lexical Semantics

Information structure canonicity in the comprehension of Spanish texts: an eyetracking study

Poster H2 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session H.

Presenter Note: Thank you for your interest in our work. We would like to receive feedback on it, so feel free to contact us and send us your comments or questions: carogattei@utdt.edu.

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Introduction: Word order alternation has been described as one of the most productive information structure markers and, thus, discourse organizers across languages. Psycholinguistic evidence about processing of declarative sentences with non canonical information structure has shown that the presentation of an argument providing new information in first position entails higher reading times irrespective of word order (SVO vs. OVS), and that overall, sentences with non canonical word order (OVS) are more difficult to understand that sentences that follow the canonical word order of the language (Kaiser & Trueswell, 2004). However, little is known about how word order and information structure interact with lexico-semantic features of argument interpretation during online reading. Evidence about Spanish sentence comprehension has shown greater difficulty to parse sentences that present a word order that does not respect the order of participants of the verb's lexico-semantic structure, irrespective to whether the sentences follow the canonical word order of the language (SVO) or not (Gattei, Dickey, Wainselboim y París, 2015a, Gattei, Sevilla, Tabullo, Wainselboim, París y Shalom, 2017). Following previous studies on this topic, the authors of these studies have accounted for such difficulty as the cognitive cost related to the miscomputation of prominence status of the argument that precedes the verb. Nonetheless, the authors only analyzed the use of different word orders in sentences in isolation, leaving the pragmatic motivation of word order alternation out of their results discussion. Methods: The current study provides further evidence about the role of information structure for comprehension of Spanish sentences with different verb classes, and sheds light on the interaction between syntax, semantics and pragmatics. To this aim, we present an eyetracking text reading task in which we manipulated syntactic word order (SVO vs OVS), verb type (Activity vs Object Experiencer psych verbs) and information structure ('given-new' vs 'new-given' referents' order). Both 'early' and 'late' eye-movement measures as well as accuracy and response times to comprehension questions were analyzed. Results: Results showed an overall influence of information structure reflected in a modulation of both early and late eye-movement measures. On average, participants took longer time to read the first argument of the target sentence and regressed significantly more and for longer time to previous regions of the sentence whenever the new information was presented in first position, independently of the word order and the verb type presented. Furthermore, the miscomputation of prominence status also modulated the probability of incoming regressions to the first argument of the target sentence, and the total fixation time of the first argument and following regions whenever the word order did not reflect the arguments order of the lexico-semantic structure of the verb. Finally, response times were also affected by non-canonical information structure, verb type, and word order. Summary: All in all, the evidence here presented replicates previous findings regarding the role of information structure hierarchy for sentence comprehension, even in sentences with different verb classes. However, it also shows that the consequences related to miscomputation of prominence are still present despite of discourse related factors.

Topic Areas: Syntax, Meaning: Lexical Semantics

Symmetric retrieval in processing Mandarin relative clauses

Poster H3 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session H.

Tzu-Yun Tung[1], Jonathan R. Brennan[1]; [1]University of Michigan

INTRODUCTION: Different types of relative clauses (RC) lead to an asymmetry in processing difficulty. Subject-relative (SR) clauses show an advantage in English [2], but advantages for both SR and object relative (OR) clauses have been documented in Mandarin [1, 5]. Discrepancies may be due to stimulus ambiguities that confound RC processing with ambiguity resolution. The current study eliminates the confound, and probes word-by-word processing of Mandarin RCs using EEG. We test predictions from two computational retrieval models: Activation [3] and Direct-access [4]. We find a subject advantage at the relative verb region, but no asymmetry at the head noun region; this aligns with the Direct-access Model. STIMULI: We use a two-by-two design, crossing RC type (SR or OR) with modification type (subject-modifying, SM or object-modifying, OM). The stimuli are adapted from [1]. To remove ambiguity, a determiner, classifier, and temporal adverbial phrase establish the expectation of an upcoming RC. SR and OR conditions only differ from each other in terms of the order of the relative verb and noun. 52 sets of 4 conditions were randomized with 104 Mandarin filler sentences with similar length but various syntactic structures. EEG METHODS: N=29 right-handed healthy Mandarin native speakers (13 male, aged 20 to 52) silently read sentences while EEG was recorded (500 Hz, band-pass filtered between 0.1 and 200 Hz). Data was epoched from -300 to 1000 ms around each target word (relative verb and head noun). Eye-movement artifacts were corrected with ICA and remaining artifacts were cleaned by visual inspection (0.9%-20% of trials removed). Statistical significance was examined by non-parametric permutation-based test. RESULTS: At the relative verb region, where a gap must be posited, a frontocentral positivity effect was elicited for SMOR versus SMSR (414-756 ms; $p = 0.008$) and also for OMOR versus OMSR (192 to 680 ms; $p < 0.001$). This effect resembles that reported in [6], which was elicited by semantically plausible but unpredictable words with high surprisal value. At the head noun, when the filler noun is integrated with the gap, no differences were seen for SMSR-SMOR, or for OMSR-OMOR. CONCLUSION: This latter result contrasts with the Activation Model which predicts an object advantage due to faster retrieval in OR because of the shorter time since the gap site compared to that of SR. The result is consistent with the Direct-access Model which predicts equal processing cost since the retrieval time for SR and OR trace is constant regardless of when the trace was previously encountered. The asymmetry we find at the relative verb region follows from the unexpectedness of the structure. These data support a content-addressable cue-based search as in the Direct-access model. Supporting figures, tables, and references are available at the following link: https://tinyurl.com/yaprapyu

Topic Areas: Syntax, Meaning: Combinatorial Semantics

Genre mediates neural activations during passage listening in early elementary school

Poster H4 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session H.

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Text genre (stories versus information text) plays a critical role in students' reading comprehension (RC). Behavioral research has shown that there are distinct cognitive demands for comprehending different genres. Additionally, neuroimaging studies have confirmed the engagement of distinct brain networks during narrative and expository passage reading in older children and adults. However, no one has examined neurobiological markers of genre differences in early childhood for listening comprehension, and how they predict later RC ability. In the present study, 40 typically developing children (age M = 7.47, SD = .36) participated in a functional magnetic resonance imaging listening task for narrative and expository passages. Behavioral RC ability was measured using the Gates-MacGinitie Reading Test at the time of neuroimaging (1st grade) and two years later (3rd grade). First, we were interested in identifying the general activation patterns of genre listening comprehension. In addition to expected neural activity in language processing regions for both genre conditions, direct comparison of expository versus narrative passages revealed significant genre differences: expository listening elicited more memory-related activation, while narrative listening showed more theory of mind-related activation. We next examined how genre activations during listening longitudinally predicted RC ability. Covariate analysis investigating RC ability at 1st grade did not show any significant activations. However, growth in RC ability from 1st grade to 3rd grade was predicted by overlapping language regions for both narrative and expository listening, and by default mode network (DMN; e.g. posterior cingulate cortex) activation for narrative only. These results suggest that growth in RC ability is predicted by local mechanisms of language processing for both genres, and additionally by global mechanisms in the DMN hub for personally-salient information for narrative listening alone. Moreover, processing narrative versus expository text involves different neurobiological mechanisms, including independent memory and social regions, respectively. This study has implications for furthering our insight into early neurobiological predictors of RC growth and explores how genre is integral to this relationship.

Topic Areas: Speech Perception, Reading

Phonetic spatial selectivity using interpretable models with high-resolution cortical recordings

Poster H5 [Poster PDF] Visit me at [Gather.Town] in the Broca room during Poster Session H.

Suseendrakumar Duraivel[1], Shervin Rahimpour[2], Chia-Han Chiang[1], Michael Trumpis[1], Katrina Barth[1], Derek Southwell[2], Nandan Lad[2], Saurabh Sinha[3], Jonathan Viventi[1], Gregory B Cogan[2]; [1]Department of Biomedical Engineering, Duke University, [2]Department of Neurosurgery, Duke University, [3]Department of Neurology, Duke University

Previous work has demonstrated that the superior temporal gyrus (STG) encodes phonetic information during speech perception and speech motor cortex (SMC) encodes phonetic articulatory information during speech production. The cortical mapping of these phonetic features can be used to develop effective speech prosthesis using electrocorticography (ECoG); however, the micro-scale spatial specificity of these features is unknown. One way to characterize this spatial specificity is through the use of Decision tree analysis, an interpretable modeling technique that can characterize the spatial importance of electrodes for phonetic feature selectivity. We therefore combined high density neural recordings with decision-tree models to produce interpretable phonetic maps in sensory and motor cortex. To validate this technique, we use an ensemble decision-tree model to predict neural-responses to auditory tones in the rat auditory cortex, since the tonotopy is well established. We played 13 different tones (90 trials each) and recorded cortical signals from an anesthetized rat's auditory cortex using a 60 channel (406 um pitch) micro-ECoG (µECoG) array. Our results reveal above-chance decoding accuracy in tone prediction (ROC-AUC: 0.93 ± 0.015), and we observed spatial clustering of decision weights for each tone in accordance with existing tonotopy. We then recorded human cortical signals using a 256 channel (1.72 mm pitch) µECoG array implanted on the STG of an awake epileptic patient who listened to 58 different sentences during resective surgery. In addition, we implanted a 128 channel (1.33 mm pitch) µECoG array on the SMC of an awake Parkinsonian patient during deep brain stimulator implantation. This patient spoke 156 non-words that had phonemic formats equally distributed between consonant-vowel-consonant and vowel-consonant-vowel. Results demonstrated above-chance decoding and spatial clustering of decision weights for phonetic and phoneme articulatory features in both STG and SMC. These findings indicate that phonetic information is spatially selective at the micro-scale in both auditory and motor speech cortex, and that decision tree modeling is a reliable tool for cortical phonetic feature mapping.

Topic Areas: Speech Perception, Speech Motor Control

Cohort entropy and phoneme surprisal during auditory single-word recognition: a temporal response function analysis

Poster H6 [Poster PDF] [Poster Tour] Visit me at [Gather.Town] in the Broca room during Poster Session H.

Presenter Note: This study is described in greater detail in Chapter 4 of the first author's dissertation, available here: https://drum.lib.umd.edu/handle/1903/26392.

Phoebe Gaston[1], Christian Brodbeck[1], Colin Phillips[1], Ellen Lau[1]; [1]University of Maryland

INTRODUCTION: Neural measures have been shown to track the dynamics of auditory word recognition by means of their sensitivity to information-theoretic lexical properties. Two important predictors of brain activity are cohort entropy (reflecting uncertainty in the distribution of possible words matching the input) and phoneme surprisal (reflecting conditional probability of the incoming phoneme). However, the pattern of correlation effects reported for these predictors has varied across studies. This may be in part because traditional analyses have been unable to model the contribution of acoustic variables and overlapping responses

to consecutive phonemes. A new approach using temporal response functions (TRFs) addresses these issues and has recently been applied to analysis of source-localized MEG data for continuous speech (Brodbeck, Hong & Simon, 2018). Here we investigate whether the TRF effects of surprisal and entropy reported for continuous speech also occur in a single-word design which removes many potential contextual influences on word recognition. We also follow up on previously reported null effects of entropy and surprisal at word-initial phonemes, potentially indicating a special status of the word-initial phoneme in lexical processing. METHODS: While recording neural data with magnetoencephalography (MEG, N = 18), we presented 1000 monomorphemic words as recorded and made available by the Massive Auditory Lexical Decision database. Visually presented semantic relatedness probes occurred pseudo-randomly. Source localized MEG responses were predicted from the acoustic spectrogram, acoustic onsets, word onsets, phoneme onsets, cohort entropy, and phoneme surprisal, the latter two represented as impulses of variable magnitude at phoneme onsets. Each predictor was assessed by comparing cross-validated model fits with an alternative model excluding that predictor, to ask whether that predictor's presence in the model improved predictions of neural data. We conducted follow-up tests for two additional predictors, uniqueness point and word frequency. RESULTS: Our main finding was that phoneme surprisal significantly improved the TRF model of single-word MEG responses, but cohort entropy did not. Further analysis of the TRF for phoneme surprisal indicates both an early (~70 ms) and a later peak (~290 ms), in temporal areas, in line with prior reports of surprisal effects in single words. In addition, a phoneme surprisal predictor consisting of only non-word-initial phonemes performed better than a predictor jointly modeling all phonemes. Surprisal at word-initial phonemes by itself did not significantly improve predictions. We did not find effects of word frequency or uniqueness point when controlling for the other predictors. CONCLUSION: In a TRF analysis of a single-word paradigm, we found phoneme surprisal but not cohort entropy effects. This fits with a pattern in prior single-word literature in which effects of cohort entropy are less robust than those of phoneme surprisal. However, entropy TRF effects were reported in prior work on continuous speech, raising the question of whether stimulus or task factors can shed light on the mechanisms underlying cohort entropy effects. Our results also suggested that non-word-initial phonemes disproportionately contributed to the surprisal effect. TRF analyses are a promising method for future work on word recognition in controlled experiments as well as in continuous speech.

Topic Areas: Speech Perception, Methods

Electrophysiological signatures of mapping alternated surface representations to underlying representations of tone: A Mismatch Negativity study

Poster H7 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session H.

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The Mismatch negativity (MMN) elicited from an oddball paradigm is sensitive to a diverse range of mental representations, from lower-level auditory representations to higher-level grouping generalizations based on ad hoc abstract rules. Most MMN studies have investigated phonemic contrasts without taking alternation into account: a morpheme that alternates has different surface forms. A consequence of alternation is a one-to-many mapping between underlying representation (SR) and surface representation (UR). Despite its crosslinguistic prevalence and its significance in our understanding of the fundamental analytic units in phonology, phonological alternation is understudied neurolinguistically. Our study addresses this gap in the literature using EEG. One example of phonological alternation — tone sandhi in Mandarin Chinese — was examined using the oddball paradigm (N = 31 participants). In Mandarin, when two Tone 3 (T3) syllables occur in sequence, the first syllable is realized as a rising tone, which is perceptually indistinguishable from Tone 2 (T2): T3 + T3 → T2 + T3. Our stimuli consist of four real disyllabic words in Mandarin: /xə2 ma3/, "hippo"; /xuaŋ2 ma3/, "Real Madrid C.F."; /xaʊ3 ma3/, "good horse"; /xai3 ma3/, "seahorse". Due to the application of T3 sandhi, the first syllable (S1) of all four words has a rising tone; all four words have an identical second syllable (S2). Experimental blocks consist of stimuli from any two disyllabic words just mentioned, creating a 2*2 design:

underlyingly matched vs. un-matched, phonologically alternated vs. un-alternated. Identity difference waves (MMN calculated based on ERP responses to the same stimuli as either standards or deviants) were examined to minimize the influence of the inevitable segmental conflict in the stimuli. This design allows us to tease apart the effects of SR from the effects of UR mismatches. Cluster-based permutations were used to identify effects without prior assumptions regarding their timing and location. The results yielded two pieces of evidence supporting the detection of UR and UR mismatch: (1) despite the apparent segmental conflict in the S1, MMN is only present when there is no alternation in either the standards or the deviants, suggesting that the mapping of an alternated sound to its UR can disrupt the normal generation of MMN; (2) the UR-mismatch conditions are more positive than the UR-match condition, in both the S1-S2 transitional region and S2. Interestingly, although it is S2 that ultimately informs the listeners of the UR of S1, because the UR effects appear in S1, we interpret our findings as evidence for incremental processing during the perception of phonologically alternated sounds, similar to the perception of speech sounds with a direct UR-SR mapping. We propose that the patterns observed in our data may reflect the following sequence of events: mapping of SR to UR, an initial realization of a UR conflict in the S1-S2 transitional region, and a confirmation of a UR conflict in S2. In short, our study provided evidence for the access to UR for phonologically alternated sounds and also demonstrates how MMN may be applied for the study of phonological alternation at the brain level.

Topic Areas: Speech Perception, Morphology

Gray matter volume in key language regions affected by early language experience: A Surface-based analysis of hearing and deaf individuals with typical or impoverished childhood language experience

Poster H8 [Poster PDF] [Poster Tour] Visit me at [Gather.Town] in the Broca room during Poster Session H.

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Language is a uniquely human cognitive function involving a distributed brain network, but it is less clear how this network emerges during early brain development. In particular, the role of early language experience is not well understood, given the ubiquitous language environment of most typically developing infants. Deaf individuals have heterogeneous language experience in early childhood. Approximately 10% of deaf individuals have deaf parents and experience a sign language as their first language from birth. By contrast, many deaf individuals do not have access to a signed or spoken language early in life. To investigate the role of early language experience on brain development, we examined the anatomical structures of language regions as a function of age of sign language onset in a sample of deaf adults whose early linguistic experience varied widely. 22 deaf adults participated, including eight native signers who acquired American Sign Language (ASL) from birth and one who began at 3 years; eight early signers who were first exposed to ASL between ages 4 to 7; and six late signers who were first exposed to ASL between ages 11 to 14 after failing to acquire functional spoken language. The control group was 21 hearing non-signers. T1-weighted MR images were acquired using a 1.5T MRI scanner and processed in FreeSurfer to reconstruct the brain surface. Next, we used the Human Connectome Project parcellation atlas (Glasser et al. 2016) to identify target language areas. Following previous neurolinguistic literature, we chose 17 language ROIs in each hemisphere, including frontal (BA44, BA45), temporal (A4, A5, STGa, STSda, STSva, STSdp, STSvp, TGd, TGv, TE1a, TE1m, TE1p), and parietal (PGi, TPOJ1, PSL) areas. We then used surface-based morphological features to calculate gray matter volume for each of the above ROIs in FreeSurfer and adjusted the volume for each participant with estimated total intracranial volume. We conducted linear regressions on the adjusted volumes with ASL onset age as the independent variable and age and gender as covariates. For ROIs significantly affected by ASL age onset, we further compared the three deaf groups with the hearing controls to determine if the effects were associated with deafness or the age onset of accessible language experience. After controlling for age and gender, we found negative effects of ASL onset age in bilateral BA45 (left: t=-3.05***; right: t=-2.71*), left posterior MTG (TE1p: t=-3.12***), right BA44 (t=-

2.21*) and right posterior STG (A4: t=-2.71*; A5: t=-2.72*). For the group comparisons with the hearing controls, we found significant group effects for the early signers in five ROIs (except for right A4) and for the late signers in all six ROIs. Crucially, no differences were found between hearing non-signers and deaf native signers, all of whom had language experience from birth, indicating that these effects are not due to deafness per se. These results suggest that impoverished language during childhood is associated with reduced gray matter volume of both frontal and posterior temporal language regions. Early language experience, regardless of modality, is essential for brain language regions to develop normally.

Topic Areas: Signed Language and Gesture, Development

Task modulation of orthographic uniqueness point effects in non-native visual word processing

Poster H10 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session H.

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The letter position in which a printed word is distinguishable from all other words in a lexicon is referred to as the orthographic uniqueness point (OUP). For instance, “sandwich” has an OUP of 5 because at the 5th letter “w”, one would be able to uniquely identify the word in English. Processing advantage of early OUP words compared to late OUP words has been taken to indicate that letters are processed serially from the left, however, recent studies have reported processing advantage for late OUP words, with N170 effect lateralized to the left hemisphere. Currently, it is unclear whether non-native readers use similar online processing strategies, and if task demands may influence this effect. In this study, 28 Chinese-English bilinguals of intermediate proficiency completed lexical decision and delayed naming tasks, where single words were presented in the center of the screen. Critical stimuli consisted of two lists of 25 real English words that significantly differed in OUP but were matched in word length, lexical frequency, orthographic neighborhood, orthographic Levenshtein’s distance, 4-letter lexical overlap, and bigram frequency. Linear mixed effects modelling was used to test if the OUP effect was found in non-native readers in behavioral and ERP data. Consistent with earlier reports in native English readers, non-native readers responded to late OUP words (666ms) significantly faster than early OUP words (702ms) in the lexical decision task ($t = 2.13$, $p = .039$). However, behavioral accuracy revealed no significant effect of OUP in either task. In the ERP data, we examined OUP effects in interaction with hemispheres or tasks at the P100 and N170 components. At the P1 component, a main effect of task was seen where delayed naming elicited more positive amplitudes than lexical decision ($t = 2.42$, $p = .023$) and it interacted with OUP. Post hoc tests with Bonferroni corrections indicated that only words with late OUP showed the task effect ($t = 3.18$, $p = .016$), but not words with early OUP. In the N170 time window, a significant main effect of OUP showed that late OUP words had increased negativity relative to early OUP words ($t = 2.25$, $p = .025$). An interaction with task showed that the N170 OUP effect was driven by the delayed naming task ($t = 3.21$, $p = .008$), but not present in lexical decision. The results for faster response time and increased neural activity at the N170 component in late OUP words relative to early OUP words cannot be accounted for by a serial letter processing model. Rather than proceeding strictly from left to right, the end of the word might be scanned in to provide facilitation in lexical access for single word reading in non-native readers. The overall time course of the ERP effects was comparable to that of native English readers. Additionally, the top-down task influence in these early ERP components suggested that this mechanism in orthographic processing is not purely automatic and may be preferentially engaged to fit task demands.

Topic Areas: Reading, Multilingualism

Modeling EEG responses to audiovisual features in quiet and noisy listening situations using naturalistic stimuli

Poster H11 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session H.

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Introduction: Speech perception involves integrating multiple sensory cues, including both auditory and visual information. Acoustic and phonological information in speech must be processed in the presence of background noise, which may include environmental sounds, music, or other speech. In our work, we have shown that both highly controlled sentence stimuli without noise and more naturalistic stimuli with background noise can be used to model EEG responses to acoustic and phonological features, and that these models generalize to controlled datasets. In this study, we extended our prior work to investigate acoustic, phonological, and visual responses in naturalistic speech using electroencephalography (EEG). We measured neural responses to continuous, controlled clean speech compared to speech in a naturalistic audiovisual stimulus set in 16 participants with typical hearing. We then employed multivariate temporal receptive field (mTRF) models to investigate neural tracking to acoustic, linguistic, and visual features of the stimuli. Our aim was to determine (1) how acoustic and phonological feature encoding differs between the controlled and naturalistic stimuli and (2) how visual information influences auditory responses and the generalizability of linear models trained on multimodal stimuli. Methods: We recorded 64-channel scalp EEG (BrainVision actiCHamp) from 16 native English speakers (8M/8F, age 20-35) while they watched and listened to movie trailers (noisy, naturalistic speech stimulus) and listened to sentences from the Texas Instruments Massachusetts Institute of Technology (TIMIT) acoustic-phonetic corpus (clean speech stimulus). EEG signals were referenced to the average of the mastoid channels, then eye movement and blink artifacts were removed using independent component analysis (ICA). Data were bandpass-filtered between 1 and 15 Hz. We fit mTRFs that predicted neural activity in response to both sets of stimuli as a function of different stimulus features. Auditory-related features included the acoustic envelope, phonological features, and pitch. Visual features were calculated from a motion energy model in which movie stimuli were decomposed into a set of spatiotemporal Gabor wavelet basis functions. Results: Our results generally demonstrated higher model performance in the clean speech condition (max, r=0.6), however we were still able to predict the actual EEG data from noisy speech (max, r=0.3). Through a variance partitioning analysis, we found joint encoding of envelope, phonological features, and pitch in both TIMIT and movie trailer responses, with more unique variance attributed to single features in the audiovisual stimulus condition. In addition, we found that the visual stimulus information contributed a significant proportion of variance in the audiovisual speech condition (average unique max, r = 0.4), but including this information did not significantly change auditory information encoding. Conclusion: These results have implications for understanding how the brain responds to complex, audiovisual stimuli, and could aid in understanding attentional and other stimuli-specific components necessary for furthering assistive hearing devices and developing a cognitive hearing aid.

Topic Areas: Perception: Speech Perception and Audiovisual Integration, Computational Approaches

The fronto-temporal language system does not support the processing of music

Poster H12 [Poster PDF] [Poster Tour] Visit me at [Gather.Town] in the Broca room during Poster Session H.

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Music and language are two human-unique capacities whose relationship has long intrigued psychologists, cognitive scientists, and neuroscientists, and remains debated. Some argue for overlap in the mechanisms that process language and music, often with a focus on structural processing, but others fail to find evidence of such overlap. To shed further light on the relationship between linguistic and musical processing, we conducted three fMRI experiments. In each experiment, we used a well-established language 'localizer' task to identify language-responsive areas in each participant individually, and then examined the responses of these language areas to music. In Experiment 1 (n=18), we included diverse musical stimuli—single-instrument music, orchestral music, drum music, and synthetic melodies—as well as a set of non-musical auditory conditions. We also examined sensitivity to manipulations of pitch and rhythmic structure in music using scrambling manipulations. In Experiment 2 (n=20), we further probed sensitivity to structure in music using another common manipulation: we compared responses to well-formed melodies vs. melodies containing a note that does not obey the constraints of Western tonal music. Finally, in Experiment 3 (n=18), we examined responses to music in native speakers of a tonal language (Mandarin), to test whether higher sensitivity to linguistic pitch might affect the strength of response to music. Across experiments, we obtained a clear answer: music processing does not recruit the language system. First, responses to musical stimuli in the language regions cluster around the level of a low-level fixation baseline, while eliciting robust responses in some auditory areas. The responses in the language regions i) are never higher than the response elicited by unstructured and meaningless linguistic stimuli (nonword strings), and ii) do not differ from non-music auditory conditions like animal vocalizations or environmental sounds. Second, none of the language regions exhibit sensitivity to musical structure, with similar responses to intact and scrambled materials and to materials with vs. without structural violations. And third, this low response to music holds even in speakers of a tonal language. In tandem, these findings demonstrate that the mechanisms that process structure (and meaning) in language do not support the processing of music, arguing against the idea of an abstract hierarchical structure processor. We argue that prior evidence for language-music overlap is consistent with the overlap arising within a brain network that is robustly sensitive to unexpected events across domains and that 'tracks' general cognitive demands.

Topic Areas: Perception: Auditory, Syntax

Differences in amplitude N400 on a lexical decision task between Spanish and Wixarika speakers

Poster H13 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session H.

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Groundbreaking studies have shown that lexical processing in distinct languages is similar due to the grounding of language into neurobiology (Friederici, 2002; Willems, Özyürek & Hagoort, 2008). However, apart from some Asian languages, most studies have replicated these findings only with European languages. Wixarika is an agglutinative Yuto-Nahua language spoken in the northeast of Mexico. In this experiment, we compared the N400 for 20 Wixaritari and 20 Spanish speakers (ages 18-27) in a lexical decision task using their mother tongue. Task consisted of hearing 50 nominal phrases for each condition: words (nuestra agua/tame haá/our water), and pseudowords type I (mi cuchillo-chicullo/my knife, xeme hikuri-hukiriti/your cactaceae) and type II (tu abeja-abeje/your bee, tame haá-hué/our water). Volunteers were required to attest if the noun in the phrase was or not a word. N400 peak was found in central channels at 423 ms (-1.4 µV) for Spanish and at 331 ms (-1.7 µV) for Wixaritari speakers. When contrasting N400 between conditions (words vs. pseudowords I and II) we found no differences neither in Spanish amplitudes (F=1.01, p=0.32) nor in latencies (F=2.30, p=0.14), and neither in Wixarika amplitudes (F=0.376, p=0.55) nor in latencies (F=2.60, p=0.15). When comparing the two groups, there were also not differences in response latencies neither in words (t=0.57; p=0.57), nor in pseudowords I (t= 1.42; p=0.167) or II (t=0.42; p=0.67). Nevertheless we found differences between groups in N400 amplitudes (t=3.28, p=0.002) but not in latencies (t=0.604, p=0.55) for processing words. Spanish speakers showed a higher N400 effect for words (M=-1.7µV) than Wixaritari (M=-0.2 µV). These findings restrict the proposal of Federmeier & Laszlo (2009) about N400 being produced by the temporal synchrony of a stimulus-driven activity (represented or not in lexicon) in a broad neural network within a language, with differences in the processing of words due to the language constraints and strategies followed by its speakers (Tune et al. 2014).

Topic Areas: Multilingualism, Meaning: Lexical Semantics

The effects of taVNS on novel language learning in young adults

Poster H14 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session H.

Presenter Note: Feel free to contact us and hear more about our work! Presenting Author: vishalthakkar0415@gmail.com or @vthakkar0415 on Twitter. Lab: www.tmcentanni.com, @tmcentanni on Twitter, or Centanni Lab at TCU on Facebook.

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Introduction: Acquiring fluency in a novel language learning is significantly more difficult after its sensitive window closes around the time of puberty. Well-marketed training programs such as Rosetta Stone and DuoLingo have been widely used by adults to learn novel languages. However, the required training time to achieve conversational level skill is quite extensive and retention is often poor, especially after a period without training. Thus, the goal of the current study was to investigate a novel approach to improving language acquisition and retention. Prior research has demonstrated that pairing invasive cervical vagus nerve stimulation (cVNS) with an external stimulus can drive meaningful plasticity in the brain. Since invasive procedures may not be practical, recent work has also demonstrated that transcutaneous auricular vagus nerve stimulation (taVNS) activates similar brain regions as cVNS, suggesting that noninvasive stimulation of the vagus nerve may yield similar benefits. Our lab has found that taVNS paired with training increases performance on rapid naming and timed decoding in a novel orthography, as compared to control groups, suggesting that this approach may be beneficial for improving reading skills. Thus, in the current study, we hypothesized that active taVNS paired with training would enhance language learning after training and at a one-week retention. Methods: Twenty-nine eligible participants (age: M = 19.48) were randomized into a sham stimulation (n = 11), 5 Hz taVNS (n = 8), or 25 Hz taVNS (n = 10) group for training. After a brief thresholding procedure, participants completed a one-hour training program in which they were exposed to thirty Palauan words and English translations. The training program was structured with alternating blocks of exposure and knowledge checks, the latter designed to track attention during training. Accuracy and reaction time data were collected from knowledge checks. Immediately after training and one week later, participants completed a free-recall test, during which they provided the English translation for each Palauan word, which were presented in a randomized order. Results: Performance was at ceiling on knowledge checks during training in all groups, indicating that participants paid attention during training. There were no effects of stimulation group on accuracy or reaction time during knowledge checks. On the free-recall assessment immediately after training, there was no effect of stimulation group on performance. However, there was a significant effect at a one-week retention, such that the 25 Hz taVNS group outperformed both the sham and 5 Hz taVNS groups. There was no difference between the sham and 5 Hz taVNS groups. Conclusion: Our results suggest that higher frequency active taVNS paired with training aids in retention of vocabulary words in a new language after a single training session. Future research should test taVNS in longer paradigms and longer retentions, as well as comparisons to other neuromodulation techniques to aid in learning and retention of novel language learning.

Topic Areas: Methods, Language Therapy

Adding New Meanings to Known Words: The Role of Consolidation

Poster H15 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session H.

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Although overnight consolidation has been shown to support the integration of novel words into the mental lexicon, its role in learning new meanings for already known words is unclear. However, this kind of new-meaning learning is very common, exemplified by learning that skate is also a type of fish long after knowing its more common roller- or ice-skating meaning. In the present study, participants learned new meanings for two sets of known words 24 hours apart – one set was studied the day before testing, while the other set was studied on the day of testing, with no opportunity for overnight consolidation. The results showed that semantic

judgments of new meanings became faster 24 hours later. However, the N400, an indicator of lexico-semantic processing, was not affected by meaning learning or overnight consolidation. Additionally, regardless of studied days, words with new meanings evoked a parietal positivity within 500-800 ms and a frontal negativity within 300-800 ms compared to exposure controls, reflecting a continuous involvement of episodic retrieval in accessing the new meanings. Additionally, meaning learning slowed down semantic judgments of original meanings on the day of learning but not 24 hours later. Overall, the processing of both new and original meanings benefits from a study-test interval involving overnight sleep, even though new meanings are not fully integrated into the mental lexicon within that period. Episodic memory remains crucial in accessing the new meanings even 24 hours later, at least in a task requiring efficient meaning access.

Topic Areas: Meaning: Lexical Semantics, Meaning: Combinatorial Semantics

Checking lexical relation between verbs and objects required for the processing of case information: An ERP study

Poster H16 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session H.

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This study investigated the processing of case information and lexical relation between verbs and objects. In Japanese, some verbs selectively require accusative-marked or dative-marked objects (marked with “o” and “ni,” respectively). It has been proposed that the information regarding the type of case that verbs require for objects is encoded in the lexical entry of verbs (Nitta, 1973/2010). Previous studies reported that the processing of gender information—which requires access to the lexical entry of words—interacted with that of semantic information around 400 ms post-stimulus onset (Hagoort, 2003; Wicha et al., 2004), which was earlier than the interaction of syntax and semantics in a sentence that occurs approximately 600 ms post-stimulus onset (Friederici, 2011). As the case and semantic information are retrieved from the lexical entry of verbs, we hypothesized that the interaction between the processing of case and lexical information would occur in the N400 time window. We used two-word sentences as stimuli consisting of objects and the abovementioned two types of verbs. By crossing the correctness of the case information and lexical relation, we created four types of stimulus sentences to investigate the interaction between the processing of case and lexical information. Two types of judgment tasks were used: a phrase task and a lexical task. In the phrase task, participants judged whether the case verbs required for objects corresponded to the case of the objects. In the lexical task, they judged whether verbs and objects were lexically related. With these tasks, we examined the processing of the case and lexical information independently. We varied the interstimulus interval between the verbs and objects (100 or 500 ms) in both task conditions, which resulted in the four experimental conditions. Each condition consisted of 140 trials. We recorded the electroencephalogram from 63 Ag/AgCl electrodes mounted in Waveguard cap (ANT neuro) by using BrainAmp (Brain Products GmbH). The experiment was approved by the Human Subject Ethics Committee of Tokyo Metropolitan University. Data from 31 undergraduate or graduate students (18 females, mean age = 20.4) were analyzed. Both case violations and lexical anomalies elicited an N400 after the onset of verbs, which suggests that the parser detected both types of violation when it accessed the lexical entry of the verbs. When participants performed the phrase task, a similar amplitude of negativity was elicited in the lexically anomalous sentences, regardless of whether the sentences included case violations. This indicates that although participants attended case information, the lexical relations between verbs and objects were predominantly processed in the brain. We propose that lexical relations should be checked in the processing of case information as the parser cannot determine the correct case to be assigned to objects by verbs. Since the interaction between the processing of case and lexical information was observed at the N400 time window, our findings suggest that the interaction between the processing of two types of lexically encoded information occurs earlier than that of syntax and semantics in a sentence, which takes place at approximately 600 ms post-stimulus onset.

Topic Areas: Meaning: Lexical Semantics, Meaning: Combinatorial Semantics

Understanding Semantic Processing Through Examination of Brain Sources

Poster H17 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session H.

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BACKGROUND: Semantic processing is the ability to comprehend the meaning of spoken word. There are well-established neural correlates associated with this particular language process such as the N400 component, a negative peak the event-related potential (ERP) occurring 400 ms after stimulus onset in adults. Semantically incongruent stimuli generate a larger deflection than congruent stimuli, and this difference in amplitude, called the N400 effect, is typically examined as a marker of semantic processing1. The neuronal regions involved in this process have been extensively studied; however, debate still exists about the exact constituents of the semantic system3. Using electroencephalogram (EEG), we investigated the N400 component, its time-frequency characteristics, and the brain sources active during semantic processing to corroborate neural regions involved during this language process. METHODS: We used a 64-electrode cap-mounted EEG to investigate the N400 during semantic categorization of auditory stimuli in 15 control adults (mean age: 22.9 years; 6 females). Participants were given a category (e.g., animals) and listened to a list of words (n=96), responding with a button press after every word if it was 'in' (semantically congruent) or 'out' of category (semantically incongruent). Brain data were recorded continuously and preprocessed (zero-phase shift filter, 1-30 Hz; eye movement artifacts removed; artifact rejection ± 200 µV; epoched -1500 to +2000 ms; re-referenced to a reference-free montage), averaged by condition for each participant, and then grand-averaged. For time-frequency analysis, complex demodulation was employed (2.0 Hz / 25 ms) and results were used to identify the frequency range and time windows for source analysis. A broadband multi-source beamforming analysis (in BESA Research 7.0) was used to identify maximum peak activation sources for three sliding, overlapping time windows (250–750, 500–1000, 750–1250 ms). RESULTS: The ERP results revealed a N400 effect in the central and frontal brain regions as expected for semantic processing. Time-frequency analysis revealed theta-beta frequency range (4–30 Hz) event-related desynchrony between 250 to 1000 ms. Across all three time windows, there was significant bilateral activation of visual (Brodmann Area 19) and motor (BA4/6) areas. In addition, the 'in' category condition showed sustained (all three time windows) bilateral activation of temporal-parietal (BA39/40) areas associated with processing word meaning, and left inferior frontal gyrus (BA45), an area important in semantic decision making. For the 'out' category condition, there was significant activation, only in the first time window, of left inferior frontal regions (BA45). DISCUSSION: Results implicate bilateral occipital and motor cortex areas along with frontal and temporal-parietal language processing regions during semantic categorization of congruent stimuli. This is largely consistent with previously published data investigating neural systems involved in word processing2,3,4. Furthermore, recent studies also suggest category-specific activation of brain regions in semantic tasks2,5, with findings for relevant semantic categories in line with our results2,6. For incongruent stimuli, surprisingly, temporal-parietal regions were not implicated; however, classical left frontal regions were briefly involved. Clarifying our understanding of the functional brain patterns and sources associated with semantic processing will allow us to compare to populations with deficits in this language domain.

Topic Areas: Meaning: Lexical Semantics, Speech Perception

Testing the effects of familial handedness on the neurophysiological correlates of sentence comprehension: A replication of Tanner & Van Hell (2014)

Poster H18 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session H.

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Event-related potential (ERP) research has found differences in the processing of grammar and semantic information in right-handers with familial sinistrality (having a left-handed blood relative) and those without (e.g., Lee & Federmeier, 2015; Tanner & Van Hell, 2014). Theoretical stances broadly associate left-handedness (self/familial) with increased reliance on lexical/semantic information and right-handedness with greater reliance on grammatical (e.g., morphosyntactic) information during sentence comprehension (e.g., Bever et al., 1999; Townsend et al., 2001; Ullman, 2004). In a study on individual differences in sentence processing, Tanner and Van Hell (2014) observed differences in ERP signatures of grammar processing between right-handers with familial sinistrality and non-familial sinistrals, i.e., right-handers with no reported familial sinistrality. Specifically, non-familial sinistrals were P600-dominant in their grammar processing whereas familial sinistrals were more variable, with some individuals being P600-dominant but about half being N400-dominant (see also Grey, Tanner, & Van Hell, 2017). These findings suggested greater reliance on lexical/semantic processes in the familial sinistrals and indicated that familial sinistrality may be an important factor underlying individual variation in the neurophysiological correlates of sentence comprehension. Indeed, there is mounting evidence for systematic individual variation in the ERP correlates of sentence processing (e.g., Kim, Oines, Miyake, 2018; Tanner, 2019). However, the various cognitive, linguistic, and neurobiological factors that underlie this variation remain unclear, and familial sinistrality has not been further examined. The present study aimed to test whether the ERP individual difference patterns related to familial sinistrality that were observed in Tanner and Van Hell (2014) replicate in a new sample of participants. The study utilized the exact same sentence stimuli, instructions, and task as Tanner and Van Hell (2014). Participants were all right-handed, college-enrolled native English speakers who completed a grammaticality judgement task while EEG/ERP data were recorded, as in Tanner and Van Hell (2014). Stimuli were written sentences that were either correct or contained a morphosyntactic error in verb tense or subject-verb agreement. The preliminary results are from 25 participants, 7 familial sinistrals and 18 non-familial sinistrals. At the group level, both the familial sinistral and non-familial sinistral groups show robust P600s in response to verb tense and subject-verb errors. When ERPs were examined at the individual level using a Response Dominance Index (RDI; Tanner & Van Hell, 2014; Grey, Tanner, & Van Hell, 2017), the results indicate that many individuals were P600-dominant in their grammar processing, but about half of the non-familial sinistrals were N400-dominant; this contrasts with Tanner and Van Hell (2014). These preliminary findings will be discussed in terms of their potential implications for understanding the factors underlying individual differences in the neurophysiology of language and the effects of handedness on language processing.

Topic Areas: Syntax, Meaning: Lexical Semantics

Do bilinguals better discriminate novel vowel contrasts? Neural correlates of perceptual assimilation using MEG decoding

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Rapid categorization of speech sounds is an essential component of successful speech comprehension. One mechanism of speech categorization is assimilation (Best, 2001; Best and Tyler, 2007), in which two contrasted speech sounds, e.g. vowels, are judged to be categorically the same, despite possessing different acoustic cues. Some also argue that bilinguals may be particularly well-adapted to perceive novel vowel contrasts (e.g. non-native /y/ vs. native /u/), due to their experience with acoustic cues from multiple languages, which facilitates speech categorization (Escudero et al., 2012). In terms of the neural correlates of speech perception, neurophysiological studies have shown that online decoding of the speech signal recruits neural populations in superior temporal gyrus ~100 ms after speech onset (Gwilliams, 2020; Mesgarani et al., 2014). Thus, based on prior research, we test the hypothesis (i) that behaviorally, English monolinguals will assimilate Swedish /ʏ/ to English /i/, but dissimilate French /y/ from English /i/, and assimilate both French /ø/ and Turkish /ɯ/ to English /u/, whereas Arabic-English and Tagalog-English bilinguals may assimilate less overall due to broader experience with acoustic cues, and (ii) that we are able to decode neural activity representing assimilation ~100ms after speech onset. In a counterbalanced ABX discrimination task, participants listen to 3 consecutive speech sounds and provide categorical judgments (e.g. Is X the same as A or B?) while MEG is simultaneously recorded. Stimuli consist of normalized vowel tokens of English /ɑ, ae, u, i/, French /ø, y/, Turkish /ɯ/, and Swedish /ʏ/. Participants judge Native trials, contrasting native vs. native vowels, and Non-native trials, contrasting native vs. non-native vowels. Data for 6 English monolinguals is presented with plans to collect additional English monolinguals as well as Arabic-English and Tagalog-English bilinguals. Initial responses for error rates show that English monolinguals accurately identify Native trials with less than 4% error rate on average. Error rates on Non-native trials vary more drastically depending on the contrast, such as 62.5% error rate for Swedish /ʏ/ as X vs. English /i/ as A/B, illustrating possible assimilation, and French /y/ as X vs. English /i/ as A/B at 4.76%, illustrating possible dissimilation, trending towards the behavioral predictions above. For neural responses, we will apply a logistic regression classifier to MEG sensor data for each vowel. The classifier will be trained on A/B tokens of either native or non-native vowels and tested on X tokens of either native or non-native vowels. Based on our neural hypotheses, we predict that at ~100 ms after speech onset, classification accuracy will mirror behavior. For example, high accuracy for Swedish /ʏ/ tested on English /i/ and low accuracy for French /y/ tested on English /i/ would suggest that certain non-native categories are representationally assimilated while others are not. Our results would illustrate that the assimilation mechanism is an interaction between the listener's native language and the acoustic identity of a given vowel, with corresponding timelines of neural activity. Additional results from bilinguals may establish whether or not top-down influences of language inventory alter assimilation for more well-adapted perception.

Topic Areas: Speech Perception, Multilingualism

Online neural monitoring of statistical learning via click detection in a word segmentation paradigm

Poster H20 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session H.

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Statistical learning, the identification of probabilistic patterns over time (e.g. syllable or phoneme order within a language), is a fundamental component of language acquisition (Romberg & Saffran, 2010; Saffran, 2001, 2003). For example, linguistic processes such as word segmentation in a novel language can be achieved via statistical learning of syllable patterns that differentiate between versus within words (Saffran, 2001). One way to evaluate online statistical learning in word segmentation is to embed targets within the word stream (Franco et al., 2015; Gómez et al., 2011). In one variant of this method, clicks are inserted at different syllable positions (between vs. within word) of the "words" and the subjects are instructed to press a button as soon as they hear a click. The idea behind this approach is that, as the auditory stream containing syllables progresses, subjects are able to statistically learn the "words" based on transitional probabilities, which interferes with the detection of target clicks, which in turn affects reaction time (RT). Behaviorally, the click detection method has proven useful for online monitoring of statistical learning (Gómez et al., 2011); however, the viability of this method for neural monitoring of online statistical learning has not been investigated. Further, the existing evidence (Franco et al., 2015; Gómez et al., 2011) has been limited to studying the effect of click insertion at first and second syllables of trisyllabic "words". In the current study, we aimed at understanding (1) The effect of click position (first, second, or third) on RT; (2) Whether the click detection method, in conjunction with electroencephalography (EEG), could be used as a neural marker to identify online statistical learning. We recruited 34 subjects (mean age = 21.3 years; 14 males) who were played three separate auditory streams of syllables. Two streams (structured) contained artificial "words", while the third stream (random) contained nonwords. Structured streams had clicks inserted either at syllable positions 1 and 2, or 1 and 3. In comparison, the random stream did not have any "words", with clicks placed at positions 1 and 2, or 1 and 3. Stimuli were binaurally presented via insert earphones, behavioral responses to clicks were collected using keyboard presses, and simultaneous EEG data were collected using a 64-channel electrode placement. We found that RT, regardless of the condition

(structured or random), increased over time. Preliminary analyses suggest a difference in the trajectory of RTs over time for the structured vs. random condition. Further, our results also indicate differences in RT trajectories between the clicks presented between vs. within words. Preliminary analyses of the EEG data suggest that click-evoked event-related potentials (ERPs) in the region of P300 (300-450 ms) differ between structured and random presentation, as do between vs. within-word click-evoked ERPs. We found that the statistical learning-induced changes observed in the behavior (RT) could also be observed in electrophysiology (P300). Overall, the current findings suggest that the click detection paradigm, in conjunction with EEG, can be used for online neural monitoring of statistical learning within the word segmentation paradigm.

Topic Areas: Perception: Auditory, Speech Perception

Learning a Second Language: Intrinsic Connectivity from Shallow to Deep Orthography

Poster H21 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session H.

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Introduction. Bilingualism provides an ideal window through which to study how language learning experiences influence connections in the brain. Investigations into the intrinsic functional connectivity of bilinguals found that variations in early language experience shape connectivity in the bilingual brain (Berken et al., 2016), individual connectivity differences are associated with the capacity to learn a second language (Chai et al., 2016), and lifelong bilingualism is related to enhanced structural and functional connectivity (Luk et al., 2011). However, to date, little is known about how intrinsic functional connectivity is impacted by variations in orthographic depth in the bilingual brain. Orthographies can be classified according to the consistency of letter-to-phoneme correspondence. Transparent or shallow orthographies refer to sound-symbol correspondences that are highly consistent; opaque or deep orthographies refer to sound-symbol correspondences that are less consistent. The purpose of the current study is to examine differences in intrinsic functional connectivity in two groups. The shallow-deep (SD) group consists of bilinguals whose first language (L1) was shallow (e.g. Italian) and their second language (L2) was deep (e.g. English). The deep-shallow (DS) group consists of bilinguals whose first language (L1) was deep and their second language (L2) was shallow. Methods. Participants (n=10) were 18-38 years old right-handed bilinguals, who acquired their L2 during childhood and adolescence. Resting-state fMRI analysis was performed using a seed-driven approach in AFNI. The VWFA was chosen as the seed ROI (x=-45, y=-57, z=-12, Dehaene & Coen, 2011). Data was preprocessed using standard spatial preprocessing steps including despiking, slice-timing correction, motion correction, alignment, normalization, extract tissue-based regressors, smoothing, nuisance regression, motion censoring (0.2), and bandpass filtering (0.01 - 0.08Hz). First-level correlation maps were produced by extracting the residual BOLD time course from the VWFA seed and computing Pearson's correlation coefficients between that time course and the time course of all other voxels in the brain. Correlation coefficients were converted to normally distributed z-scores using the Fisher transformation to allow for second-level analysis. Two sample t-tests were performed to compare the connectivity maps between SD and DS groups. Results. Preliminary results showed that the SD group had a greater positive correlation in activation between the VWFA (seed region) and the right hemisphere VWFA homologue region, as compared to the DS group (Z = 1.63). Conclusion. Deeper orthographies have inconsistent sound-to-letter mappings, making word naming and lexical access more difficult. For individuals who learned shallow orthographies as their first language, recruitment of their right homologue region likely supported later L2 development in a deep orthography. The present results indicate that beginning life with a shallow L1 and learning a deep L2 leads to enhanced interhemispheric connectivity.

Topic Areas: Multilingualism, Morphology

Movie-watching versus task and resting-state fMRI for presurgical language mapping in brain tumor patients

Poster H22 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session H.

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Introduction Presurgical functional magnetic resonance imaging (fMRI) language mapping has proven valuable for assessing the risk of causing language deficits against the benefit of surgically resecting brain tumors adjacent to putative language areas. In an effort to extend the use of this non-invasive technique to patients who cannot perform conventional task-based fMRI (tb-fMRI) due to neurological deficits, we developed a novel movie-watching fMRI (mw-fMRI) paradigm not involving an explicit task and previously tested it in healthy subjects. Movie-watching simulates multimodal, real-world perception, and is therefore hypothesized to facilitate more comprehensive fMRI language mapping than a modular language task. The goal of this study was to assess mw-fMRI language mapping in brain tumor patients, relative to commonly used tb-fMRI, and resting-state (rs-fMRI). Methods mw-fMRI and antonym generation tb-fMRI were conducted in 34 patients with brain tumors (mean age = 47 years, 20 females), 22 of whom also underwent rs-fMRI. Language maps were generated from the tb-fMRI using a general linear model, and from the mw-fMRI and rs-fMRI using independent component analysis (ICA). Functional language regions-of-interest (ROIs) in the frontal, temporal, and inferior parietal cortex were defined using the terms “language”, “phonological”, and “semantic” in the Neurosynth platform and adjusted individually to discount lesion tissue (based on manual segmentation). A primary language component, and secondary angular gyrus component with distinct time course, were identified from ICA of mw-fMRI based on spatial correlation with the language ROIs, and temporal correlation with the time courses derived from the healthy group mw-fMRI. For rs-fMRI, a language component was identified based on spatial correlation with the language ROIs. Language mapping sensitivity, specificity, and lateralization index (LI) were calculated at thresholds determined using the top 5%, 10%, 15%, and 20% values in each ROI. Pearson’s correlation, non-parametric tests, and multiple comparisons with Bonferroni correction were employed to measure statistical differences between language maps obtained with each paradigm. Results Relative to tb-fMRI, mw-fMRI was associated with less head motion ($p<0.005$), resulted in higher language mapping specificity across the whole-brain ($p<0.01$), as well as higher sensitivity in the temporal cortex ($p<0.05$) but lower sensitivity in the frontal cortex ($p<0.01$). Relative to rs-fMRI, mw-fMRI resulted in equivalent head motion and mapping sensitivity, but higher specificity ($p<0.01$). The LI showed good agreement among ROIs within each paradigm, and better agreement between mw-fMRI and rs-fMRI than mw-fMRI and tb-fMRI in the temporal cortex ROI. Conclusions Compared with tb-fMRI, mw-fMRI demonstrated reduced head motion, higher language mapping specificity, and higher sensitivity in the temporal cortex, consistent with the hypothesis that a naturalistic paradigm can engage the language system effectively. The finding of strong agreement in language lateralization between ROIs (within each paradigm) has implications for language mapping in patients with a brain tumor encroaching on part of the language territory: even though the fMRI measurements may be invalid in the peritumoral area (due to neurovascular uncoupling), LI could potentially be estimated based on language ROIs removed from the tumor. Overall, the findings demonstrate that the language network can reliably be mapped using mw-fMRI.

Topic Areas: Methods, Disorders: Acquired

Lexical vs. Semantic Processing in the Temporal Lobe: An HD-tDCS Study

Poster H23 Poster PDF Visit me at Gather.Town in the Broca room during Poster Session H.

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An increasing number of studies have implicated the anterior temporal lobe (ATL) and occipito-temporal cortex (OTC) in lexico-semantic processing. Here, we aim to examine their contributions to lexical vs. semantic processing. We used high definition transcranial direct current stimulation (HD-tDCS) to probe the role of left lateral ATL and OTC in tasks that vary in semantic demands (low, high) and lexicality (lexical, nonlexical). Thirty six right handed subjects were randomly assigned into either ATL or OTC stimulation groups (18 subjects per group). They received both anodal and sham stimulations on different days. The order of stimulation (anodal and sham) was counterbalanced across subjects in both groups, and subjects were blinded to the type of stimulation in each session. In each session, subjects received 20 minutes of stimulation and after stimulation they were asked to perform four tasks with different lexico-semantic loads. The tasks were lexical decision (LD; lexical and low semantic), word-picture matching (WPM; lexical and semantic), semantic judgement (SJ; lexical and high semantic), and picture plausibility (PP; nonlexical and high semantic). LD and WPM were presented in both auditory and visual modalities, while others were presented only in the visual modality. The results showed that compared to sham stimulation, anodal HD-tDCS of left lateral ATL accelerated response time for LD and WPM regardless of stimuli modality, and also modulated SJ, but did not modulate the non-lexical task PP. In contrast, HD-tDCS over OTC slowed subjects' response for PP relative to sham stimulation. The results suggest a lexical, as opposed to semantic, role of the left lateral ATL. Overall, our findings elucidate the role of ATL and OTC in lexical and semantic processing. They show similar patterns as some patients with primary progressive and stroke aphasia, and have translational implications.

Topic Areas: Meaning: Lexical Semantics, Language Production

Semantics or Morphosyntax? Verb Aspect Processing Depends on Obligatoriness of Morphological Encoding

Poster H24 Poster PDF Poster Tour Visit me at Gather.Town in the Broca room during Poster Session H.

Presenter Note: Questions? Ideas? Contact Anna Katikhina: akatikhina@email.arizona.edu or visit Cognitive Neuroscience of Language lab led by Dr. Vicky Lai at https://neurolang.lab.arizona.edu/

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Verb aspect is a lexico-grammatical feature that defines the temporal distribution of an event. Specifically, perfective aspect (washed) emphasizes event completion within a temporal boundary, while imperfective (was washing) presents an unfolding event. In English, past simple (perfective), although often associated with completion, can be used with both completed and in-progress events. Past progressive (imperfective) is restricted to unfolding events, although empirical research has shown that it can activate multiple stages of events (Madden & Zwaan, 2003). Past research has investigated whether aspect processing is semantic or morphosyntactic, with more support for the latter (e.g. Zhang & Zhang, 2008). However, aspect violations were typically induced at sentence level and did not account for crosslinguistic differences. In this study we ask whether aspect processing with relation to event status (completed, in-progress) is semantic or morphosyntactic in languages with different degree of aspect marking obligatoriness. In English, perfective is conveyed by aspectually unmarked past simple, while imperfective, by aspectually marked past progressive. In Russian, aspectual marking is obligatory, with perfective formed by adding a perfectivizing prefix to imperfective (испекла 'finished-baking'). We hypothesize that when aspectual marking is less obligatory, aspect processing relies on semantic mechanisms, whereas when aspectual marking is obligatory, it is morphosyntactic. Native English (N=17) and Russian (N=16 speakers. The design was 2 Event (In-progress, Completed) x 2 Aspect (Perfective, Imperfective). The stimuli were 256 pictures and descriptions, presented in 4 blocks. In the 2 experimental blocks, events in pictures and verb stems in descriptions matched semantically. In the perfective block, all verbs were perfective. Half were preceded by completed events (congruent), and the other half, in-progress events (incongruent). Likewise in the imperfective block, all verbs were imperfective, preceded by completed events (incongruent) and in-progress events (congruent). In the 2 control blocks, events and verb stems did not match semantically, leading to an outright semantic violation, serving as a reality check. In each

trial, a picture was presented for 500 ms, followed by a description, presented word-by-word. Comprehension questions appeared after each trial. In control blocks, semantic violation at verbs in both perfective and imperfective blocks elicited N400 effects in both groups. Both groups successfully identified semantic mismatches. Perfective violations in the English group elicited N400-like negativity starting at 280 ms and sustained throughout, with a right anterior distribution, without any late positivity, suggesting semantic processing not followed by morphosyntactic repair. Perfective violations in the Russian group elicited a late positivity effect from 600-900 ms, indicating morphosyntactic processing. Imperfective violations in the English group elicited a right anterior negativity from 280-720 ms (at auxiliary verb "was"), also without a subsequent late positivity, again suggesting semantic mechanisms. This enhanced negativity was not maintained during the processing of the lexical verb. In the Russian group, Imperfective violations did not elicit any effects, pointing to flexible nature of this form. In conclusion, these findings advance our understanding of the semantic and morphosyntactic nature of aspect processing and highlight the role of crosslinguistic differences with respect to obligatoriness of aspectual marking.

Topic Areas: Meaning: Lexical Semantics, Morphology

The Impact of Parkinson's Disease on Social Communication: Eye Tracking Evidence

Poster H31 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session H.

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Social communication deficits such as interpreting facial expressions and speaker intentions, such as sarcasm, are a less-understood component of the cognitive signature of Parkinson's disease (PD). Understanding these impairments is critical because they are linked to impaired social relationships, less efficient conversation exchanges, and poorer quality of life. We used eye-tracking and multimodal videotaped vignettes to compare the interpretation of speaker intentions (i.e., sarcasm and teasing) in individuals with PD and healthy controls. Thirteen participants with mild-moderate Parkinson's disease and eight matched controls took part in this study. All participants completed neuropsychological assessments and eye movements were monitored while they watched social interactions in videos from the Relational Inference in Social Communication (RISC) database. The participant's task was to select whether the speaker from each video was sincere or sarcastic after watching and listening to the multi-modal vignette. Significant group differences were found for recognizing teasing ($t=6.73$, $p<.0001$) statements, with higher accuracy for HC individuals. Furthermore, we found positive correlations for individuals with PD between task accuracy and memory ($R=.71$, $p<0.01$), visuospatial functions ($R=.72$, $p<0.01$), executive functions ($R=.57$, $p<0.05$), and attention skills ($R=.61$, $p<0.05$), showing that participants with higher cognitive skills have an advantage in recognizing social intentions. For all intentions, controls looked at faces at a higher proportion than those with PD (interaction intention*group, $\chi2=1811$, $p<.0001$), which could indicate advantages in directing attention for HCs. These differences in visual attention might explain the differences we found in task accuracy and suggests that the PD group misses specific facial cues that aid the interpretation of speaker intentions, especially when considering the proportion spent on the person receiving the statement. These data suggest that eye tracking is a feasible experiment methodology for understanding information processing in PD while revealing the influence of cognitive measures such as memory and executive functions.

Topic Areas: Meaning: Discourse and Pragmatics, Control, Selection, and Executive Processes

Cortical tracking of rapid meaning processes during language comprehension

Poster H32 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session H.

Katherine Aboud[1], Tin Nguyen[1], Stephanie N. Del Tufo[2], Catie Chang[1], David H. Zald[1], Alexandra F. Key[1], Bennett A. Landman[1], Laurie E. Cutting[1]; [1]Vanderbilt University, [2]University of Delaware

The present study identifies a real-time system of neural networks that is predictive of language comprehension (LC) efficiency. We examined twenty six typical adults as they read sentences in the MRI and, in a separate session, while EEG data was collected. Sentences were constructed to vary in their semantic cognition demands, with the sentence-final word determining whether the sentence was congruent or incongruent in overall meaning (i.e. whether the sentence made sense or did not make sense). Using a novel application of joint independent component analysis (jICA), we were able to track functional networks with a high degree of temporal specificity. In jICA, independent components for fMRI and EEG are simultaneously estimated. Compared to other multimodal analysis approaches, jICA allows for the spatial and temporal components of fMRI and EEG, respectively, to influence each other, and is consequently considered to truly be a “fused” data analysis approach (Mijović et al., 2012). We found that meaning processes in the context of complex language are supported by rapid trade-offs between widespread neural networks. Specifically, semantic cognition after sentence reading was marked by early signals (~300 ms post-stimulus) in the bilateral temporal poles (TP) corresponding with the P300, followed by TP coupling with the canonical fronto-temporal language circuit corresponding with the N400. Strikingly, these activations were followed by three P600 sub-peaks corresponding with three independent functional networks: (1.) hippocampal and right superior temporal gyrus (STG) coupling (“P600a”; peak at ~500 ms), (2.) ventral and dorsal inferior frontal gyrus (IFG) coupling (“P600b”; peak at ~700 ms), and (3.) default mode network (DMN) coupling centered on the posterior midline (“P600c”; peak at ~750 ms). Individual difference metrics were used to further characterize the functions of each P600 sub-peak, revealing that P600a correlated with sequential working memory, P600b was independently associated with both vocabulary and syntactic ability, and the P600c correlated with global conceptual integration processes. The particular mappings and behaviors for each P600 subcomponent consequently appear to correspond with previous psycholinguistic theories of sentence comprehension after the thematic semantic processes occurring the P300/N400 window, including: schematic memory checks potentially related to syntactic-semantic binding (P600a; hippocampus, right STG), semantic-syntactic re-appraisal (P600b; ventral and dorsal IFG, respectively), and global conceptual integration (P600c; precuneus and DMN). In a second set of analyses, we found that less efficient LC was marked by early underactivations in the bilateral TP; this underactivation was followed by the temporal poles over-coupling with a wider language network related to the N400. This compensatory complex was then followed by a later diminished response in the comprehension areas of the DMN. Our results reveal that semantic cognition during complex language involves a rapid exchange between cortical networks, and components of this exchange are important for efficient LC. These findings invite additional applications of fused analytical frameworks to piece apart brain network dynamics normally hidden within single modality approaches, particularly in relation to the neural etiology of clinical differences/disorders.

Topic Areas: Meaning: Combinatorial Semantics, Reading

Influences of Familial Sinistrality on the “Semantic P600” — Evidence from Brain Potentials

Poster H33 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session H.

Presenter Note: If you have any questions, please contact us via r08142005@ntu.edu.tw (Yun Chuang, Graduate student in National Taiwan University) or chialinlee@ntu.edu.tw (Chia-Lin Lee, Associate Professor in National Taiwan University).

Yun Chuang[1], Nai-wen Chang[1], Chia-Lin Lee[1]; [1]National Taiwan University

Sentences involving semantic reversal anomalies have been shown to elicit the “semantic P600” effects. With similar central-parietal scalp distributions and late time courses, the “semantic P600” is assumed by some theories to reflect similar functional and neural underpinnings as the “syntactic P600” elicited by syntactic

errors or syntactic processing difficulties. This view, however, is not without controversy, as an alternative hypothesis holds that semantic P600 may be functionally equivalent to the late positive complex (LPC)—another late central parietal positive deflections that are usually seen to semantic anomalies. Past findings demonstrated non-identical modulatory influences of familial sinistrality (FS, whether or not one has left-handed biological relatives) on LPCs and syntactic P600s. Compared to FS- individuals, FS+ individuals are less likely to elicit LPCs to semantic anomalies. FS+ individuals elicit similar syntactic P600s to syntactic anomalies like FS- individual do, but are more likely to show additional N400 responses. In light of these findings, the present study set out to examine whether and how FS might modulate semantic P600s to help delineate the functional correlates of the semantic P600. 28 FS- and 28 FS+ young right-handed Taiwan Mandarin speakers were recruited to read sentences with or without sentence final semantic, syntactic, or thematic anomalies. Participants read these sentences one word at a time from the center of a computer screen and judged if the sentences were plausible by pressing hand-held buttons. As expected, FS- participants showed significant positive responses to all three types of anomalies. Replicating prior findings of FS influences, FS+ participants showed significant syntactic P600s to syntactic anomalies, but no LPCs to semantic errors. In addition, FS+ elicited much reduced positive responses to thematic anomalies that failed to reach statistical significance. These results endorse differential influences of FS on late central parietal positive components and do not support the idea that syntactic P600 and the semantic P600 are the same effect. Keywords: familial sinistrality, individual difference, ERPs, syntactic P600, semantic P600, LPC

Topic Areas: Meaning: Combinatorial Semantics, Meaning: Lexical Semantics

Informative use of “not” is N400-blind

Poster H34 Poster PDF Poster Tour Visit me at Gather.Town in the Wernicke room during Poster Session H.

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While sentences are generally processed incrementally, negation seems an exception. Several studies have found that the N400 ERP component is not modulated by the presence of negation (Fischler et al., 1983; Haase et al., 2019; Lüdtke et al., 2008). However, others have argued that negation is processed incrementally when it is pragmatically licensed (Nieuwland et al., 2010; Nieuwland & Kuperberg, 2008; Schiller et al., 2017). We investigate whether negation is processed incrementally when it is used informatively, as participants infer the meanings of novel pseudowords. We replicate Fischler et al., using within-subject variables TRUTH (true vs. false) and FORM (affirmative vs. negative), and the addition of the between-subject variable INFORMATIVENESS (real word vs novel pseudoword). Each stimulus sentence was preceded by a context statement (e.g., I saw a trante with exotic gills in the National Aquarium), which invites an inference about the pseudoword’s meaning. Negation is under-informative in the real word condition because the stimuli convey no new information. In the pseudoword condition, however, participants cannot be completely certain that their inference about the pseudoword’s meaning is correct. A stimulus sentence (e.g., A trante is not a fish.) can then be interpreted as a correction or confirmation to their inference, rendering the use of negation informative. 39 undergraduate students were randomly assigned either to the real word (N=16) or the pseudoword condition (N=22). Participants read a context sentence at their own pace. The stimulus sentence was then presented in three chunks (subject- auxiliary-object), each presented for 175 ms with 800 ms ISI. Participants judged whether the stimulus sentence was true/plausible or false/implausible. We recorded ERPs time-locked to the object word and measured reaction times. A 2×2×2 repeated measures ANOVA on reaction time revealed significant main effects of TRUTH and FORM. False sentences were about 43 ms slower than true sentences, ($p < 0.01$), and negative sentences were 206 ms slower than affirmatives, ($p < 0.00001$), indicating the processing cost of negation. There was a significant interaction between truth and form, ($p < 0.0005$). These results replicated previous behavioral findings (Fischler et al., 1983). There were no main effect or interactions involving INFORMATIVENESS. We conducted a Principal Components Analysis on ERP data to select a combined temporal and spatial region for analysis (Dien, 2010). A 2×2×2 repeated measures ANOVA found significant main effects of FORM ($p < 0.001$) and TRUTH ($p < 0.05$) and a significant interaction ($p < 0.0001$). We found an N400 to false sentences in the absence of negation and an N400 to true sentences in the presence of negation—a negation-blind N400 pattern. There was no significant main effect or interaction with INFORMATIVENESS. Even when negation was used informatively, it did not result in incremental effects on interpretation. Nieuwland and Kuperberg's suggestion that meaningful use of negation causes incrementality does not extend to informativeness. Our findings provide new support for the theory that negation is incorporated "late" when building sentence meaning, which provides ERP evidence that quantifier scope relies on LF-movement (May, 1985).

Topic Areas: Meaning: Combinatorial Semantics, Meaning: Discourse and Pragmatics

Human atlas of multifunctional cortical networks for language

Poster H35 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session H.

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Language comprises manifold distinct processes that arise from a shared cortical architecture. The operant modulation of these conserved networks for multiple separate linguistic functions is central to understanding the neurobiology of language and domain-general cognition. To resolve the functional architecture of such networks and evaluate their changing behavior, we used large-scale electrocorticography of two essential and categorically dissociated tasks –visually-cued noun and verb naming – to generate the first complete atlas of multifunctional cortical dynamics in humans. Intracranial electrodes (n=27074, 151 patients) implanted for the evaluation of epilepsy, including both surface grid electrodes and penetrating stereotactic depth electrodes, yielded complete bilateral coverage of the cortex. Surface-based mixed-effects multilevel analysis of broadband gamma activity with narrow overlapping time windows produced a time-varying map of relative cortical engagement in noun and verb naming. The state dynamics and inter-regional connectivity were subsequently captured by an autoregressive hidden Markov model (ARHMM) that integrated network activity across patients and tasks. We identified a parallel sequence of network state dynamics in noun and verb naming involving a conserved set of distributed neural substrates spanning the language dominant hemisphere. Both tasks evoked a convergent network state for visual recognition immediately following picture presentation. The cortical response subsequently diverged – while the same architecture was engaged, the intranodal connections were unique. Concurrent with articulation, these distinct streams fused in network states corresponding to production and self-monitoring. With this analysis, we identify underappreciated roles for middle fusiform gyrus, supplementary motor area, dorsomedial prefrontal cortex, and posterior middle temporal gyrus in language production. This work characterizes the divergent behavior of conserved cortical language networks, forming the foundation of ongoing development of closed-loop multi-site stimulation designs for the modulation of evoked behavior. In addition to answering long-standing questions regarding the neurobiology of language, we present a powerful analytic framework that may be used in the future to study generalized human cognition.

Topic Areas: Language Production, Control, Selection, and Executive Processes

Using Dual Regression to identify biomarkers associated with correct responses on picture naming test in chronic post-stroke aphasia

Poster H36 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session H.

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Impairment in naming (anomia) is a complicated, yet a widely occurring symptom in patients with aphasia. While prior research suggests that impaired naming is associated with damage to a specific set of brain areas including posterior frontal, temporal, inferior parietal and anterior occipital cortices, little is known about the relationship between naming and functional connectivity within this network. Here, we utilize a novel approach

that combines multi-subject ICA with a dual regression to estimate the relationship between resting-state connectivity and performance on the Philadelphia Naming Test (PNT) in individuals with chronic post-stroke aphasia. Sixty-four participants with chronic post-stroke aphasia were recruited as part of an aphasia treatment trial. Participants included 39 males and 25 females, who were on average 59.98 years old (SD=11.58), and 52.13 months post-stroke (SD=54.39). All participants received a comprehensive behavioral and neuroimaging workup at baseline. The Western Aphasia Battery-Revised (WAB-R) was used to determine aphasia type and aphasia severity (measured using the WAB-R aphasia quotient, AQ). The mean WAB-R AQ was 58.9 (SD=24.85), indicating that, on average, participants had moderately severe aphasia. We used resting-state functional magnetic imaging (rfMRI) to investigate brain networks supporting naming performance, as measured by the PNT. We used probabilistic group Independent Component Analysis (GICA), a model-free multivariate method that avoids many pitfalls common in traditional seed-based approaches, to assess functional connectivity. Estimated ICs at the group level were then estimated using a back-reconstruction approach for each subject using Dual Regression (DR) yielding subject-specific spatial maps and timecourses for each estimated component. Randomized permutation testing (3000 permutations) was used correct for multiple comparisons while computing cross-subject statistics for each group-ICA component. Functional connectivity (FC) in several cortical regions was correlated with naming performance. In the left hemisphere, increased FC in regions including the middle occipital gyrus, and angular gyrus was associated with higher PNT scores ($p<0.05$). In the right hemisphere, functional connectivity in the pre-cuneus and middle occipital gyrus was significantly correlated with higher scores on the PNT ($p<0.05$). Finally, we observed a significant positive correlation between PNT scores and FC in the bilateral cerebellum ($p<0.05$). The current research shows functional connectivity is associated with individuals' performance on a naming test, suggesting that naming ability is correlated with synchrony in regions in both the right and left hemisphere. Discussion will focus on the role of resting-state networks in supporting language production, and the extent that functional connectivity underlies intact naming in aphasia.

Topic Areas: Language Production, Language Therapy

Anatomical Connectome Bypasses Predict Variance in Aphasia Severity After Stroke

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The severity of language function impairment (aphasia) after stroke is strongly predicted by the size and location of the lesioned tissue. However, the degree to which language function is preserved could result from the ability of the brain to reroute neural processes through residual available anatomical connections to bypass damaged tissue. While prior research has suggested the presence of bypasses, their behavioral relevance and location have not been examined. To do so, we defined bypasses as the shortest paths through residual post-stroke anatomical connectomes that are longer than the shortest path between the same nodes in a comparable healthy sample (i.e., elongated relative to controls). We hypothesized that aphasia severity (WAB-AQ) would be inversely associated with (1) the length of the bypasses relative to the comparable shortest path in controls (bypass elongation), because longer paths could lead to signal delay or decay; and (2) the degree to which bypasses rely on a subset of anatomical connections (bypass overlap), because many bypasses relying on the same white matter could cause signal disruption. To test these hypotheses, we trained Support Vector Regression (SVR) models to predict WAB-AQ from feature matrices that separately encoded bypass overlap and elongation. Specifically, we computed the bypass overlap and elongation matrices for 41 stroke subjects, based on differences in anatomical connections relative to a sample of 36 healthy controls. The feature matrices were normalized by edge density (number of edges in stroke networks compared to healthy controls) to control for lesion size. We reduced the number of input features to each SVR using iterative mutual information (MI) feature selection. SVR hyperparameters were selected via cross-validated RBF-kernel grid-search. The final cross-validated SVR model predicting WAB-AQ from bypass elongation and overlap resulted in an r^2 of .399 and .353, respectively. We also permutation tested these models by shuffling the WAB-AQ vector relative to the features for each SVR model (10000 permutations) and found that the r^2 values from the observed data were significantly greater than the r^2 obtained from any of the permuted inputs (p<.0001). This suggests that model complexity (number of input features) did not explain the performance of the final models. Finally, we backprojected the behaviorally-relevant features to identify those most related to the AQ. Behaviorally-relevant bypass elongations were concentrated in left intrahemispheric connections between inferior temporal and superior frontal and parietal lobes, and interhemispheric left temporal and parietal connections to right frontal and parietal lobes. Behaviorally relevant bypass overlap edges were concentrated in connections between left subcortical / inferior cortex intrahemispherically to left posterior parietal lobule, as well as interhemispherically to broad areas on the right parietal and temporal lobules. The cross-hemispheric link between left putamen and right superior frontal area was most predictive. Thus, the degree of reliance on anatomical bypasses involving contralateral perisylvian language areas, frontoparietal executive systems, and subcortical mediating pathways could serve as important moderators of individual differences in post-stroke aphasia severity. Future studies could investigate the extent to which anatomical bypasses account for functional plasticity and mediate specific dimensions of aphasia.

Topic Areas: Disorders: Acquired, Methods

Altered oscillatory responses to language in the semantic variant of PPA: Converging evidence from MEG, Voxel-Based Morphometry, and Diffusion Weighted imaging.

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Introduction. In the semantic variant of primary progressive aphasia (svPPA), gradual atrophy of ventral and lateral portions of the anterior temporal lobes (ATL) results in impaired single word comprehension and object naming, with relatively preserved grammatical structure and fluency. In the present study, we examined patterns of MEG induced oscillatory responses during sentence comprehension in a single case with svPPA. Electrophysiological responses were measured to identify changes in oscillatory patterns and neural recruitment in response to semantic and syntactic aspects of sentences. We examined how gray matter atrophy in the ATL, and disruption in white matter diffusivity and connectivity in the connected ventral white matter tracts, contribute to altered patterns of language-related oscillatory activity in svPPA. Methods & Procedure. Participants performed a sentence comprehension task while their brain responses were examined using magnetoencephalography (MEG). The sentences included semantically and syntactically anomalous words that evoked distinct electrophysiological responses and recruited different brain regions. To characterise patterns of gray matter atrophy and white matter disconnectivity, we collected structural and DWI scans. Gray matter atrophy was examined using Voxel Based Morphometry (VBM) implemented in SPM12, and white matter tract connectivity and integrity was examined with bidirectional iterative parcellation (BIP). BIP estimates white matter atrophy with tract volumes and diffusion metrics, and characterizes the volumes of connected cortical regions anchored by these tracts. Results. In svPPA, we observed altered patterns of oscillatory responses to sentences with semantic anomalies in the left ATL. These regions were extensively atrophied based on the VBM analysis. More importantly, the abnormal oscillatory responses during language tasks extended to the left and right posterior frontal, postcentral, and right superior parietal areas that were not visibly affected by neurodegeneration. Analyses of DWI data revealed that neurodegeneration affected integrity of the ventral white matter tracts that connect the ATL to the inferior frontal and posterior temporal cortices. The significant increase in mean and radial diffusivity metrics pointed to myelin damage in svPPA. Compared to controls, in svPPA the ATL was less connected to frontal and temporal regions. Together, the results of VBM and BIP analyses, indicated that that this disconnectivity was due to loss of gray matter in the ATL, and pruning or thinning of connected white matter fibers. Conclusions. In the present study, the pattern of language-induced oscillatory responses in svPPA was examined in the context of gray mater atrophy and alterations in white matter connectivity. Abnormal oscillatory responses during language tasks and extensive cortical atrophy in the ATL were accompanied by white matter damage and disconnection. The combined measures revealed the extent of neural tissue that is structurally and functionally compromised in svPPA.

Topic Areas: Disorders: Acquired, Meaning: Lexical Semantics

Semantic Network Resting State Connectivity in Healthy Controls and Persons with Aphasia

Poster H40 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session H.

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Introduction. Neuroplasticity in aphasia recovery, occurring spontaneously and with intervention, is an adaptive process of restoration or reorganization of function. This recovery may result in improved performance (accommodative) or may be maladaptive, resulting in persistence of errors. For example, word retrieval for verbal expression in individuals with aphasia may improve over time as (1) a restorative process given intervention and (2) a result of learned compensatory strategies to improve communicative effectiveness. But, that individual's verbal expression may continue to contain semantic, phonologic paraphasias. Thus, it is important to understand reorganization of the brain following stroke in terms of what remains relatively intact versus what is an accommodative versus maladaptive change in language network dynamics. Method. Functional connectivity (FC) strength amongst ROIs of a semantic network in resting-state fMRI were evaluated in 22 people with aphasia (PWA) and 18 healthy, age-matched control participants to identify group differences. The network included: right and left homologues of the anterior middle temporal gyrus (aMTG), planum polare (PP), anterior temporal fusiform cortex (atFusi), posterior supramarginal gyrus (pSMG), and angular gyrus (AG). Pearson correlations were computed between extracted time series of each of the ROIs to examine FC and r-values were transformed to Fisher's Z values. Paired t-tests compared PWA and controls. Connected language samples, from the Western Aphasia Battery-Revised Picnic Scene, were evaluated for evidence of correct and erroneous (e.g., paraphasias) semantic access. Picture descriptions were transcribed using CHAT/CLAN – two independent raters transcribed, then met to reach consensus regarding transcription disagreements. Principal Component Analysis of CHAT/CLAN results was performed to find a semantically loaded component (production measures loaded onto component 3: Type Token Ratio (TTR), density, percent nouns, percent present participle, percent preposition, and number of semantic errors). Univariate analyses and linear regression with backward, stepwise elimination were used to determine whether FC amongst the ROIs could predict amount/percentage of errors (semantic paraphasia, significant pauses) committed in picture description, or semantic factor from PCA; corrected for lesion volumes. Results. Three connections were similar among both controls and patients: laMTG-raMTG, lpSMG-lAG and raMTG-lAG. All other connections were unique to either controls or patients. The hubs, ROIs with the most connections to other ROIs, were laMTG in controls, and raMTG and lAG in PWA. It is noteworthy that the raMTG is the only right hemisphere ROI with significant connections in PWAs, and its FC in two connections (lpSMG-raMTG, lPP-raMTG) positively correlated with semantic errors. Conclusion. These results suggest evidence of maladaptive neuroplasticity, as the connections that correlated with more semantic errors were not significant connections in the control-only group. The raMTG was a hub of connectivity for the PWAs, which may implicate the right hemisphere's elevated role in language when the left hemisphere is lesioned, with new neural pathways made to compensate for left hemisphere damage. However, this neuroplastic process may indicate maladaptive plasticity given that the strength of these right hemisphere connections positively correlates with semantic errors.

Topic Areas: Disorders: Acquired, Language Production

Investigating the role of left IFG in speech control in aphasia: a concurrent tDCS-fMRI study

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Anomia is a debilitating deficit in object naming most commonly caused by a left hemisphere aphasic stroke. Transcranial direct current stimulation (tDCS) targeting the left inferior frontal cortex (IFC) can improve naming. However, object naming requires both language and general cognitive control processing, and due to a lack of control tasks used in previous work, the specificity of tDCS effects to language processing remains unclear. Also, the neural mechanisms that underlie effects of tDCS on speech production remain elusive. Here we use concurrent fMRI and tDCS targeting anatomically intact, left IFC in 18 aphasic patients with lesions involving left temporo-parietal cortices to test whether (i) anodal tDCS (atDCS) compared to sham specifically affects spoken language performance, as opposed to cognitive control processes and (ii) whether an individual's response to atDCS is associated with neural activity within targeted LIFC. In a fully-balanced, crossover designed study patients viewed objects while performing two overt speech tasks: (i) object Naming (language task) and (ii) object size Judgement (non-language, cognitive control task). On two separate occasions they received either 2mA anodal or sham tDCS targeting LIFC for 20 mins concurrently with both tasks. To analyse behaviour, we applied linear mixed effects to model speech efficiency scores (RT÷%correct) using stimulation and task as main predictors. We used multiple linear regression to assess the relationship between atDCS-induced efficiency change and fMRI signal intensities. Behaviourally, atDCS compared to sham improved Naming performance ($t = -3.102$, $p = .002$), whereas atDCS impaired Judgement performance ($t = 4.678$, $p < .001$). Neurally, at a group level activity in the LIFC (BA44/45) and the anterior cingulate cortex (ACC), was observed specifically in the Judgement task, but not in the Naming task. There was a positive association between each patient's atDCS driven change in Judgement performance and neural activity in the targeted LIFC ($t = 2.860$, $p = .019$). In other words, where aTDCS enhanced a patient's Judgment performance there was a positive increase in LIFC activation. In contrast, there was a negative association with activity in the ACC ($t = -3.480$, $p = .007$), i.e. a decrease in ACC activation was related to an increase in aTDCS driven change in Judgement performance. There was no association with atDCS effects on Naming performance (ps > .05) in either brain region – future analyses will examine this issue further. In sum, online atDCS targeting LIFC in aphasic patients modulated speech production in both language and non-language tasks, indicating residual LIFC's viability to control speech. atDCS exerted its effects both proximally, under the stimulated target and distally on the anatomically connected main cognitive control hub. These findings show that its mechanism of action is best understood as a complex interaction between current task demands and the underlying neural dynamics. Fundamentally, these behavioural and neuroimaging results together support the hypothesis that LIFC is not specific for language processing per se but has a more general role in cognitive control of speech responses, required for both language and non-language tasks.

Topic Areas: Disorders: Acquired, Control, Selection, and Executive Processes

Investigating factors of aphasia recovery

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Background Over the last several decades, one of the most intriguing questions in aphasia is the nature of language recovery. Although most investigators agree that there is a degree of language improvement after the onset of stroke even in untreated aphasic patients, in acute or chronic phase, the exact relationship between recovery of particular language functions and possible predicting factors, such as demographic or lesion variables, is yet to be fully understood. In the present study we attempt to investigate such relationships focusing on two language domains: comprehension and naming. Methods Forty-one patients (13 women), with acquired aphasia due to a left single stroke, 23-84 old (mean: 56,8; SD: 14,79) with 6-18 years of formal schooling (mean: 11,43, SD: 3,63) were recruited. All participants were right-handed and native Greek speakers. CT and/or MRI scans were obtained for each patient and lesion sites were identified and coded by two independent neuroradiologists for 16 predetermined left hemisphere areas. The total number of lesioned areas served as an index of lesion extent (lesion score).The patients were assessed in two testing times by a neuropsychologist. Mean time post onset for the first examination was 18,68 days and for the second was 305,53 days. To assess language deficits, we used the Boston Diagnostic Aphasia Examination – Short Form (BDAE-SF), and the Boston Naming Test (BNT). Results The BNT score and specific BDAE-SF subscales, that is the three auditory comprehension subscales (words, commands, complex material) were included in the analyses. Comparison between the two times of testing using paired-samples t-test showed that mean performance was significantly higher for all measures in the second examination. Regression models revealed that score differences between testing times were not shown to be generally affected by lesion extent, age of onset, and years of formal schooling, with one exception: age seemed to be a marginally significant predictor for improvement of comprehension of commands scores (having an inverse association with performance). We then selected four specific lesion loci (inferior frontal, superior and middle temporal gyri, as well as the inferior parietal lobule) and tried to investigate whether lesion in these areas may have an effect on performance separately for the first and second examination phase, as well as on the score differences between the two testing times, by using independent-samples t-test. Although there were no significant results regarding score differences, there was a significant effect of temporal and parietal lesions on performance in the acute/subacute phase, but not in the chronic phase. Conclusion Our group showed overall improvement of naming and comprehension skills from the acute/subacute phase to the chronic phase. However, our findings do not provide a clear-cut answer with regard todemographic or lesion factors that may have contributed to the recovery of such language functions. Interestingly, specific lesion loci seemed to affect performance in the acute/subacute but not in the chronic phase. This finding suggests that lesions affecting temporal and parietal cortices may be crucial in the early stages of aphasia, but of lesser importance in chronic patients.

Topic Areas: Disorders: Acquired, Language Production

Distinct neural correlates of linguistic demand and domain-general demand

Poster H43 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session H.

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In this study, we investigated how the brain responds to task difficulty in linguistic and non-linguistic contexts. This is important for the interpretation of functional imaging studies of neuroplasticity in post-stroke aphasia, because of the inherent difficulty of matching or controlling task difficulty in studies with neurological populations [1-3]. Twenty neurologically normal individuals were scanned with fMRI as they performed a linguistic task (deciding if pairs of words were semantically related) and a perceptual matching task (deciding if pairs of symbol strings were identical), each of which had two levels of difficulty. Critically, the tasks were matched across domains (linguistic, perceptual) for accuracy and reaction time, such that the differences between the easy and difficult conditions were equivalent across domains. In a whole brain analysis, we found highly significant interactions of domain by difficulty (voxelwise $p < 0.005$, corrected $p < 0.05$ based on permutation testing of cluster extent). Left-lateralized language regions (inferior frontal gyrus, posterior temporal cortex) and bilateral semantic regions (anterior temporal lobe, angular gyrus, medial prefrontal cortex, precuneus) were differentially modulated by linguistic demand, while bilateral multiple demand (MD) regions (inferior frontal junction, anterior insula, pre-supplementary motor area and anterior-mid cingulate, intraparietal sulcus) were differentially modulated by domain-general demand. Follow-up analyses based on individualized regions of interest [4] revealed that all MD regions were also modulated by linguistic demand, albeit to a much lesser extent than their modulation by domain-general demand. In sum, linguistic demand and domain-general demand have strikingly different neural correlates. These findings can be used to interpret or reinterpret functional imaging studies of patients recovering from aphasia. Some reported activations in these studies can be attributed to task difficulty confounds, while others can be more confidently attributed to neuroplasticity. References: [1] Binder et al. NeuroImage 2005; 27: 677-93. [2] Price et al. J Magn Reson Imaging 2006; 23: 816-26. [3] Geranmayeh et al. Brain 2014; 137: 2632-48. [4] Fedorenko et al. J Neurophysiol 2010; 104: 1177-94.

Topic Areas: Disorders: Acquired, Control, Selection, and Executive Processes

Reading acquisition refines phonological processing in the inferior frontal cortex in children from 7 to 9 years old

Poster H44 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session H.

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By using a cross-lagged panel design and functional magnetic resonance imaging (fMRI), our previous study (Wang et al., 2020) found a scaffolding effect of early phonological processing in the superior temporal gyrus (STG) in 6-year-old children on later behavioral reading skill in 7.5-year-old children. However, we did not find any evidence that reading skill refined phonological processing in the brain. Other than this previous study, nothing is known about longitudinal change in the bidirectional relation between reading skill and phonological processing in the brain. Neuroimaging studies point to a progression from the importance of phonological representations in STG in younger children to phonological access in the inferior frontal gyrus (IFG) in older children. Thus, any refinement effects may be confined to the frontal cortex in older children. In the current study, we used the same experimental paradigm as in Wang et al.(2020) to measure children's reading skill and brain activity during an auditory phonological awareness task, but with children who were 7.5 years old at Time 1 (T1) and about 1.5 years later when they were 9 years old at Time 2 (T2). The phonological awareness task included both small grain (i.e. onset) and large grain (i.e. rhyme) conditions. We found that reading skill at T1 predicted brain activation in IFG at T2 for onset processing after controlling for brain activation at T1, and accounting for covariates of no interest including non-verbal IQ and phonological working memory. We did not find that reading skill at T1 predicted brain activation at T2 in IFG for rhyme processing or in STG for either onset or rhyme processing. Together, these results suggest that reading skill in this age range has a selective effect on refining access in the frontal cortex to small grain size phonemes. In addition, we did not find any effects of phonological processing in the brain at T1 on reading skill at T2, consistent with previous behavioral literature suggesting an age-related decline in the scaffolding effect. Together with our previous study, these findings shed light on how individual differences in phonological processing may result in or may be caused by reading deficits. In early elementary school, the nature of phonological representation in the temporal cortex appears to scaffold reading acquisition. Yet in middle elementary school, reading skill influences the effectiveness of accessing those representations in the frontal cortex, particularly at a small grain size.

Topic Areas: Development, Phonology and Phonological Working Memory

A Unique Pattern of Stuttering in a Bilingual Adult: A Case Study

Poster H45 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session H.

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Stuttering is a neuropsychological speech disorder that involves frequent and significant disruptions with normal fluency and flow of speech. Research on stuttering is limited, particularly on bilingual stuttering. In this study, for the first time in the literature, we describe a bilingual adult, MM, who stutters in her mother tongue (L1: Bulgarian), but not her second language (L2: English). Methods: After signing a consent form, the participant completed a questionnaire including demographic data, information on stuttering patterns in L1 and L2, and language proficiency and use (LEAP-Q), both about the present time (adulthood) and retrospectively about her childhood experiences. Results and Discussion: The participant was a monolingual Bulgarian speaker and lived in a monolingual environment up to age 8. At 8, MM moves to a monolingual English environment and learns English as a second language at school but continues to speak Bulgarian at home. As a child, MM noticed that she stuttered much less in L2. As an adult, MM almost never stutters in L2 but stutters in L1, specially when she communicates with her family. MM is highly educated and fluent in all four modalities in both languages. The participant reports not to have received any therapy in any languages. Comparison analyses of the stuttering pattern in L1 and L2 at childhood vs adulthood reflect different patterns of stuttering in L1 and L2 in all environmental and situational conditions. The results of the detailed survey on adulthood experiences confirm different stuttering patterns in L1 and L2; especially in environmental situations, communication partners or tasks requiring executive functioning. In addition, different patterns of stuttering was reported in L1 vs L2, at different levels of L2 proficiency levels. L2 proficiency levels are associated with different loads of cognitive demand and mostly controlled by executive function (Abutalebi & green, 2007; Ghazi Saidi & Ghazi Saidi et al., 2013). Further, there is prominent evidence for stronger executive functions including cognitive control in bilingual speakers as compared to their monolingual peers (Ansaldo et al., 2015). Learning a new language is associated with an enhancement of working memory, executive function and motor planning and programming (Ghazi Saidi & Ansaldo, 2018). On the other hand, neuroimaging provides evidence that stuttering is associated with dysfunction of pre-motor and motor processing, as well as working memory deficit (Yang et al., 2019) and executive dysfunction (Anderson & Ofoe, 2019). The distinct stuttering patterns in L1 and L2 in this bilingual case can be justified by different loads of cognitive control demand in L1 vs L2, which leads to better control of her stuttering in L2. This argument is in line with evidence reported for a bilingual advantage to offset stuttering (Kornisch & Jones, 2017), as well as a better attentional control at dual tasking in individuals who do not stutter as compared to their peers who do (Bosshardt, 2006). To better understand the connection between executive functions and bilingual stuttering, a future study should employ neuroimaging to compare neural correlated of the two languages of this unique case.

Topic Areas: Control, Selection, and Executive Processes, Multilingualism

Oscillatory Dissociation of Linguistic Prediction and Error: Evidence from Naturalistic EEG and Temporal Response Functions

Poster H46 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session H.

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During language comprehension, listeners tend to predict upcoming words based on the prior lexical-semantic context. Moreover, they routinely adapt their internal mental model of the semantic context based on the degree of mismatch between the predicted and incoming word—that is, the degree to which their prediction was an error. It has been hypothesized that neural oscillations in two complementary frequency bands subserve prediction and error, respectively: The beta band (~13–30 Hz) is thought to mirror the generation of predictions from the prior context and the adaptation of the internal model proportional to the error. In contrast, the low/mid gamma band (~30–70 Hz) is thought to monitor the degree to which the incoming word matches the prediction. We report the first within-study observation of both of these relationships during language comprehension. We took a naturalistic approach, analyzing the EEG of 18 native speakers of Persian who listened to six sections of the Persian translation of Alice in Wonderland. At each word onset of the narrative, the (un)certainty with which listeners' can derive a lexical-semantic prediction from the prior word sequence was modeled as word entropy. Conversely, the degree to which this prediction (mis)matches the linguistic input was modeled as surprisal. Complexity metrics were derived from a lexicalized language model. After preprocessing, the EEG recording was filtered within the above beta– and gamma-band cutoffs; oscillatory power was calculated by squaring the absolute of the filtered signals' Hilbert-transforms. We then regressed the complexity metrics of prediction and error against power using temporal response functions. In line with recent evidence, beta-band power was increased under both low entropy (i.e., strong predictions) and low surprisal (i.e., small error), possibly reflecting the strengthening of the mental model of the semantic context. In contrast, gamma-band power decreased under high surprisal (i.e., large error), consistent with a role in monitoring how well predictions fit the linguistic input. The mean time point of these effects was ~500 ms post word onset, consistent with the canonical time window of semantic integration. Together, these results are consistent with the predict-and-match hypothesis, under which oscillatory power, often taken to reflect synchronicity of neuronal firing, rises when predicted and incoming information fits. Our findings directly link frameworks of probabilistic lexical-semantic language comprehension to domain-general systems-neuroscientific theories of the electrophysiology that underlies predictive processing.

Topic Areas: Computational Approaches, Meaning: Combinatorial Semantics

Event related potential and time frequency exploration of the organizational structure of abstract versus concrete words in neurologically intact younger adults

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Chaleece W. Sandberg[1], Erika Exton[2], Kelly L. Coburn[1], Soyeon Chun[1], Carol Miller[1]; [1]Penn State, [2]University of Maryland

The nature of the concreteness effect and therefore the underlying representation and organization of abstract and concrete words in the semantic system is currently under debate. One recent hypothesis is that abstract words are organized thematically (i.e., via association), while concrete words are organized taxonomically (i.e., via similarity; Crutch, Connell, & Warrington, 2009). This project aims to determine if this hypothesis is supported with EEG data. While differences between abstract and concrete word processing have been established using ERP analyses (e.g., Barber, Otten, Kousta, & Vigliocco, 2013; Kounios & Holcomb, 1994), this particular hypothesis has not been explored. Similarly, while there appear to be differences in alpha versus theta power for taxonomic versus thematic processing of concrete words (Maguire, Brier, & Ferree, 2010), time frequency analysis has not been applied to the question of whether abstract and concrete words are organized thematically or taxonomically. Twenty-six right-handed English-speaking neurologically intact younger adults (NIYA; 9 male), ranging in age from 18-36 (μ=24.08), received an EEG scan while completing lexical decision and semantic relatedness tasks. One participant's data was dropped due to excessive sleepiness. The lexical decision task included 60 abstract, 60 concrete, and 120 nonwords and was included to replicate previous work (e.g., Kounios & Holcomb, 1994). The semantic relatedness task was adapted from Crutch et al. (2009) to test the different representational frameworks hypothesis. Forty semantically related word pairs were presented in each of four conditions: abstract similar, abstract associated, concrete similar, and concrete associated. Unrelated word pairs were included to balance yes/no responses. For both tasks, the abstract and concrete stimuli lists were matched on frequency and familiarity, but differed on imageability and concreteness. ERP and time frequency data will be analyzed using EEGLAB and ERPLAB. Data are being preprocessed using a standard pipeline, including ICA to mitigate the effects of eye blinks. Repeated measures ANOVA will be used to compare ERP amplitudes across conditions within the N400 time window. Time frequency analyses will also be performed

to examine potential differences in oscillations among conditions. We hypothesize that the lexical decision task will align with previous ERP work showing a larger N400 for concrete words. We also hypothesize that words in their ‘dispreferred’ context (concrete = associative; abstract = categorical/similarity) will have a larger N400 than words in their ‘preferred’ organizational context (concrete = categorical/similarity; abstract = associative). Based on previous work showing differences in theta power related to semantic information during lexical decision (e.g., Bastiaansen, Oostenveld, Jensen, & Hagoort, 2008), we hypothesize differences in theta power between abstract and concrete word processing during lexical decision. Based on previous work showing differences in alpha versus theta power for taxonomic versus thematic processing of concrete words (e.g., Maguire et al., 2010), we expect differences among conditions in the semantic relatedness task to emerge in these power bands.

Topic Areas: Meaning: Lexical Semantics, Language Production

Dissociating and localizing prediction in language comprehension: An MEG study on Japanese classifier-noun processing

Poster H48 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session H.

Hiromu Sakai[1], Yohei Oseki[1,2], Aine Ito[3], Atsushi Matsumoto[4], Michiru Makuuchi[1,5]; [1]Waseda University, [2]University of Tokyo, [3]Humboldt University, [4]Kansai University of Welfare Sciences, [5]Research Institute of National Rehabilitation Center

Introduction: Recent research on neurocognitive processes of language comprehension revealed that language comprehenders continuously generate prediction about upcoming input (Altmann & Mirkovic, 2009; Federmeier, 2007; van Patten & Luka, 2012, among many others). Researchers have been trying to dissociate the predictive processes form other processes and localize the neural mechanisms for generating predictions in human brain. The present research aims to contribute to this goal by conducting magnetoencephalography (MEG) experiment measuring neural activities during comprehension of Japanese sentences including classifier-noun combinations. Although MEG has advantage in localizing the source of neural activities, in previous prediction research using MEG (Dikker & Pylkkanen, 2013; Maess et al., 2016; Lau et al., 2016), the effect of prediction is not completely dissociated from the effect of semantic integration into the preceding contexts. Using Japanese classier-noun combination (Mueller et al, 2015 for Japanese and Chou et al, 2016 for Chinese classifier processing), our experiment design enabled to manipulate predictive validities and control for integration difficulties. Material: Japanese is one of the languages that employ a classifier system in counting elements. For instance, “three cars” must be expressed as “san dai-no kuruma (lit. three bodies of car)”. Based on the analysis of BCCWJ corpus (Balanced Corpus of Contemporary Written Japanese, the National Institute of Japanese Language and Linguistics), we selected the classifier “-tsu (piece)” and “-dai (body)” for this experiment. The classifier -tsu is most widely used with either concrete or abstract objects and imposes little semantic restrictions on the associated nouns, whereas -dai (body) is used only with a large machinery such as cars and thus narrowly restricts semantic types of associated nouns. This makes it possible to construct a stimuli set that controls for both the target noun frequency and the bigram frequency of classifier-noun combinations (“yot-tsu-no seihin (two pieces of products)” and “yon-dai-no basu (four bodies of bus)” having the same bigram frequency), and at the same time contrasts the transition probabilities from the classier to the noun (the probability of “seihin (products)” given “yot-tsu (four pieces)” being significantly lower then the probability of “basu (bus)” given “yon-dai ‘(four bodies)”). A total of 216 stimuli sentences were created using typical or atypical classifier-noun combination to each of the two classifiers, and classified into four experimental conditions. Methods and Results: Thirteen native Japanese speakers participated in the experiment. MEG data were recorded using a whole-head 306 channel MEG system (Electa-Neuromag) while the participants were reading stimuli sentences projected word-by-word on a transparent screen located in a magnetically shielded room. Recorded data were preprocessed and analyzed by MNE python. The results of data analysis are delayed because of the delay of data processing schedule due to COVID-19 and expected to be completed in August 2020. We expect modulation of neural activation in left temporal cortex based on previous MEG research on linguistic prediction. The focus of activation reduction in highly predicted nouns is expected to be more localized because of dissociation of prediction effect from semantic integration effect.

Topic Areas: Meaning: Combinatorial Semantics, Meaning: Lexical Semantics

The role of the right hemisphere in language processing in post-stroke aphasia: Pilot data for an ongoing investigation of language network re-organization

Poster H49 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session H.

Lynsey Keator[1], Samaneh Nemati[1], Alexandra Basilakos[1], Grigori Yourganov[1], Chris Rorden[1], Leo Bonilha[2], Julius Fridriksson[1]; [1]University of South Carolina, [2]Medical University of South Carolina

Background: Aphasia is a language disorder resulting from damage to eloquent language cortex in the left hemisphere (LH). Work from our group suggests damage to structural connectivity networks has substantial impact on language in the chronic stages of recovery (Yourganov et al., 2016; Bonilha et al., 2015). Recent studies suggest lesion location may influence language reorganization such that involvement of right hemisphere (RH) cortex occurs following damage to frontal, but not temporo-parietal regions of the LH (Stockert et al., 2020). Our aim is to identify associations between structural connections and language function to determine how lesion location and lesion size affect language reorganization in ipsi- and contralateral hemispheres in chronic aphasia. Given the extensive variation in lesion location and size in an existing cohort of participants, pilot data presented here include a subset of participants with Broca's aphasia. Pilot data will inform future analyses for a larger cohort of participants (n = 107) with more diverse patterns of damage. Methods: NiiStat software was used to determine associations between structural connectivity and language scores (n = 43) using dual stream regions of interest form Fridriksson et al., 2016. Total lesion volume was included as a covariate to control for extent of LH damage. Results: White matter connections between anterior RH regions and posterior LH regions are associated with language performance in both expressive (Sentence Completion [SC] and Responsive Speech [RS] subtests of the WAB-R) and receptive tasks (Auditory Word Recognition [AWR]). SC scores are associated with connections between left inferior temporal gyrus (ITG) and right precentral gyrus (z = 4.2), right postcentral gyrus (z = 3.58) and right middle frontal gyrus, posterior segment (z = 3.41). RS scores are positively correlated with left ITG to the right angular gyrus (z = 3.64), left posterior middle temporal gyrus and right pre- and postcentral gyrus (z = 3.83 and 3.72, respectively) and left middle occipital gyrus to the left angular gyrus (z = 3.58) and left ITG (z = 3.75). AWR scores are positively correlated with connections between the left ITG and right posterior insula (z = 3.44) and the left LTG and right middle frontal gyrus, posterior segment (z = 3.54). Conclusion: Results demonstrate structural connectivity between left hemisphere perisylvian areas and right hemisphere homologue regions are correlated with expressive and receptive language performance (greater connectivity between these regions facilitates better language performance). These pilot data inform connectivity related to lesions encompassing anterior and posterior regions of the LH in a cohort of participants with Broca's aphasia. Future analyses will determine how such associations differ with varying degree and location of damage to perisylvian LH regions in a larger and more diverse cohort of participants. Specifically, we will calculate and factor out anterior and posterior ROI lesion loads and control for lesion location to determine the extent to which damage to the LH affects associations between structural connectivity and language function. Results will further inform the dynamics of language network re-organization in the chronic stages of aphasia recovery.

Topic Areas: Disorders: Acquired, Methods

The contribution of white matter pathology, hypoperfusion, and stroke recurrence to language deficits following acute subcortical left hemisphere stroke

Poster H50 Poster PDF Visit me at Gather.Town in the Wernicke room during Poster Session H.

Massoud Sharif[1], Erin Meier[2], Alex Walker[2], Emily Goldberg[2], Argye Hillis[2]; [1]Johns Hopkins University, [2]Johns Hopkins University School of Medicine

Aphasia, the loss of language ability following damage to the brain, is among the most disabling and common consequences of stroke. Subcortical stroke, occurring in the basal ganglia, thalamus, and/or deep white matter can result in aphasia, often characterized by word fluency, motor speech output, or sentence generation impairments. The link between greater lesion volume and acute aphasia is well documented, but the independent contributions of lesion location, cortical hypoperfusion, prior stroke, and white matter degeneration (leukoaraiosis) remain unclear. We aimed to disentangle the contributions of each factor on language impairments in left hemisphere (LH) acute subcortical stroke. Eighty patients (36 women, mean age: 55.66 years) with acute LH subcortical stroke (<10 days post-onset) participated. We manually traced acute lesions on DWI scans and prior lesions on T2-weighted scans and calculated lesion volume/location using NiiStat. Ipsi- and contra-lesional leukoaraiosis were rated on T2-weighted scans using the Fazekas et al. (1987) scale, a visual rating scale ranging from 0 (none) to 3 (severe) periventricular (PVH) or deep white matter (DWMH) hyperintensities. Fluid-attenuated inversion recovery (FLAIR) scans were evaluated for hyperintense vessels (HV) in each vascular territory from 0 (none) to 2 (≥3 HVs per slice or HVs in ≥3 slices), providing an indirect measure of hypoperfusion in lieu of perfusion-weighted scans. A binary aphasia variable was generated from z-scores reflecting naming and auditory comprehension (cutoff: -0.322). We compared stroke variables between people with/without aphasia using Wilcoxon rank sum and chi-square tests. Age, sex and days post stroke-onset were included as nuisance variables in a logistic regression predicting aphasia status from previously-significant stroke variables. Leukoaraiosis did not differ between hemispheres (PVH: $p=0.697$; DWMH: $p=0.617$), so further analysis was performed by subscale only. While older age was linked to more severe leukoaraiosis (PVH: $r=0.553$, $p<0.001$; DWMH: $r=0.534$, $p<0.001$), sex and leukoaraiosis were not significantly associated ($p\geq0.456$). Hypoperfusion did not vary by either age or sex ($p\geq0.300$). Compared to people without aphasia, patients with aphasia had larger lesion volume ($p=0.019$) but similar likelihood of prior stroke ($p=0.251$). Patients with aphasia had more basal ganglia ($p=0.041$), corona radiata ($p=0.031$), and internal capsule ($p=0.003$) damage than those without aphasia, but none of these lesion sites survived when controlling for stroke volume ($p\geq0.168$). We found no significant differences between groups in either leukoaraiosis subscale ($p\geq0.088$) or hypoperfusion ($p=0.509$), likely because only 3/80 had substantial speech or language deficits. The only significant predictor of aphasic status was older age ($p=0.014$) in the logistic regression. That few differences in stroke variables existed between people with/without aphasia is unsurprising; while subcortical stroke can cause aphasia, it usually does not. The 3 participants with marked deficits ((z-scores 1.5 SD below the mean), had large basal ganglia lesions and/or cortical hypoperfusion. We will discuss profiles of performance across language tests which can be largely accounted for by deficits in executive function and/or motor speech impairments.

Topic Areas: Disorders: Acquired, Speech Motor Control

Systematic review and meta-analysis of non-motor language symptoms due to cerebellar damage

Poster H51 [Poster PDF] Visit me at [Gather.Town] in the Wernicke room during Poster Session H.

Roza Vlasova[1], Yana Panikratova[2], Ekaterina Pechenkova[3]; [1]UNC at Chapel Hill, USA, [2]Laboratory of Neuroimaging and Multimodal Analysis, Mental Health Research Center, Moscow, Russia, [3]National Research University Higher School of Economics, Moscow, Russia

Introduction. Although much is already known about structural and functional organisation of the cerebellum, the particular functional role of the cerebellum in language processing is not clear yet. One of the main challenges for defining cerebellar contribution into language is the diversity of non-motor language symptoms that might be observed after cerebellar lesions. We conducted a systematic review and meta-analysis of non-motor cerebellar language symptoms reported in case studies to find out whether there is one or several patterns of cerebellar language deficit. Methods. As a result of PubMed search 140 items were found and 45 papers were included after manual search through references. After abstract review and full text inspection, 15 papers remained for systematic review with 17 case descriptions. Exclusion criteria were: patient age less than 7 y.o.; no lesion in the cerebellum; lesions outside the cerebellum; no language symptoms. Reviewing of selected cases revealed several language symptoms: word-finding difficulties; expressive agrammatism; impressive agrammatism; spontaneous speech reduction and dysprosody. Binary vector was created representing five language symptoms for each of the 17 patients with “1” meaning patient demonstrating particular symptom and “0” otherwise. This binary approach for symptom coding allowed us to overcome the problem of different methodology used in case studies all over the world. On the basis of 17✕17 cosine matrix reflecting patients similarity according to their language symptoms, hierarchical cluster analysis was performed in R. Results. Seven clusters of patients were revealed with maximized validation average silhouette width – 0.705 and the correlation between the original cosine matrix and the cophenetic distances – 0.71, agglomerative coefficient 0.96. Cluster 1: three patients had spontaneous speech reduction and expressive agrammatism with no signs of impressive agrammatism and word-finding difficulties. Cluster 2: three patients had only spontaneous speech reduction. Cluster 3: two patients demonstrated both expressive and impressive agrammatism. Cluster 4: two patients had only word-finding difficulties. Cluster 5 contained only one patient with word finding difficulties and spontaneous speech reduction. Cluster 6: two patients had mixed symptom with combination of dysprosody and word finding difficulties, and one patient also had an expressive agrammatism; Cluster 7: four patients had dysprosody, word finding difficulties, spontaneous speech reduction, expressive or impressive agrammatism or both. Conclusion. According to our review and meta-analysis, cerebellar lesions can cause morpho-syntactic and lexico-semantic difficulties as well as reduction of spontaneous speech independently. This finding suggests that the functional contribution of the cerebellum into language is manifold. Absence of the consistent co-occurrence between diverse language symptoms allows us to say that to date there is no evidence for such entity as the cerebellar language syndrome as well as unitary language-specific region in the cerebellar functional anatomy. The diversity of language symptoms after cerebellar injury can be explained via cerebellar involvement into several distributed brain networks subserving different aspects of language function.

Topic Areas: Disorders: Acquired, History of the Neurobiology of Language

Spoken Word Processing in the Bilingual Brain

Poster H52 [Poster PDF] Visit me at [Gather.Town] in the Wernicke room during Poster Session H.

Kehui Zhang[1], Xin Sun[1], Rebecca Marks[1], Xiaosu Hu[1], Tai-Li Chou[2], Twila Tardif[1], Ioulia Kovelman[1]; [1]University of Michigan, [2]National Taiwan University

Learning to read changes mind and brain. How does learning to read in two structurally-distinct orthographies, English and Chinese, influence the emerging neural organization for reading? Word reading is often understood in terms of interconnections between word sounds, meaning, and print. Cross-linguistic perspectives on learning to read in English versus Chinese often focus on the differences between sound-to-print and meaning-to-print associations because of the salience of phonology in the English alphabet and of meaning in Chinese characters. Yet, there are also important cross-linguistic differences in spoken word structure such as the polysemic nature of Chinese syllables. Here we test the hypothesis that cross-linguistic differences in learning to read are related to how children form neural associations between word sound and meaning. In particular, we predict that young learners would form stronger sound-to-meaning associations in Chinese than in English. To address this hypothesis, we tested bilingual children with early and systematic exposure to English and Chinese (N = 85, ages 5-10). The children were born in Chinese-speaking households in the US and attended English language schools as well as Chinese language afterschool programs. During fNIRS neuroimaging, children heard three words and decided which of the two words matched either phonologically or morphologically. The hypotheses are addressed through comparisons of children’s phonological and morphological processes with each of their two languages. While we expect for phonological and morphological processes to engage the dorsal and ventral neural pathways for language, respectively, we also predict cross-linguistic differences. In English, we predict finding robust differences between phonological and morphological processing along the dorsal/phonological and ventral/semantic neural pathways, especially in dorsal versus ventral inferior frontal gyrus (IFG) as well as superior versus middle temporal gyrus (STG vs MTG), respectively. In contrast, in Chinese, we predict reduced differences between the phonological and morphological processes, with greater co-activation of the dorsal and ventral networks during each of the respective tasks. Finally, we also expect for the cross-linguistic effects to vary as a function of children's dual language experience and proficiency in each of their languages. More specifically, English-dominant learners are predicted to exhibit a more English-like pattern of brain activity during Chinese languages and vice versa for the Chinese-dominant learners. The findings will therefore help to reveal universal as well as language-specific aspects of language processing that underlie child literacy development, as well as the effects of bilingualism on children's emerging neural pathways for learning to read.

Topic Areas: Development, Multilingualism

Active search for antecedents in backwards anaphora does not depend on sustained neural activity: evidence from ERPs

Poster H53 [Poster PDF] Visit me at [Gather.Town] in the Wernicke room during Poster Session H.

Aura A L Cruz Heredia[1,2], Ellen Lau[1]; [1]University of Maryland, College Park, Linguistics, [2]University of Pennsylvania, Psychology

For successful communication, speakers and comprehenders must draw on a shared set of knowledge of the discourse, i.e., the things being talked about. For example, to successfully interpret the pronoun in the forwards anaphora case in "Because John...he", one must be able to access the referent, whereas in a backwards anaphora case ("Because he...John"), one must remember what is predicated of the initial pronoun in order to connect it to the subsequently-mentioned referent. Such tasks depend on working memory (WM) resources that keep track of these discourse referents across an unbounded number of words. However, the neurocognitive mechanisms underlying the ability to process such non-adjacent relations in language remain largely underspecified. Here, we focus on backwards anaphora and ask whether the encoding of cataphoric dependencies requires sustained neural activity in the region between the pronoun and antecedent. Prior work in psycholinguistics indicates that encountering a referent-less pronoun in a backwards anaphoric (he-John) dependency triggers an active search for an antecedent, and that this search is sensitive to syntactic constraints. In contrast, such a prediction is not formed in forwards anaphora (John-he). Moreover, ERP work contrasting these kinds of dependencies has largely focused on identifying signatures of WM operations at the second element of the dependency (where the antecedent presumably has to be retrieved and integrated with the referent), rather than at the first element (where a dependency can be established by cataphora but not anaphora). Here we analyze the first NP and look for evidence of a sustained response driven by an active search for an antecedent in cataphora. We used ERPs to evaluate whether the processing of cataphoric dependencies involves sustained neural activity in the dependency region. Specifically, we searched for evidence of sustained anterior negativities (SAN), which have been previously reported for wh-questions, where the presence of a wh-phrase instantiates an active search for an object gap position. 31 participants read a total of 60 target sentences similar to above (30/condition) and 60-80 filler sentences of various structures, presented word-by-word (500ms/word). Subjects were asked a comprehension probe following approximately 1/3 of all trials. Epochs were time-locked to the onset of the first NP in both conditions, and spanned throughout the dependency. Sustained effects were evaluated using a condition x anteriority ANOVA across 20 scalp electrodes (10 anterior/10 posterior), from 250ms to 2000ms. Behavioral accuracy: 99.1% for anaphora; 98.1% for cataphora. Visual inspection of the grand average waveform and scalp plots showed no sustained differences across the 20 relevant electrodes. This was confirmed by the ANOVA (cond x anteriority: $F(30) = 0.94$, $p = 0.34$). These results suggest that the active search mechanism engaged during the processing of cataphoric dependencies does not rely on sustained neural activity, at least as indexed by the SAN previously observed for filler-gap dependencies. Moreover, this study is the first to report direct evidence against the idea that anterior negativities are robust indices of "identifying and encoding" the first element of a dependency for future retrieval when an active search is possible.

Topic Areas: Control, Selection, and Executive Processes, Syntax

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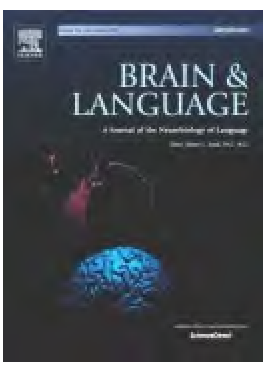

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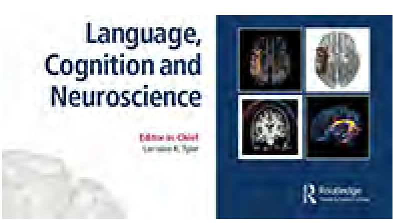

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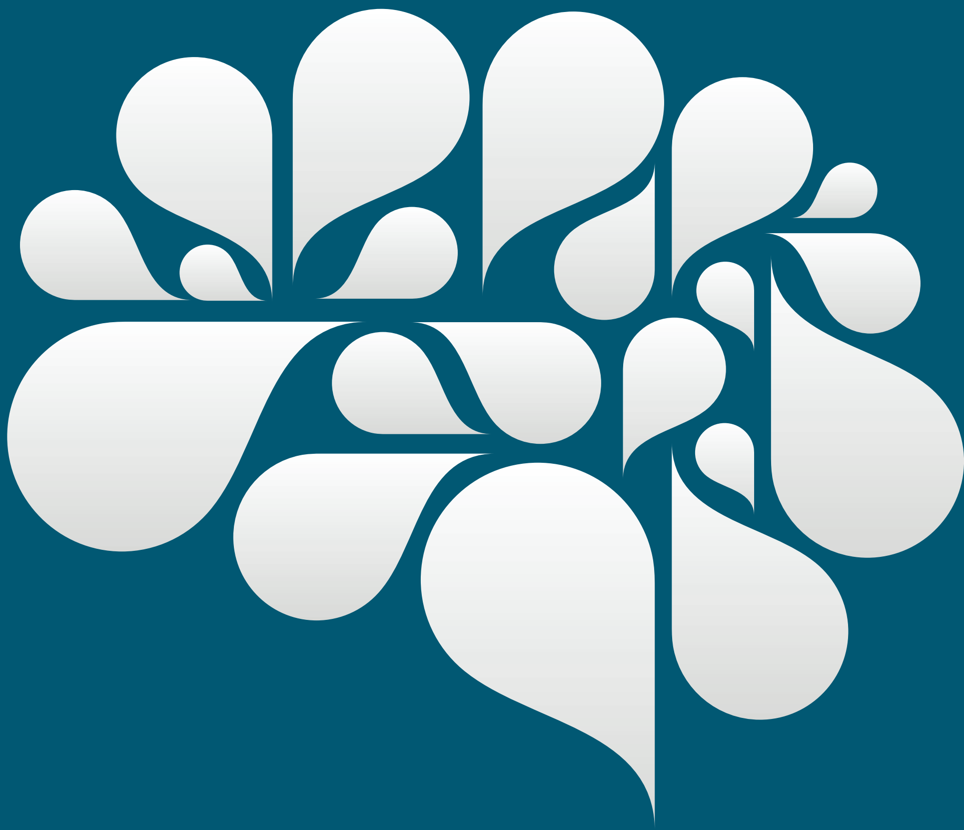

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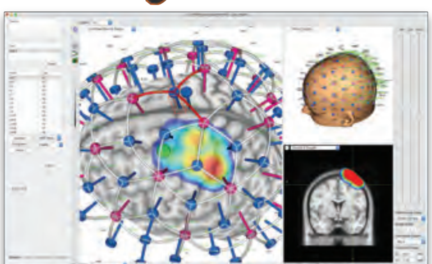

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