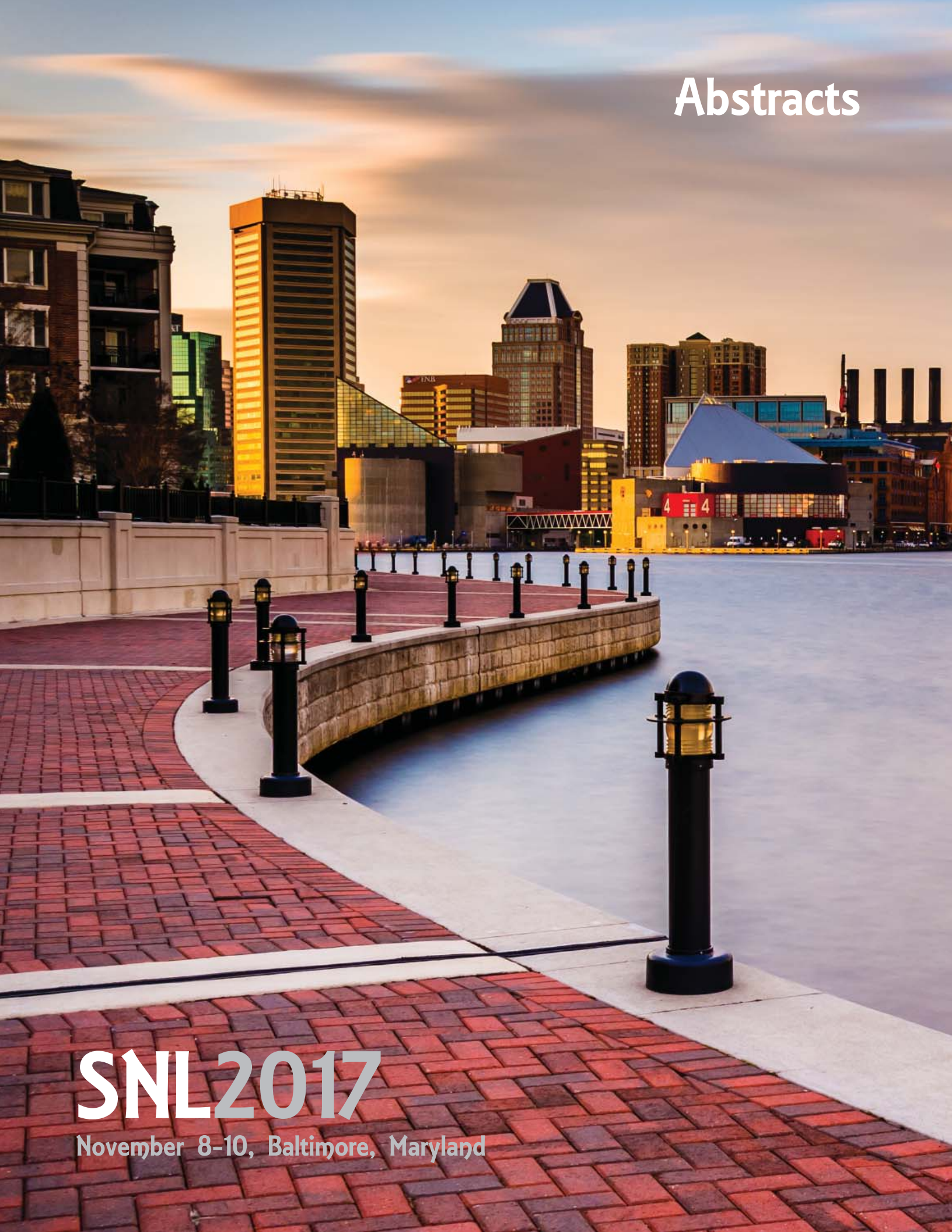
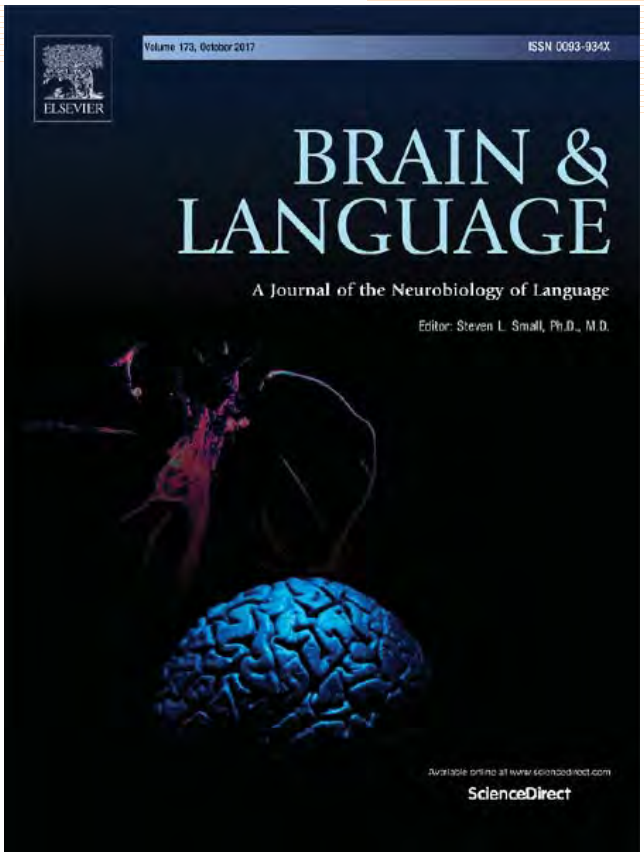
Abstracts



SNL2017

November 8–10, Baltimore, Maryland



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Brain and Language

Editor-in-Chief:

Steven Small
University of California at Irvine, Irvine, California, USA

Aims & Scope

An interdisciplinary journal, Brain and Language focuses on the neurobiological mechanisms underlying human language. The journal covers the large variety of modern techniques in cognitive neuroscience, including lesion-based approaches as well as functional and structural brain imaging, electrophysiology, cellular and molecular neurobiology, genetics, and computational modeling. All articles must relate to human language and be relevant to an elaboration of its neurobiological basis. Along with an emphasis on neurobiology, journal articles are expected to take into account relevant data and theoretical perspectives from psychology and linguistics.

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Welcome to the Ninth Annual Meeting of the Society for the Neurobiology of Language

On behalf of the SNL Board and the local organisers, I welcome you to Baltimore. This year we have organised an interesting and wide-ranging programme, using a variety of different formats. For those of you who like your thrills we have a new addition to the programme – the Poster SLAM – where, in ONE minute, presenters will whet our appetites by highlighting the most exciting findings of their research. We can follow these presentations up afterwards by chatting to presenters over their posters during the regular poster sessions.

We also have four distinguished keynote speakers who will present their cutting-edge research on a wide variety of key topics in the neurobiology of language, ranging from: recovery from acute stroke and how it relates to reorganisation of the neural networks involved in language functions (**Argye Hillis**), to ways in which we might bridge the gap between deep learning and neuroscience in order to better understand the neural computations involved in language and cognition (**Yoshua Bengio**), the emergence of language in infants, based on characterizing the properties of early brain organization and how this changes during development (**Ghislaine Dehaene-Lambertz**), and research using eCOGs to map the detailed functional organization of the encoding of speech sounds for speech perception and production (**Edward Chang**). We have also included a Symposium in which four speakers discuss their perspectives on how interdisciplinary research combining computational and and data-driven methods with neuroimaging data provides new opportunities for understanding language and the brain.

We will also hear from **Carolyn McGettigan & Jason Yeatman** who are the first recipients of our new Early Career Award. This award was initiated to honour researchers in the early stages of their careers for their high quality research and academic citizenship. Carolyn and Jason are the first awardees. They will, before describing their research, each briefly tell us a little about how they became interested in the neurobiology of language.

The core of our programme, however, remains the poster sessions, giving plenty of opportunity for discussion on the very latest research in the neurobiology of language by researchers from 24 countries around the world. We also include two slide sessions which are always very popular.

We have arranged two social events. First, a reception to be held at the world-renowned National Aquarium immediately following our opening night talk by **Dr Diana Reiss** on marine mammal communication. This looks to be an experience no-one will want to miss, so be sure to be there early. We will also have a social hour during the posters on Thursday evening. These events should provide lots of opportunity to mingle with colleagues from around the world.

I would like to thank the SNL Programme Committee for putting together this exciting scientific programme: David Corina, Patti Adank, Matt Davis & Karen Emmorey, and our meeting planners, Shauney Wilson and Shawna Lampkin, for helping to organize this year's meeting. I would like to thank our abstract reviewers who always ensure the excellent quality of our presentations.

Steve Small, who founded SNL with Pascale Tremblay, also deserves our special thanks for continuing to obtain NIH funding to support our meetings. We also thank our sponsors (*Brain & Language; Language, Cognition & Neuroscience; and Rogue Research Inc.*) for their generous support for the meeting.

I look forward to seeing you all at this year's meeting.

Lorraine K Tyler
Chair, Society for the Neurobiology of Language

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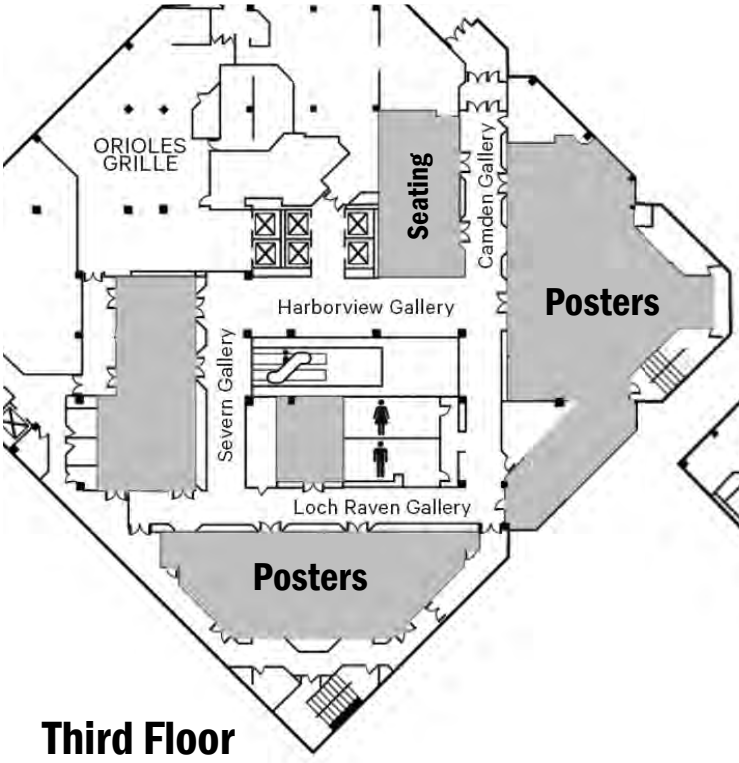
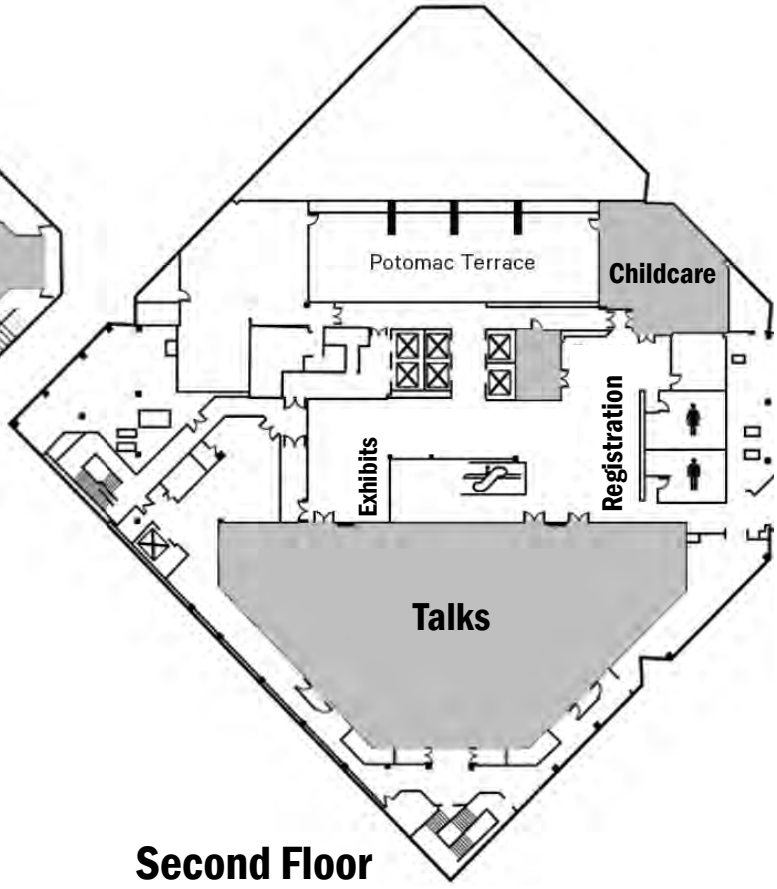
The Ninth Annual Meeting of the Society for the Neurobiology of Language will be held November 8–10, 2017 at the Sheraton Inner Harbor Hotel in Baltimore, Maryland.

Sheraton Inner Harbor Hotel Floor Plans





Schedule of Events

All events are held at the Sheraton Inner Harbor Hotel, except the Opening Night Reception, which is being held at the National Aquarium.

Wednesday, November 8, 2017

7:00 am – 5:30 pm	Meeting Registration *Chesapeake Gallery*
8:15 – 9:00 am	Continental Breakfast *Harborview Gallery*
8:40 – 9:00 am	Opening Remarks: Lorraine Tyler, Chair *Chesapeake Ballroom*
9:00 – 10:00 am	**Keynote Lecture: Argye Hillis** *Chesapeake Ballroom*
10:00 – 10:30 am	Coffee Break *Harborview Gallery*
10:05 – 10:20 am	Poster Slam Session A *Chesapeake Ballroom*
10:30 – 11:45 am	Poster Session A *Harborview and Loch Raven Ballrooms*
11:45 am – 1:00 pm	Lunch *On Your Own*
1:10 – 2:30 pm	Slide Session A *Chesapeake Ballroom*
2:30 – 3:00 pm	Coffee Break *Harborview Gallery*
2:35 – 2:50 pm	Poster Slam Session B *Chesapeake Ballroom*
3:00 – 4:15 pm	Poster Session B *Harborview and Loch Raven Ballrooms*
4:30 – 5:30 pm	**Marine Communication Talk: Diana Reiss** *Chesapeake Ballroom*
7:00 – 10:30 pm	Opening Night Reception *Offsite at the National Aquarium*

Thursday, November 9, 2017

7:00 am – 7:00 pm	Meeting Registration *Chesapeake Gallery*
7:30 – 8:15 am	Continental Breakfast *Harborview Gallery*
8:15 – 8:30 am	Announcements *Chesapeake Ballroom*
8:30 – 9:30 am	**Keynote Lecture: Yoshua Bengio** *Chesapeake Ballroom*
9:30 – 10:00 am	Coffee Break *Harborview Gallery*
9:35 – 9:50 am	Poster Slam Session C *Chesapeake Ballroom*
10:00 – 11:15 am	Poster Session C *Harborview and Loch Raven Ballrooms*
11:15 am – 12:00 pm	**Early Career Award Presentations: Carolyn McGettigan** and **Jason Yeatman** *Chesapeake Ballroom*
12:00 – 1:30 pm	Buffet Lunch Served *Various Locations*
1:30 – 3:30 pm	**Invited Symposium: Leila Wehbe, Odette Scharenborg, Barry Devereux, John Hale** *Chesapeake Ballroom*
3:30 – 4:00 pm	Coffee Break *Harborview Gallery*
4:00 – 5:00 pm	**Keynote Lecture: Ghislaine Dehaene-Lambertz** *Chesapeake Ballroom*
5:00 – 5:45 pm	Business Meeting *Chesapeake Ballroom*
5:50 – 6:05 pm	Poster Slam Session D *Chesapeake Ballroom*
6:15 – 7:30 pm	Poster Session D and Social Hour *Harborview and Loch Raven Ballrooms*

Friday, November 10, 2017

7:30 am – 1:40 pm	Meeting Registration *Chesapeake Gallery*
7:30 – 8:15 am	Continental Breakfast *Harborview Gallery*
8:15 – 8:30 am	Announcements *Chesapeake Ballroom*
8:30 – 9:30 am	**Keynote Lecture: Edward Chang** *Chesapeake Ballroom*
9:30 – 10:00 am	Coffee Break *Harborview Gallery*
9:35 – 9:50 am	Poster Slam Session E *Chesapeake Ballroom*
10:00 – 11:15 am	Poster Session E *Harborview and Loch Raven Ballrooms*
11:20 am – 12:40 pm	Slide Session B *Chesapeake Ballroom*
12:40 – 1:30 pm	Future Planning and Closing Remarks: Karen Emmorey, Chair-Elect and Pascale Tremblay, 2018 Local Organizing Committee Chair *Chesapeake Ballroom*

Keynote Lecture: Argye Hillis

Argye Hillis

Professor of Neurology, Physical Medicine & Rehabilitation, and Cognitive Science, Johns Hopkins University

Professor Hillis serves as the Executive Vice Chair of Neurology, and Director of the Cerebrovascular Division. She began her career as a Speech-Language Pathologist and Director of Neurological Rehabilitation, focusing on studies of novel treatments of aphasia and communication disorders after right hemisphere stroke. She also studied Cognitive Neuropsychology in the Cognitive Science Department at Johns Hopkins, where she later became a faculty member. Her research focused on identifying the cognitive processes underlying language and spatial representations through the study of aphasia and hemispatial neglect, and how these investigations might help focus rehabilitation. Dr. Hillis then completed medical training and neurology residency at Johns Hopkins, and integrated her training in the fields of Speech-Language Pathology and Cognitive Science with Neurology to continue her investigations of aphasia and right hemisphere cognitive and communicative impairments and how they recover. Her research combines longitudinal task-related and task-free functional imaging and structural imaging with detailed cognitive and language assessments to reveal the dynamic neural networks that underlie language and cognitive functions, such as empathy and prosody. Her lab studies changes from the acute stage of stroke through the first year of recovery, to improve our understanding how language and other cognitive functions recover after stroke and how to facilitate recovery.

ROAD BLOCKS IN BRAIN MAPS: LEARNING ABOUT LANGUAGE FROM LESIONS

Wednesday, November 8, 9:00 – 10:00 am
Chesapeake Ballroom

Chair: Brenda Rapp, Cognitive Science Department, Johns Hopkins University

Just as Google Maps can provide several ways of looking at routes between hubs or points of interest, various brain mapping techniques yield different ways of looking at structural and functional connections between processing areas critical for various language tasks. Lesions to the brain present road blocks, but there are generally alternative routes for information to flow from one critical area to another. These alternative routes may take longer, and errors can arise from "off roading"; but eventually the routes are made more efficient and effective as they are used more. I will discuss how various approaches to brain mapping of language at distinct times after "road blocks" can yield converging information about critical hubs and how one can get around them to recover language. I will illustrate with studies of task-related and resting state fMRI, connectome-symptom mapping, as well as structural and perfusion imaging studies of word comprehension and naming in stroke survivors at different stages of recovery. I will show that posterior superior temporal gyrus is one of the critical hubs for both word comprehension and naming early after stroke, but there important alternative routes that may be available depending on the size of the lesion.

Keynote Lecture: Yoshua Bengio

Yoshua Bengio

Professor, Director of MILA, Department of Computer Science and Operations Research and Canada Research Chair in Statistical Learning Algorithms, University of Montreal, Canada

Yoshua Bengio is the world-leader expert on Deep Learning and author of the best selling book on that topic. His research objective is to understand the mathematical and computational principles, which give rise to intelligence through learning. He contributed to a wide spectrum of machine learning areas and is well known for his theoretical results on recurrent neural networks, kernel machines, distributed representations, depth of neural architectures, and the optimization challenge of deep learning. His work was crucial in advancing how deep networks are trained, how neural networks can learn vector embeddings for words, how to perform machine translation with deep learning by taking advantage of an attention mechanism, and how to perform unsupervised learning with deep generative models. He is the author of three books and more than 300 publications, is among the most cited Canadian computer scientists and is or has been associate editor of the top journals in machine learning and neural networks.

BRIDGING THE GAP BETWEEN BRAINS, COGNITION AND DEEP LEARNING

Thursday, November 9, 8:30 – 9:30 am
Chesapeake Ballroom

Chair: Matt Davis, MRC Cognition and Brain Sciences Unit, Cambridge

Connectionist ideas from three decades ago have fuelled a revolution in artificial intelligence with the rise of deep learning methods. Both the older connectionist ideas and the newer ones owe a lot to inspiration from the brain, but the gap between deep learning and neuroscience remains wide. We lay down some of these old ideas, based on learning distributed representations in order to jointly optimize by a gradient-based method all the modules of the system with respect to an objective function linked to a task or to capturing many aspects of the observed data. We also discuss the new ideas from deep learning, including a discussion of the newly acquired theoretical understanding of the advantages brought by jointly optimizing a deep architecture. Finally, we summarize some of the recent work aimed at bridging the remaining gap between deep learning and neuroscience, including approaches to implement functional equivalents to backpropagation in a more biologically plausible way, as well as ongoing work connecting language, cognition, reinforcement learning and the learning of abstract representations.

Keynote Lecture: Ghislaine Dehaene-Lambertz

Ghislaine Dehaene-Lambertz

Pediatrician, Director of the Developmental Brain Imaging Lab, INSERM U992, Neurospin/CEA, Paris-Saclay, France

Ghislaine Dehaene-Lambertz and her team investigate the development of cognitive functions in infants and children using brain imaging techniques. Their goal is to understand how complex cognitive functions, such as language, music, mathematics, etc… emerge in the human brain, thanks to a thorough description of the brain initial structural and functional organization. She published pioneering work using high-density event-related potentials (Nature 1994), functional resonance magnetic imaging (Science 2002) or optical topography (PNAS 2003-2013) to study language acquisition, and the neural signatures of consciousness (Science 2013) in the infant brain. She is the recipient of several national and international awards (Prix Justine and Yves Sergent 2013, Grand Prix Scientifique de la Fondation de France, 2015, et de L'Institut de France, 2016).

THE HUMAN INFANT BRAIN: A NEURAL ARCHITECTURE ABLE TO LEARN LANGUAGE

Thursday, November 9, 4:00 – 5:00 pm
Chesapeake Ballroom

Chair: Patti Adank, University College London

Although different human languages use different sounds, words and syntax, most children acquire their native language without difficulties following the same developmental path. Once adults, they use the same specialized networks, located primarily in the left hemisphere around the sylvian fissure, to process speech. Thanks to the development of brain imaging, we can now study the early functional brain organization and examine on which cerebral resources, infants rely to learn their native language. Although these studies are still sparse, several characteristics are noticeable: first, parallel and hierarchical processing pathways are observed before intense exposure to speech with an efficient temporal coding in the left hemisphere and, second, frontal regions are involved from the start in infants ' cognition. These observations are certainly not sufficient to explain language acquisition but illustrate a new approach that relies on a better description of infants ' brain activity during linguistic tasks, which compared to results in animals and human adults should clarify the emergence of language in the human species.

Keynote Lecture: Edward Chang

Edward Chang

Professor of Neurosurgery, UC San Francisco

Dr. Chang specializes in functional neurosurgery, with particular expertise in brain mapping for the safe treatment of refractory epilepsy, cranial nerve disorders, and brain tumors. His research focuses on the discovery of higher-order neurological function in humans, such as speech and neuropsychiatric processing.

DISSECTING THE FUNCTIONAL REPRESENTATIONS OF HUMAN SPEECH CORTEX

Friday, November 10, 8:30 – 9:30 am
Chesapeake Ballroom

Chair: Lorraine Tyler, University of Cambridge

Our work seeks to understand the representations encoded by neural populations in the human speech cortex. In this presentation, I will cover new discoveries on speech sound encoding in the superior temporal plane/gyrus for speech perception, and vocal tract movement encoding in the ventral sensorimotor cortex for speech production. These findings advance new, highly-detailed models of functional organization (maps) of speech cortex, but more importantly, move us closer to an algorithmic understanding of speech-related cortical computations.

Opening Night Reception

Wednesday, November 8, 7:00 – 10:30 pm
National Aquarium

SNL invites you to our Opening Night Reception on Wednesday, November 8, 7:00 pm at the world-renowned National Aquarium, just steps away from this year's meeting venue. Join your colleagues for an elegant evening of food, drinks and stimulating conversation against the backdrop of a spectacular aquatic wonderland.

The National Aquarium is widely considered to be one of the world's greatest aquaria. Its mission is to inspire conservation of the world's aquatic treasures. With breathtaking views of the Baltimore Inner Harbor and five levels of award-winning exhibits, the reception at the National Aquarium promises to be a once-in-a-lifetime experience.

Don't miss this occasion to experience one of the world's greatest aquariums and an opportunity to socialize with colleagues and friends before the meeting commences.

NATIONAL AQUARIUM.

REFLECTING ON DOLPHIN COMMUNICATION & COGNITION

4:30 - 5:30 pm, Chesapeake Ballroom

Speaker: Diana Reiss

Chair: Clara D. Martin, Basque Center on Cognition, Brain and Language (BCBL), Spain

Diana Reiss is a cognitive psychologist, a marine mammal scientist, and a professor in the Department of Psychology at Hunter College and the Animal Behavior and Comparative Psychology Doctoral program at The Graduate Center, CUNY. Her research focuses on dolphin cognition and communication, comparative animal cognition, and the evolution of intelligence.

CHILDCARE AT SNL

Thanks to generous funding from the National Institutes of Health, SNL is pleased to offer free onsite childcare as part of the 2017 meeting! Back by popular demand, childcare will allow you to enjoy time with colleagues, while the little ones create their own fun memories in Baltimore.

This year, we have contracted with *A Helping Hand*, an event childcare service. Activities will include age appropriate arts and crafts, educational activities, interactive games, skits, dancing, and much more! All *A Helping Hand* staff are Infant and Child CPR certified, First Aid certified, background checked, and trained to care for children from newborn and up.

Childcare will be offered free of charge for children 0-12 years of age. Space is limited and will be filled on a first-come, first-served basis. Chidcare is in the Potomac Room on the third floor of the Sheraton Inner Harbor Hotel.

To reserve a spot, please see the Registration Desk in the Chesapeake Gallery on the third floor of the Sheraton Inner Harbor Hotel.

Childcare Schedule

Wednesday, November 8, 8:15 am – 6:15 pm

Thursday, November 9, 7:45 am – 7:45 pm

Friday, November 10, 7:45 am – 2:15 pm

Invited Symposium

Computational and quantitative methods in understanding the neurobiology of language

Thursday, November 9, 1:30 – 3:30 pm, Chesapeake Ballroom

Speakers: Leila Wehbe, University of California, Berkeley
Odette Scharenborg, Radboud University Nijmegen
Barry Devereux, Queen's University, Belfast and University of Cambridge
John Hale, Cornell University, New York
Chair: Lorraine Tyler, University of Cambridge

Modern methods in computational and quantitative linguistics incorporate a wealth of data on language, from statistical information about the acoustic and phonological regularities of speech and syntactic structure, to distributed models of word semantics and utterance meaning. An emerging area of interest is the integration of computational linguistics, big data, computational modelling and neuroimaging methods to study the neurobiology of language. This approach is attractive because it allows theoretical claims about different properties of language function to be explicitly formulated and quantified, using statistical data about specific linguistic phenomena derived from the linguistic environment. In this symposium, the 4 speakers will discuss their perspective on how interdisciplinary approaches that combine computational and data-driven methods with cognitive theory provide new opportunities for understanding language and the brain.

MODELING BRAIN RESPONSES TO NATURAL LANGUAGE STIMULI

Leila Wehbe works on studying language representations in the brain when subjects engage in naturalistic language tasks. She uses functional neuroimaging and natural language processing and machine learning tools to build predictive models of brain activity as a function of the stimulus language features. She completed her PhD in the Mitchell Lab in Carnegie Mellon University where she focused on modeling the different processes engaged in natural reading.

Abstract

Due to the complexity of language processing, most neurobiology-of-language studies focus on answering a specific hypothesis by using highly controlled stimuli. While controlled experiments are often seen as hallmarks of good science, the natural interdependence of language properties such as syntax and semantics makes it nearly impossible to vary only one of them in a controlled experiment. As a result, carefully handcrafted stimuli either fail to be "controls", as they unintentionally vary many parameters simultaneously, or they can be highly artificial and run the risk of not generalizing beyond the experimental setting. For studying language, we argue that naturalistic experiments along with predictive modeling provide a promising alternative to the controlled approach. These studies sample the stimulus space broadly and then learn the relationship between stimulus features and brain activity. In this talk, I will outline some details of this approach using a specific example in which subjects read a complex natural text while their functional neuroimaging data was acquired. Different natural language processing tools were used to annotate the semantic, syntactic and narrative features of the stimulus text. Encoding models were then fit to predict brain activity as a function of the different language features. The performance of these models allows us to formulate and test hypotheses about the function of different brain regions. I will describe the spatio-temporal functional brain language maps we built using this approach. I will also present a new online engine (boldpredictions.gallantlab.org) we have built which allows researchers to compare the results of our naturalistic language experiments with more traditional controlled experiments.

INSIGHTS INTO THE COGNITIVE PROCESSES UNDERLYING SPEECH PROCESSING IN THE PRESENCE OF BACKGROUND NOISE

Odette Scharenborg is an associate professor at the Centre for Language Studies, Radboud University Nijmegen, The Netherlands, and a research fellow at the Donders Institute for Brain, Cognition and Behaviour at the same university. Her research interests focus on narrowing the gap between automatic and human spoken-word recognition. She did a PhD, on the same topic, with Lou Boves and Anne Cutler in Nijmegen, the Netherlands. Odette is interested in the question where the difference between human and machine recognition performance originates, and whether it is possible to narrow this difference, and investigates these questions using a combination of computational modelling and behavioural experimentation. In 2008, she co-organised the Interspeech 2008 Consonant Challenge, which aimed at promoting comparisons of human and machine speech recognition in noise in order to investigate where the human advantage in word recognition originates. She was one of the initiators of the EU Marie Curie Initial Training Network "Investigating Speech Processing In Realistic Environments" (INSPIRE, 2012-2015). In 2017, she will be co-organising a 6-weeks Frederick Jelinek Memorial Summer Workshop on Speech and Language Technology on the topic of the automatic discovery of grounded linguistic units for languages without orthography. She is currently PI on a 5-year (Vidi) project funded by the Netherlands Organisation for Scientific Research on the topic of non-native spoken-word recognition in noise.

Abstract

Most people will have noticed that communication in the presence of background noise is more difficult in a non-native than in the native language – even for those who have a high proficiency in the non-native language involved. Why is that? I will present results of several behavioural experiments and computational modelling studies investigating the effect of background noise on native and non-native spoken-word recognition, in particular, on the underlying processes of multiple word activation and the competition between candidate words. These results show that the effects of background noise on spoken-word recognition are remarkably similar in native and non-native listening. The presence of noise influences both the multiple activation and competition processes: It reduces the phonological match between the input and stored words and consequently increases the set of candidate words considered for recognition during spoken-word recognition resulting in delayed and elongated phonological competition. Moreover, both native and non-native listeners flexibly adjust their reliance on word-initial and word-final information when a change in listening conditions demands it.

THE SPATIO-TEMPORAL DYNAMICS OF LANGUAGE COMPREHENSION: COMBINING COMPUTATIONAL LINGUISTICS AND RSA WITH MEG DATA

Barry Devereux received a B.Sc. in Mathematics and Computer Science and a Ph.D. in Cognitive Science from University College Dublin, Ireland, before going on to do postdoctoral training in cognitive neuroscience and the neurobiology of language at the Centre for Speech, Language and the Brain, Dept. of Psychology, University of Cambridge. His work investigates spoken language comprehension and object processing from a multidisciplinary perspective, combining computational modelling of language and object processing with cognitive theory and neuroimaging. From July 2017, he is an assistant professor in Cognitive Signal Processing at Queen's University, Belfast.

Abstract

Spoken language comprehension involves cortical systems supporting several complex and dynamic processes, from acoustic analysis and word recognition, to building syntactic structure and representing sentence meaning. Recent advances in computational and quantitative linguistics have seen an explosion in the availability of language data and increasingly sophisticated language models relevant to these processes. In a series of MEG experiments where participants listened to natural sentences, we investigate how lexically-driven expectations and syntactic structure-building interact over time by analysing how corpus-derived statistical models of lexico-syntactic information influence the multivariate spatiotemporal dynamics of incremental language comprehension in the brain. The results of these experiments demonstrate how quantitative measures of specific linguistic properties can yield a detailed picture of processes of integration during sentence comprehension in the brain.

WORD-BY-WORD NEURO-COMPUTATIONAL MODELS OF HUMAN SENTENCE PROCESSING

John Hale serves as Associate Professor of Linguistics at Cornell University. He received his PhD from Johns Hopkins University in 2003 under the direction of Paul Smolensky. His early work on information-theoretical complexity metrics was honored with awards such as the EW Beth dissertation prize. He is the author of Automaton Theories of Human Sentence Comprehension and principal investigator in the NSF-ANR joint project "Neuro-computational models of natural language" in collaboration with Jonathan R. Brennan, Christophe Pallier and Éric de La Clergerie. For more information, browse https://courses.cit.cornell.edu/jth99/.

Abstract

The "mapping problem" (Poeppel 2012) between language structures and brain mechanisms stands in the way of a truly computational neurobiology of language. This talk offers a candidate solution, rooted in time-series predictions about comprehension effort. Such predictions are derived by traversing representations such as syntactic phrase structure trees in the manner of an incremental parsing algorithm. The resulting values serve to predict, word-by-word, neural signals such as BOLD collected during naturalistic listening. Using multiple regression, one can model incremental comprehension at many different levels of structure simultaneously. The results point to a spatial division of labor, isolating specific types of comprehension work to specific anatomical regions.

THURSDAY EVENING SOCIAL HOUR

Thursday, November 9, 6:15 – 7:30 pm, Harborview and Loch Raven Ballrooms

Join your colleagues for Social Hour during the Thursday evening poster session. Your first drink is on us! You'll find a drink ticket in the back of your badge.

Abstract Merit Awards

The Society for the Neurobiology of Language Abstract Merit Awards are given to the students and postdocs who submitted the highest ranked abstracts.

Graduate Student Merit Award Winners

Esti Blanco-Elorrieta, New York University, USA

Kiefer Forseth, University of Texas Medical School at Houston, USA

Post Doctoral Merit Award Winners

Claudia Männel, Max Planck Institute for Human Cognitive and Brain Sciences, University of Leipzig, Germany

Dorian Pustina, University of Pennsylvania, USA

Travel Awards

This year, the Society for the Neurobiology of Language granted 24 Travel Awards. The awards, funded by the National Institutes of Health (NIH), help to cover travel and registration costs for the 2017 Society for the Neurobiology of Language Meeting in Baltimore.

Through the travel awards, SNL aims to encourage and foster the participation of junior scientists who are members of underrepresented groups.

The 2017 Travel Award winners are:

Jane Aristia, University of Lille, France

Jose Ceballos, University of Washington, USA

Kulpreet Cheema, University of Alberta, Canada

Linda Drijvers, Donders Institute, Radboud University, The Netherlands

Giulia Elli, Johns Hopkins University, USA

Danielle Fahey, University of South Carolina, USA

Xiaoping Fang, University of Pittsburgh, USA

Emilia Fló Rama, Universidad de la República, Uruguay

Rachida Ganga, Utrecht Institute of Language, The Netherlands

Ezequiel Gleichgerrcht, Medical University of South Carolina, USA

Jixing Li, Cornell University, USA

Linda Lönnqvist, University of Helsinki, Finland

Laura Morett, University of Alabama, USA

Emma Nguyen, University of Connecticut, USA

Andrea Olguin, University of Cambridge, UK

Claudia Peñaloza, Boston University, USA

Eleni Peristeri, Aristotle University, Greece

Yanina Prystauka, University of Connecticut, USA

Rachel Romeo, Harvard University & MIT, USA

Roy Seo, University of Washington, USA

Christine Tseng, University of California, Berkeley, USA

Robert Wiley, Johns Hopkins University, USA

Marina Zhukova, Saint-Petersburg State University, Russia

Naama Zur, University of Haifa, Israel

Early Career Awards

The Society for the Neurobiology of Language is pleased to announce the 2017 Early Career Award winners: Carolyn McGettigan and Jason Yeatman.

Thursday, November 9, 11:15 am - 12:00 pm, Chesapeake Ballroom

Chair: Jonathan Peelle, Washington University in St. Louis

Carolyn McGettigan

Professor
Department of Psychology, Royal Holloway,
University of London

Carolyn McGettigan started her career at Cambridge where she gained a first class honours degree in Natural Sciences in 2003 followed by a PhD from UCL in 2007. She then completed postdoctoral work in London and Leipzig before taking up a lectureship in 2012 at Royal Holloway, University of London, where she was promoted to Professor in 2017. Dr. McGettigan's early research investigated the comprehension of degraded speech, and the wider role of the human voice in communication (including the perception of laughter, and the modulation of identity in speech production). Her current research focuses on the neurobiology of the human voice as a highly complex and flexible social signal, with which listeners can convey and perceive linguistic, emotional and indexical information. Dr. McGettigan has published 44 articles and chapters with an H index of 13 (WoS), and has won a number of awards, attesting to her cutting-edge research in the neurobiology of language. Moreover, she has an exceptional record as a science communicator and in public engagement.

STUDYING THE SOCIAL LIFE OF VOICES

While it is readily accepted that the human face is a social stimulus, the wider cognitive neuroscience community tends to see the voice as a medium for language. In this talk, I will describe how my research programme attempts to forefront the para-linguistic and non-verbal roles of the voice, both in its production and perception. This will include examples from my recent studies of vocal flexibility in speech production, in which we have used functional MRI and vocal tract MR imaging to probe the processes of imitation. I will also describe the insights we have gained from studies of vocalizations such as laughter and crying. Throughout, I will highlight some of the people and experiences that have most influenced my career so far.

Jason Yeatman

Assistant Professor
Institute for Learning & Brain Sciences (I-LABS),
Department of Speech & Hearing Sciences,
University of Washington

Jason Yeatman received his Ph.D. in 2014 from Stanford University, and after a one-year appointment as a research scientist at the Institute for Learning and Brain Sciences at the University of Washington (UW), Seattle, Dr. Yeatman was appointed Assistant Professor in the Department of Speech and Hearing Sciences at UW. Dr. Yeatman's research on white matter and reading development has led to novel models of the biological mechanisms that drive changes in the white matter and to a better understanding of the relationship between principles of brain development and learning to read. Additionally, he has been at the forefront of developing new MRI methods for quantifying white matter tissue properties and algorithms for analyzing these data. Three years after having received his Ph.D., he has co-authored 33 peer reviewed journal articles (10 as lead author). Dr. Yeatman has clearly distinguished himself in productivity and creativity early in his career.

WHITE MATTER PLASTICITY AND LEARNING TO READ

Reading instruction prompts the emergence of neural circuits that are specialized for rapidly translating printed symbols into sound and meaning. Understanding how these circuits differ in children with dyslexia, and change with learning, is an important scientific challenge that holds practical implications for education. In this talk I will present new data linking changes in the white matter to the process of learning to read. Combining intensive reading intervention programs, with longitudinal MRI measurements, we find that altering a child's educational environment can dramatically change white matter circuits and behavior over the timescale of weeks.

Attendee Resources

ATM

An ATM is located in the main lobby of the hotel.

Abstracts

The full text of poster, slide, and symposium abstracts can be found in the SNL 2017 Abstracts book, which can downloaded in PDF format from www.neurolang.org.

Audio-Visual

An LCD projector (e.g., for PowerPoint presentations) will be provided in the ballroom; however, computers are NOT provided. Presenters must bring their own computers and set them up BEFORE the start of the session in which they are presenting. The stage is set with two lecterns which can be used for alternating between speakers. A switch box is provided to switch the projector display between lecterns. To avoid setup problems affecting your presentation, presenters are strongly encouraged to arrive at their scheduled room a minimum of 30 minutes before their talk.

Baggage Check

A secure space will be allocated for luggage. Please contact a bellman for assistance.

Certificate of Attendance

A Certificate of Attendance is included on the back of your official meeting badge. If you require any amendments, we will be happy to email/mail a copy after the meeting. Please contact us at info@neurolang.org.

Childcare

Thanks to the funding from the National Institutes of Health, SNL is pleased to be able to offer onsite childcare at this year's meeting in Baltimore. See "Childcare at SNL" on page 10.

Contact Us

To contact us onsite, visit the Registration Desk, or send an email to info@neurolang.org. We will respond to your email at our earliest opportunity.

Copying, Printing and Office Supplies

A Business Center is located in the hotel lobby. Boarding passes and up to five pages may be printed free of charge.

Disclaimer

The SNL Program Committee reserves the right to make changes to the meeting program at any time without notice. This program was correct at the time of printing.

Food Service

Complimentary food and beverage service is available to all registered attendees at the following times:

Wednesday

Continental Breakfast, 8:15 – 9:00 am *Harborview Gallery*

Coffee Break, 10:00 – 10:30 am *Harborview Gallery*

Afternoon Coffee, 2:30 – 3:00 pm *Harborview Gallery*

Thursday

Continental Breakfast, 7:30 – 8:15 am *Harborview Gallery*

Coffee Break, 9:30 – 10:00 am *Harborview Gallery*

Buffet Lunch, 12:00 – 1:30 pm *Various locations on the 2nd and 3rd floors*

Afternoon Coffee, 3:30 – 4:00 pm *Harborview Gallery*

Friday

Continental Breakfast, 7:30 – 8:15 am *Harborview Gallery*

Coffee Break, 9:30 – 10:00 am *Harborview Gallery*

Future Meetings

SNL 2018 will be held August 16-18, 2018 in Québec City, Canada.

Guest Policy

Guests are allowed complimentary entry into one SNL session (for the purposes of seeing the poster or slide of the person they are a guest of). Guests are welcome to attend the Opening Night Reception.

Guests must register at the SNL Registration Desk upon arrival and must be accompanied by the SNL attendee. Guests must wear a badge for entrance into the session they are attending and for social events as well.

Internet Access

Internet access is complimentary in the guest rooms at the Sheraton Inner Harbor Hotel. Wifi in the meeting space is also available. See the Registration Desk for the login instructions.

Lost & Found

Please check with the SNL Registration Desk for lost and found items.

Meeting Rooms

All general sessions (Keynotes, Invited Symposium, Slides, and Poster Slams) are held in Chesapeake Ballroom.

Messages

A bulletin board will be available for messages and job postings near the SNL Registration Desk.

Mobile Phones

Attendees are asked to silence their mobile phones when in sessions.

Name Badges

For security purposes, all attendees must wear their name badges to all sessions and social functions. Entrance into sessions is restricted to registered attendees only. If you misplace your name badge, please go to the Registration Desk for a replacement.

Parking

There is covered parking available at the Sheraton Inner Harbor Hotel. SNL attendees will receive the discounted price of $18.00 per day for self parking.

Phone Charging Station

For your convenience, a phone charging station is located at the Registration Desk.

Poster Sessions

Posters are located in the Harborview and Loch Raven Ballrooms. See "Poster Schedule" on page 27.

Poster Slam Sessions are located in the Chesapeake Ballroom. See "Poster Slam Schedule" on page 24.

Registration

The SNL Registration Desk is located in Chesapeake Gallery on the third floor of the Sheraton Inner Harbor Hotel. The Registration Desk hours are:

Wednesday, November 8, 7:00 am – 5:30 pm
Thursday, November 9, 7:00 am – 7:00 pm
Friday, November 10, 7:30 am – 1:40 pm

Social Events

Opening Night Reception at the National Aquarium

Join your colleagues on Wednesday, November 8 at 7:00 pm for an elegant evening of food, drinks and stimulating conversation against the backdrop of the world-renowned National Aquarium. The National Aquarium is a short, picturesque stroll from the Sheraton Inner Harbor Hotel. Directions to the National Aquarium are available at the VSS Registration Desk. For guests needing extra assistance getting to the event, please contact the VSS Registration Desk.

Thursday Evening Social Hour

Attendees are invited to enjoy a special Social Hour in the Harborview and Loch Raven Ballrooms during the Thursday evening poster session. Your first drink is on us! You'll find a drink ticket in the back of your badge.

Social Media

Join the SNL discussion on Twitter!

- Follow @SNLmtg for meeting information
- Follow SNL colleagues (like @kemmorey1)
- Tag meeting-related tweets with #snlmtg17
- Join in the conversation by searching for tweets tagged #snlmtg17

Smoking

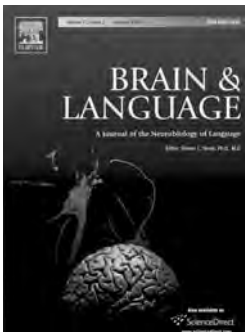
Smoking, including the use of e-cigarettes, is not permitted inside the the Sheraton Inner Harbor Hotel. Three designated outdoor smoking areas are available. These are located outside the main entrance to the hotel, on the second floor skywalk, and on the third floor terrace.

Speakers

Please ensure that you are available at least thirty minutes before the start of the session. See "Audio-Visual" on page 16.

Sponsors and Exhibitors

The Society for the Neurobiology of Language thanks the following companies for their support of our 2017 meeting. Please visit our exhibitors in the Chesapeake Gallery.

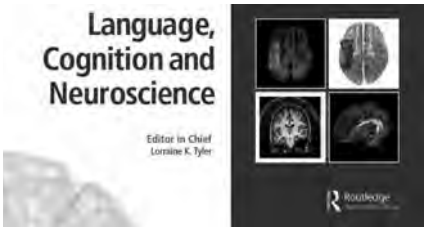


Brain & Language (Elsevier) Gold Sponsor and Exhibitor

An interdisciplinary journal, *Brain & Language* focuses on the neurobiological mechanisms underlying human language. The journal covers the large variety of modern techniques in cognitive neuroscience, including lesion-based approaches as well as functional and structural brain imaging, electrophysiology, cellular and molecular neurobiology, genetics, and computational modeling. All articles must relate to human language and be relevant to an elaboration of its neurobiological basis. Along with an emphasis on neurobiology, journal articles are expected to take into account relevant data and theoretical perspectives from psychology and linguistics.

Language, Cognition and Neuroscience (Routledge) Silver Sponsor

Language, Cognition and Neuroscience publishes high-quality papers taking an interdisciplinary approach to the study of brain and language, and promotes studies that integrate cognitive theoretical accounts of language and its neural bases. The Journal publishes both high quality, theoretically-motivated cognitive behavioural studies of language function, and papers which integrate cognitive theoretical accounts of language with its neurobiological foundations.



Rogue Research Inc. Silver Sponsor and Exhibitor

Rogue Research develops the Brainsight® family of products, including Brainsight TMS. Our unique Brainsight NIRS system allows acquisition during TMS and simultaneous fNIRS along with EEG, fMRI or MEG. Brainsight cTMS provides unequalled control of the TMS pulse parameters. Brainsight Vet and surgical robot extends navigation to small animal surgery.

ANT-NA Exhibitor

ANT-NA provides complete solutions for clinical neurodiagnostics and neuroscience research.

Brain Vision, LLC Exhibitor

Brain Vision is the leader in innovation for EEG research. We offer full integration of EEG with many leading eye tracking and audiology systems. We provide flexible and robust solutions for high density, active EEG, wireless EEG, dry EEG, high-end ABR integration, and a wide range of bio-sensors like GSR, EKG, Respiration, and EMG. We integrate language research paradigms and EEG with other modalities such as fMRI, TMS, fNIRS, tES/HDtES and MEG. If you want to hear how our research solutions can improve your language paradigms, please talk to us. Let us help you push the edge of what is possible.

Cortech Solutions, Inc. Exhibitor

Cortech Solutions is your source for EEG, NIRS, fMRI, TMS, and other functional neuroimaging tools. We are your sales and support contact in the US for leading brands from around the world, including Biosemi ActiveTwo EEG / ERP, Cambridge Research Systems vision science tools, including the BOLDscreen fMRI compatible display and LiveTrack eye-tracking, Mag and More PowerMAG TMS, Artinis Oxymon NIRS, and more. Leave the technology to us—you focus on the science!

Rogue Resolutions Exhibitor

At Rogue Resolutions, we specialize in bringing together and combining technologies, techniques and services for neuroscience and in doing so, help our customers to conduct robust, credible, replicable and cutting edge research. We achieve this by offering state of the art equipment combined with unrivalled service and support from our experienced team of product and application specialists.

Slide Sessions

Slide Session A

Wednesday, November 8, 1:10 – 2:30 pm, Chesapeake Ballroom

Slide Session A

Chair: Karen Emmorey

Speakers: Kiefer Forseth, Neal Fox, Esti Blanco-Elorrieta, Lotte Schoot

1:10 pm

A1 Predictive Neural Instruments of Early Auditory Cortex *Kiefer Forseth[1], Gregory Hickok[3], Nitin Tandon[1,2]; [1]Vivan L Smith Department of Neurosurgery, University of Texas Medical School at Houston, Houston, TX, USA, [2]Memorial Hermann Hospital, Texas Medical Center, Houston, TX, USA, [3]Department of Cognitive Sciences, University of California, Irvine, CA, USA*

Neural computations in the brain are not merely a passive, stimulus-driven response – rather, cortical networks could be expected to anticipate patterns of sensory events. Acoustic rhythms contain the requisite information for such the prediction of future events. While the importance of rhythm in auditory perception seems intuitively clear, the neural mechanisms of auditory entrainment and the interactions of entrained cortex with incoming stimuli are not fully understood. Intracranial electrodes (n = 3247, 15 patients), implanted as part of a stereotactic electrocorticographic evaluation (sEEG) for epilepsy, furnish the full spectrum of neural oscillations at millimeter spatial and millisecond temporal resolution and provide an ideal methodology by which to study neural prediction of rhythms and of implicit rhythms in human language perception, in early auditory cortex. We used an innovative stimulus with a period of amplitude modulated white noise followed by a period of constant amplitude white noise. In half of the trials and at variable delay, a pure tone was presented in the second period (coincident and partly masked by the white noise). Patients were asked to report the presence of the tone in each trial: a single-interval two-alternative forced-choice task. Analysis of the behavioral data showed a modulation of perceptual accuracy by the phase of the entraining rhythmic stimulus. Data from depth electrodes placed along the dorsal superior temporal gyrus in these 15 individuals revealed a consistent posterior to anterior gradient of selectivity for distinct elements of the acoustic stimulus: onset, entrainment, and offset. These responses were characterized by consistent alignment of gamma (60 - 120 Hz), beta (15 - 30 Hz), and low frequency (1 - 15 Hz) power relative to the stimulus, as well as rhythmic low frequency phase reset. Interestingly, when we repeated the experiment using non-penetrating high density subdural grid electrodes (n = 3 patients), the ECoG responses were muted, suggesting that these unique features are coded along the depths of the planum temporale. In a second experiment on the same individuals we found that the quasi-rhythmic amplitude envelope of speech specifically engaged delta, theta, and gamma oscillations – perhaps packaging the acoustic signal into discrete units. These neural representations of rhythm may constitute an adapted computational solution – cascaded neural oscillators – to enable predictive coding and timing. We demonstrate that the descriptive relationship between neural oscillations and the amplitude envelope of rhythmic acoustic signals extends to a predictive relationship that modulates subsequent sensory selectivity. The identification of such specific neural mechanisms that may guide the development of computational models of anticipatory speech processing for use in neural prosthetics.

1:30 pm

A2 Transforming continuous temporal cues to a categorical spatial code in human speech cortex *Neal Fox[1], Matthias Sjerps[1,2,3], Matthew Leonard[1], Edward Chang[1]; [1]University of California, San Francisco, [2]University of California, Berkeley, [3]Radbound University*

During speech perception, listeners extract acoustic cues from a continuous sensory signal to map it onto behaviorally relevant phonetic categories. Many such cues are encoded within the fine temporal structure of speech. For example, voice-onset time (VOT), the interval between a stop consonant's release and the onset of voicing, distinguishes voiced (e.g., /b/, short VOT) from voiceless (e.g., /p/, long VOT) stops in English. Despite the ubiquity of time-dependent cues like VOT in the world's languages, the neurophysiological mechanisms that allow listeners to distinguish sounds that differ along temporal dimensions remain unclear. To investigate this question, we recorded neural activity directly from the cortex of nine human subjects while they listened to and categorized syllables along a VOT continuum from /ba/ (0ms VOT) to /pa/ (50ms VOT). We found that spatially distinct neural populations respond preferentially to one category (either /b/ or /p/). In both populations, responses are sensitive to VOT differences within the preferred, but not the non-preferred, category. This graded VOT encoding rapidly evolves to reflect the ultimate (categorical) behavioral response function, showing that categorical perception of VOT emerges across time in auditory cortex. Additionally, /b/-selective responses are lagged depending on VOT, while /p/-selective responses are time-locked to the burst, suggesting differential sensitivity to spectral cues indicative of burst vs. voicing. To probe what computations might give rise to these response properties, we implemented a neural network model that simulates neuronal populations as leaky integrators tuned to detect either coincident

or temporally-lagged burst and voicing cues. The same temporal dynamics and encoding patterns observed in real neural data emerged in the computational model, suggesting that local tuning for distinct spectral cues at precise lags may underlie temporal cue integration in auditory cortex. Finally, we also recorded neural responses to naturally-produced sentences containing multiple speech sounds differing in VOT (e.g., /d/ vs. /t/, /g/ vs. /k/). Results demonstrated that neuronal tuning for this temporal cue generalized across speech sounds containing different spectral cues. Our results provide direct evidence that continuous temporal information is transformed into a categorical spatial code by discrete, phonetically-tuned neural populations in human auditory cortex.

1:50 pm

A3 Turning a language "off" is cognitively effortful, but turning a language "on" is not: MEG evidence from bimodal language switching

Esti Blanco-Elorrieta[1,4], Karen Emmorey[2], Liina Pylkkanen[1,3,4]; [1]Department of Psychology, New York University New York, NY 10003, USA, [2]School of Speech, Language and Hearing Sciences, San Diego State University San Diego, CA 92181, USA, [3]Departments of Linguistics, New York University New York, NY 10003, USA, [4]NYUAD Institute, Abu Dhabi, United Arab Emirates

Introduction. The ability to switch languages is a unique aspect of bilingualism. While this phenomenon has been the object of much research (e.g, Blanco-Elorrieta & Pylkkänen, 2016; Crinion et al., 2006; Meuter & Allport, 1999), crucial questions regarding the mechanisms of language control have remained unanswered because the bilinguals in these studies used two spoken languages ("unimodal" bilinguals). For these bilinguals, language switching involves suppression of the non-target language (turning "off" a language) while simultaneously activating the target language (turning "on" a language). In this experiment we asked whether these two actions are directed by the same set of control processes or whether there is a fundamental difference between the "off" and "on" procedures involved in switching? Methods. 21 native American Sign Language (ASL) – English bilinguals performed a picture naming language-switching task in which they switched between producing English, ASL, or both languages simultaneously (code-blending) in an unpredictable fashion, following a language cue presented 300 ms before the to-be-named picture. This design allowed us to tease apart the processes involved in turning a language "on" (when going from ASL or English into a code-blend (CB)) or turning a language "off" (when going from a CB to ASL or English). Univariate analyses focused on prefrontal and cingulate cortices (PFC/ACC) previously implicated for language switching (Abutalebi & Green, 2007), left inferior prefrontal cortex (LIPC) previously related to lexical retrieval and language production (Thompson-Schill et al., 1997) and the left temporal lobe, implicated in lexical access. Multivariate decoding analyses aimed at discerning underlying language representations and potential proactive language activation were conducted in sensor-space. Results. Turning a language "off" led to increased engagement of the ACC and PFC, while turning a language "on" did not differ from non-switch trials. This effect was observed ~100 ms after the presentation of the cue and ~100 ms after the to-be-named picture. Decoding analyses accurately classified turning a language on vs. off starting at 110 ms after picture presentation. Activity in the left temporal lobe increased during ASL sign production (either alone or in a code-blend) compared to producing English words alone. Finally, we successfully decoded the to-be-produced language starting 260 ms after language cue presentation (40 before picture presentation). Conclusion. Our results show that it is turning a language "off" and not turning another language "on" that is cognitively effortful. Further, although some flavor of language control has to mediate both processes, their neural underpinnings are distinct and start to diverge ~100 ms after a to-be-named picture is presented. The results from the language decoding analysis show that bilinguals can successfully utilize proactive control to prepare for the upcoming language before lexical retrieval processes start. However, given that our experiment included a condition in which both languages were simultaneously produced, it is unclear to what extent this proactive control is utilized to apply inhibition to the non-target language (Thierry & Wu, 2017). It is also possible that proactive control is used for (re)activation of the target language or to direct attention to the correct lexicon.

2:10 pm

A4 Spatiotemporal dissociations for fulfilling and violating predictions at multiple levels of representation: A multimodal approach

Lotte Schoot[1,2], Lin Wang[1,2], Nate Delaney-Busch[1,2], Eddie Wlotko[2,3], Edward Alexander[1,2], Minjae Kim[1,2], Lena Warnke[1,2], Arim Choi Perrachione[1,2], Sheraz Kahn[1], Matti Hamalainen[1], Gina Kuperberg[1,2]; [1]Athinoula A. Martinos Center for Biomedical Imaging, Massachusetts General Hospital, USA, [2]Department of Psychology, Tufts University, USA, [3]Moss Rehabilitation Research Institute, USA

INTRODUCTION: There is growing evidence that we use linguistic context to predict at multiple levels of representation. Using multimodal imaging (ERP, MEG, fMRI), we asked whether and when distinct neuroanatomical networks are engaged to inputs that fulfill or violate strong contextual predictions generated at the level of specific lexical items and/or semantic-thematic structure. METHODS: 32 subjects participated in fMRI and ERP/MEG sessions. They read and judged the acceptability of three-sentence scenarios that varied in their contextual predictability (High Constraint HC, Low Constraint LC) and in whether critical nouns in the third sentence fulfilled or violated contextual predictions and/or the selection restrictions (SRs) of their preceding verbs

(examples below). The first two sentences appeared in full; the third sentence appeared word-by-word. Stimuli were counterbalanced across conditions, within and across fMRI and EEG/MEG sessions. RESULTS: (1) ERPs showed selectively reduced activity on the N400 (300-500ms) to predictable critical nouns (HC_pred), relative to all other conditions, reflecting semantic facilitation. In fMRI, all these contrasts revealed reduced activity throughout the left anterior temporal lobe (ATL) and within the left inferior frontal gyrus (IFG). MEG source localization showed that only the left ATL was modulated within the N400 time window. (2) Nouns that violated high constraint contexts (HC_lexviol) selectively evoked an anteriorly-distributed positivity ERP between 600-1000ms, relative to all other conditions. In fMRI, all these contrasts revealed activity not only within the left ATL and IFG, but also within the left-lateralized posterior superior/middle temporal gyrus (S/MTG), premotor cortex (PC) and inferior parietal lobule. MEG source localization within the later time window revealed enhanced activity within the left post-S/MTG and PC. (3) Words that violated the SRs of their preceding verbs (HC_SRviol) selectively evoked a larger posteriorly-distributed positivity/P600 ERP between 600-1000ms, relative to all other conditions. In fMRI, all these contrasts revealed modulation within the left ant-DLPFC and right motor cortex. MEG source localization within the later time window revealed modulation within the left ant-DLPFC. DISCUSSION: These findings provide strong evidence that the brain engages partially distinct networks, distinguished both in their timing and neuroanatomical localization, in response to inputs that fulfill versus violate strong predictions. Incoming words that fulfill strong lexico-semantic predictions are associated with reduced activity within left ATL between 300-500ms. Inputs that violate strong lexical predictions lead to the additional engagement of left IFG and post-STG, perhaps reflecting prolonged attempts to retrieve unpredicted lexico-semantic items, and infer the event dictated by the bottom-up input. Inputs that violate semantic-thematic predictions, however, lead to the engagement of a distinct region – the ant-DLPFC, perhaps reflecting prolonged efforts to relate the properties of the verbs and arguments, thereby inferring novel event structures dictated by the bottom-up input. EXAMPLE STIMULI The lifeguards received a report of sharks near the beach. Their immediate concern was to prevent any incidents in the sea. Hence they cautioned the… swimmers (HC_pred); trainees (HC_lexviol); drawer (HC_SRviol)… Eric and Grant received the news late in the day. They decided it was better to act sooner than later. Hence, they cautioned the…trainees (LC_unpred).

Slide Session B

Friday, November 10, 11:20 am – 12:40 pm, Chesapeake Ballroom

Slide Session B

Chair: Michal Ben-Shachar

Speakers: Laurel Buxbaum, Benjamin Gagl, Thomas M.H. Hope, Elissa L. Newport

11:20 am

B1 The role of conflict and feedback in action error monitoring and correction: evidence from conduite d'approche

Laurel Buxbaum[1], Cortney Howard[1], Tamer Soliman[1], Louisa Smith[2]; [1]Moss Rehabilitation Research Institute, [2]University of Colorado, Boulder

Monitoring and correction of speech errors has traditionally been explained as a function of the perceptual (comprehension) system acting on overt utterances and/or intended meaning (Levelt, 1989). More recently, motor-control-influenced accounts have proposed that monitoring and correction are based on predicted error in the production system; evidence comes from dissociations between comprehension and monitoring abilities in aphasic speakers (e.g., Pickering & Garrod, 2013). Finally, a recent account suggests that conflict between alternative representations provides a signal that monitoring and correction are required (Nozari et al., 2011). The study of conduite d'approche (CD) behavior in aphasia —successive phonological approximations to target utterances—is of both practical and theoretical relevance to this debate. Practically, CD presents an important opportunity to study error correction. Theoretically, successful CD is seen in patients with impaired phonology but intact semantics, indicating that potential responses are constrained by the match between intended and produced meaning. Studying the determinants of error correction in CD may thus shed light on the interplay of meaning systems and production systems. CD in action has also been observed, but not studied experimentally. Recently, we documented higher rates of CD when limb apraxics produced gesture pantomimes to objects associated with several conflicting actions (e.g., calculator) than to objects associated with a single predominant action (e.g., hammer) (Watson & Buxbaum, 2014). The present study extended this work by testing competing predictions derived from theories of monitoring and correction in language. Perceptual self-monitoring accounts suggest that the integrity of action comprehension and the availability of visual feedback should predict CD and successful correction. Production-based monitoring accounts predict no relationship with comprehension, but rather that the integrity of the production system will predict successful correction. The conflict detection account predicts that stimuli eliciting multiple potential responses should increase CD. To test these predictions, 12 left hemisphere stroke survivors

pantomimed the use of 40 tools after passively viewing them. Action conflict and visual feedback of the limb were manipulated within-subjects. Separate action recognition and gesture production tasks were also administered. Data were analyzed with mixed-effect logistic regressions. CD was more frequent under high than low conflict conditions ($p<.001$). Visual feedback increased the probability of CD ($p < .05$) and successful error correction ($p<.001$). Successful correction was less frequent in high conflict conditions ($p<.001$). Gesture production did not predict CD or successful correction (p's > .2). High action comprehension scores predicted successful correction, but only when visual feedback was available ($p < .05$). In support of perceptual accounts, patients with relatively intact action comprehension successfully corrected errors when visual feedback was available. Conflict detection accounts were also partially supported: Conditions increasing conflict resulted in more CD, suggesting that the presence of conflict may trigger self-monitoring behaviors in action, as in language. The status of the production system did not predict CD or successful corrections, suggesting potential differences from the patterns observed in the language domain. Of future interest will be parallel examination of self-monitoring across language and action domains in the same patients.

11:40 am

B2 Visual word recognition relies on a sensory prediction error signal *Benjamin Gagl[1,2], Jona Sassenhagen[1], Sophia Haan[1], Fabio Richlan[3], Christian J. Fiebach[1,2]; [1]Department of Psychology, Goethe University Frankfurt, Frankfurt am Main, Germany, [2]Center for Individual Development and Adaptive Education of Children at Risk (IDeA), Frankfurt am Main, Germany, [3]Centre for Cognitive Neuroscience, University of Salzburg, Salzburg, Austria*

How do we process visual information in visual word recognition? Here we propose a visual optimization algorithm that "explains away" redundant information on the basis of visual word knowledge. The present model implements, in accordance with the predictive coding theory, a subtraction computation where the sensory information (i.e. visual information of a stimulus) is reduced by a prediction. In the absence of contextual constraints, this prediction is built on our knowledge about the redundancies in a script that arises from experience with that script, and includes those general visual features that are shared by most words (i.e. that contribute little to nothing to the unique identification of words). We propose that during perception of written words, this redundant portion of the visual percept is subtracted from the visual input, thereby substantially reducing the amount of information to be processed to the unique, i.e., non-redundant portion of the percept (i.e., the predictions error). We realized this template-based prediction by estimating a pixel-wise mean from overlaid images that present all words from a lexicon (e.g. SUBTLEX database), and calculated a PE representation for each word by subtracting the mean template from each individual word, thereby achieving an information reduction of ~41%. Interestingly, the PE reflects orthographic familiarity in a pure form, since the PE is associated to orthographic word-characteristics (e.g. Orthographic neighborhood) without a relation to higher-level lexical concepts (e.g. Word frequency). In addition, we found in four behavioral datasets (lexical decision tasks from English, French, Dutch and German; all Ns > 53) that reaction times (RT) were positively associated with PE (faster RTs for words with low PE and vice versa). In an fMRI dataset (silent reading; N=39) we found the same PE effect localized to occipital fusiform gyrus and lateral occipital gyrus in both hemispheres. Using EEG (silent reading; N=31), we observed that the PE predicted the amplitude of the ERP around 170 ms. In a final evaluation we investigated the readability of handwritings and found that handwritings with a low PE were rated more readable. Combined, these findings suggest that in single-word reading, i.e., in the absence of contextual constraint, visual information is optimized by a template-based word-knowledge prediction providing an optimal representation for efficient lexical access.

12:00 pm

B3 Predicting language outcomes after stroke: is structural connectomics necessary? *Thomas M.H. Hope[1], Alex P. Leff[1], Cathy J. Price[1]; [1]University College London*

INTRODUCTION: For decades, researchers have sought to understand whether and when stroke survivors with aphasia will recover their speech and language abilities. There is broad agreement that lesion location information should play some role in these predictions, but there is still no consensus on the best or right way to encode lesion-symptom associations. Here, we address the emerging emphasis on the structural connectome in this work – specifically the claim that disrupted connectivity conveys important, unique, prognostic information for stroke survivors with aphasia. METHODS: Our sample included 956 stroke patients extracted from the PLORAS database, which associates structural MRI from stroke patients with language assessment scores from the Comprehensive Aphasia Test (CAT) and basic demographic data. Patients were excluded only when their lesions were too diffuse or small (<1cm3) to be detected by the Automatic Lesion Identification toolbox, which we used to encode their lesions as binary images in standard space. Lesion location was encoded using the 116 cortical regions defined by the Automatic Anatomical Labelling atlas. We examined models driven by both 'lesion load' in these regions (i.e. the proportion of each region destroyed by each patient's lesion), and by the disconnection of the white matter connections between them. The latter was calculated via the Network Modification toolbox, as the mean disconnection implied by each lesion, of structural connectomes defined for 73 neurologically normal controls.

Prognostic models were built using Gaussian Process Model regression for the 7 'summary language scores' defined by the CAT, which assess: the comprehension of (a) spoken and (b) written language, (c) auditory repetition, (d) naming, (e) spoken picture description, (f) reading and (g) writing. The models' predictive performance was assessed using 10-fold cross-validation, and models were compared via Bayes Factors (BF) calculated from Akaike Information Criteria. RESULTS: The connectivity disruption models were able to predict all of the language outcomes: correlations between predicted and empirical scores were all > 0.66 (max. = 0.75, for naming). However, and contrary to past results, models based purely on cortical lesion load were equally good (min. r = 0.64 for writing; max. r = 0.74 for naming; BF < 1.1 and > 0.99 for every model comparison). Using principle components analysis on a composite of the lesion load and connectivity disruption data, we found that every component which, individually, explained at least 1% of the total variance also loaded significantly onto both types of data. This suggests that the two data types convey shared prognostic variance, which explains why we could not distinguish them here. CONCLUSION: Structural connectivity may play a critical role in the neurobiology of language. But this is no guarantee that connectivity disruption data – which is difficult to measure, particularly in the damaged brain – will be clinically useful. Our results demonstrate that these data do convey prognostic information, but also that this information is shared with more traditional variables based on lesion load. When predicting language outcomes after stroke, structural connectivity analyses do not appear to be necessary.

12:20 pm

B4 Developmental plasticity and language reorganization after perinatal stroke

Elissa L. Newport[1,2], Barbara Landau[3], Anna Greenwald[1,2], Catherine E. Chambers[1], Peter E. Turkeltaub[1,2], Alexander W. Dromerick[1,2], Madison M. Berl[4], Jessica Carpenter[4], William D. Gaillard[4]; [1]Georgetown University Medical Center, [2]MedStar National Rehabilitation Network, [3]Johns Hopkins University, [4]Children's National Medical Network

A prominent theme in the literature on brain injury and recovery has been early developmental plasticity. This has been a particular focus in work on language, but overarching principles and constraints remain unclear. In healthy adults, language is virtually always lateralized to the left hemisphere (LH) (Broca, 1865; Wernicke, 1874). Some researchers have suggested that the LH is privileged for language and that recovery after early brain injury necessarily entails LH perilesional cortex (Fair et al. 2010; Raja et al. 2010; Vargha-Khadem et al. 1985). In contrast, other researchers have suggested that, after perinatal LH stroke, children can develop language in the homotopic regions of the RH (Booth et al. 2000; Gaillard et al. 2007; Lenneberg 1967; Lidzba et al. 2006; Rasmussen & Milner, 1977; Staudt et al, 2002; Stiles et al, 2012). A third hypothesis is that there is enormous flexibility in early development and a wide range of brain areas can take on language after early injury or input alterations (Bates et al 2001; Bedny et al 2011). Here we re-examine these alternatives by assessing the long-term outcomes for language and its neural basis in teenagers who had a perinatal stroke destroying most or all of the normal LH language network, with no other accompanying disease; and, for comparison, their healthy siblings and a matched group of teenagers who had a RH perinatal stroke. We administered to each participant a battery of language tests and 2 fMRI language tasks performed in a 3T scanner. Our main fMRI task asks which brain areas show activation during sentence comprehension (listening to sentences like 'A large gray animal is an elephant' compared to the same items played backwards); in healthy children and adults this task activates LH frontal and temporal cortex. A second fMRI task assesses activation for covert naming (ordinarily LH frontal). Behavioral tasks include measures of simple and complex syntax and morphology from the CELF-5, TROG-2, and tasks designed in our lab. Data have been collected from 12 teens who had a LH perinatal stroke to the middle cerebral artery, their healthy siblings, and 8 teens who had a RH perinatal stroke; further testing is ongoing. Participants all show normal levels of performance on all language tasks. While IQ and executive function show deficits after perinatal stroke, core language abilities are intact (including complex syntax and morphology). When listening to sentences or covert naming in the scanner, healthy siblings and those with RH stroke activate traditional LH language regions. Those with LH perinatal stroke show activation in precisely homotopic regions of the RH (RH frontal and temporal cortex). No other pattern of functional reorganization appears. Our results show that there are strong and specific constraints on developmental plasticity for language; in particular, that RH areas homotopic to the normal LH language network are capable of supporting language after very early stroke. We suggest that the neural distribution of language in early development, which is more bilateral than language in adults, may underlie and support language reorganization after stroke.

Poster Slam Schedule

A Poster Slam is a new type of event that provides a fast-paced and entertaining showcase for posters. Sixty posters, twelve from each poster session, have been selected to present a one-minute, one-slide overview of their poster. A Poster Slam session will take place before each poster session. Participants will present their Slam on the main stage in the Chesapeake Ballroom. Presenters will highlight an exciting or provocative finding, highlight how their data or technique addresses current issues in the Neurobiology of Language, or challenges current dogma.

Session	Date	Time	Room
Session A	Wednesday, November 8	10:05 – 10:20 am	Chesapeake Ballroom
Session B	Wednesday, November 8	2:35 – 2:50 pm	Chesapeake Ballroom
Session C	Thursday, November 9	9:35 – 9:50 am	Chesapeake Ballroom
Session D	Thursday, November 9	5:50 – 6:05 pm	Chesapeake Ballroom
Session E	Friday, November 10	9:35 – 9:50 am	Chesapeake Ballroom

Information for Presenters

SNL staff will be present in the main auditorium for an Information Session during which we will explain logistics and information about your Poster Slam session. We will provide you with details about where to line up, use of the microphone, timing, and so on. It is highly recommended that you attend your Information Session.

You must arrive no later than your Speaker Arrival Time shown below. This is 15 minutes prior to your session start time. Proceed to the stage and identify yourself. SNL staff will line you up and provide last minute instructions as necessary.

Session	Date	Information Session	Speaker Arrival Time
Session A	Wednesday, November 8	7:15-7:45 am	9:50 am
Session B	Wednesday, November 8	12:00-12:30 pm	2:20 pm
Session C	Thursday, November 9	7:15-7:45 am	9:20 am
Session D	Thursday, November 9	12:00-12:30 pm	5:35 pm
Session E	Friday, November 10	7:15-7:45 am	9:20 am

Poster Slam Sessions

For poster details, see "Poster Sessions" on page 29.

Poster Slam Session A

Wednesday, November 8, 10:05 – 10:20 am
Chesapeake Ballroom
Chair: David Corina, University of California, Davis

A9 **Auditory attention and predictive processing co-modulate speech comprehension in middle-aged adults** *Sarah Tune*

A10 **Semantic context reverses the polarity of P200 effects during word planning** *Daniel Kleinman*

A11 **Transcranial 10-Hz stimulation but also eye closure modulate auditory attention** *Malte Wöstmann*

A23 **Impact of aging and aphasia on incremental sentence production: eye-tracking while speaking** *Jiyeon Lee*

A34 **White Matter Connectivity and Lexical Access in Aphasia** *William Hula*

A43 **Dissociating the roles of ventral versus dorsal pathways in language production: an awake language mapping study** *Stephanie Ries*

A44 **Different contextual effects modulate the representation of word meaning in the human brain** *Christine Tseng*

A54 **Gliosis+ for continuous lesion quantification in VLSM to map brain-language relationships** *Lisa Krishnamurthy*

A67 **Spontaeous fluctuations of dorsal and ventral reading networks in bilinguals** *Jaione Arnaez-Telleria*

A69 **Processing of contrastive pitch accent in native and L2 English speakers** *Aleuna Lee*

A73 **Stress-timing via Oscillatory Phase-locking in Naturalistic Language** *Phillip M. Alday*

A77 **A tDCS study of the implicit learning of foreign cognate and non-cognate words** *Joshua Payne*

Poster Slam Session B

Wednesday, November 8, 2:35 – 2:50 pm
Chesapeake Ballroom
Chair: Clara D. Martin, Basque Center on Cognition, Brain and Language (BCBL), Spain

B12 Mental Self-Government of Brain's Multi-Leveled Reading and Writing Systems: Before and After Multi-Leveled Language Instruction *Todd Richards*

B24 Investigating the neural mechanisms of syntactic expectations *Leon O. H. Kroczek*

B33 The neural representation of concrete and abstract verb processing in aphasia *Reem S. W. Alyahya*

B34 Left hemisphere frontotemporal effective connectivity during semantic feature judgments: Differences between patients with aphasia and healthy controls *Erin Meier*

B36 Changes in neural activity during a semantic verification task as a result of treatment in persons with aphasia *Shreya Chaturvedi*

B50 Representations of amplitude modulations in auditory onsets, ramp tones, and speech in the human superior temporal gyrus *Yulia Oganian*

B58 Enhancing Speech Motor Learning With Noninvasive Brain Stimulation *Adam Buchwald*

B59 Orthographic priming for tactile Braille alphabet in the ventral Occipito-Temporal cortex of congenitally blind *Katarzyna Rączy*

B66 Areas predicting tDCS effects in primary progressive aphasia (PPA) *Kyrana Tsapkini*

B69 Ventral occipito-temporal responses to written texts and fingerspelling in congenitally deaf adults *Tae Twomey*

B73 The visual representation of lipread words in posterior temporal cortex studied using an fMRI-rapid adaptation paradigm, functional localizers, and behavior *Lynne E. Bernstein*

B75 Inferior frontal gyrus activation is modulated by phonetic competition: An fMRI study of clear and conversational speech *Xin Xie*

Poster Slam Session C

Thursday, November 9, 9:35 – 9:50 am
Chesapeake Ballroom
Chair: Matt Davis, MRC Cognition and Brain Sciences Unit, Cambridge

C11 The time-course of statistical learning in patients with left hemisphere stroke *Kathryn D. Schuler*

C13 The cortical organization of syntactic processing in American Sign Language: Evidence from a parametric manipulation of constituent structure in fMRI and MEG *William Matchin*

C24 Speeded grammatical processing in Tourette syndrome *Cristina Dye*

C32 Morpho-lexical Recognition Ability and Related Brain Regions in Individuals with Mild Cognitive Impairment, Alzheimer's Dementia, and Cognitively Normal Elderly *JungMoon Hyun*

C34 Mapping Both Lesion and Behaviour Structures in Stroke Aphasia *Ying Zhao*

C41 Language and multiple demand regions jointly predict individual differences in sentence comprehension: Evidence from a network approach *Qiuhai Yue*

C42 Extracting Single Word Voxel Patterns from Self-Paced Reading using Simultaneous Eye-Tracking and Multiband fMRI *Benjamin Schloss*

C48 Cognitive Control Mediates Age-Related Reductions in Adaptation to Speaker-Specific Predictability *Shruti Dave*

C57 The intensity of sensory-perceptual features regulates conceptual processing in the anterior temporal lobe's semantic hub *Jet M. J. Vonk*

C66 Speech processing and plasticity in the right hemisphere predict real-world foreign language learning in adults *Zhenghan Qi*

C68 The language network of polyglots *Olessia Jouravlev*

C76 Cortical entrainment depends on temporal predictability, not periodicity *Geoffrey Brookshire*

Poster Slam Session D

Thursday, November 9, 5:50 – 6:05 pm
Chesapeake Ballroom
Chair: James Magnuson, University of Connecticut

D12 Decoding the P600: late ERP positivities to syntactic mismatch share neural patterns with nonlinguistic oddballs, but not face or semantic manipulation patterns *Jona Sassenhagen*

D20 Frontal Shift of the Imageability Effect on N400 in Elders *Chih-Ting Chang*

D21 Developmental change in cerebellar white matter pathways is associated with reading proficiency in children *Lauren R. Borchers*

D22 Can microstructural properties of cerebellar pathways improve prediction of reading skills in children? *Lisa Bruckert*

D23 Language pathway development requires childhood language acquisition: Effects of sensorimotor modality and language deprivation on brain connectivity for language *Qi Cheng*

D32 Using background connectivity to index recovery of function in acquired language impairments *Yuan Tao*

D49 The fate of the unexpected: Downstream repetition effects for prediction violations *Melinh K. Lai*

D51 Regions that preferentially respond to verbs or nouns are more sensitive to semantic differences among words in their preferred grammatical class: An MVPA fMRI study. *Giulia V. Elli*

D61 Cross-linguistic differences in MMN asymmetry: Voicing underspecification in Japanese *Yasuaki Shinohara*

D62 Tracking phoneme processing during continuous speech perception with MEG *Christian Brodbeck*

D74 Manual directional gestures facilitate learning of Mandarin tones *Anna Zhen*

D76 Investigating voice imitation using fMRI and real-time anatomical MRI of the vocal tract *Carolyn McGettigan*

Poster Slam Session E

Friday, November 10, 9:35 – 9:50 am
Chesapeake Ballroom
Chair: Patti Adank, University College London

E9 Language exposure is associated with the cortical thickness of young, low-SES children *Rachel Romeo*

E10 Becoming a balanced, proficient bilingual: Predictions from age of acquisition & genetic background *Kelly A. Vaughn*

E20 Functional subspecialization of Broca's area in the controlled selection of verbal and nonverbal representations and fluent sentence production. *Denise Y. Harvey*

E21 Lower axon density in residual temporal white matter is related to semantic paraphasia prevalence *Emilie McKinnon*

E23 Interventions for Primary Progressive Aphasia: A scoping review *Yara Inuy*

E24 Decoding the cortical sensitivity of spoken acoustic variability in persons with aphasia *Caroline Niziolek*

E28 Robust Electrophysiological Indices of Semantic Surprisal during Natural, Ongoing Speech Processing. *Michael Broderick*

E34 Electrophysiological Evidence for Memory Retrieval during Referential Processing *Hossein Karimi*

E52 Investigating brain mechanisms of natural reading by combining EEG, MEG and eye-tracking *Olaf Hauk*

E56 Multimodal MRI converging evidence on the role of ventro-occipito-temporal cortex in reading: Integrating opposing views *Garikoitz Lerma-Usabiaga*

E78 Phase entrainment of neural oscillations with tACS causally modulates fMRI responses to intelligible speech *Benedikt Zoefel*

E80 Enhanced accuracy of lesion to symptom mapping with multivariate sparse canonical correlations *Dorian Pustina*

Poster Schedule

Poster sessions are scheduled on Wednesday, November 8 through Friday, November 10. Poster sessions are one hour and fifteen minutes long. Presenting authors are expected to be present the entire time. Posters are located in Harborview and Loch Raven Ballrooms. You may post your materials on the board assigned to you starting at the scheduled "Set-up Begins" time shown below. Please note that any posters not removed by "Teardown Complete" time will be discarded. Do not leave personal items in the poster room.

Date & Time	Posters	Topics
Poster Session A Wednesday, November 8 10:30 – 11:45 am *Harborview and Loch Raven Ballrooms* Setup Begins: 8:00 am Teardown Complete: 12:15 pm	A1, A46 - A47, A57	Computational Approaches
	A2 - A11	Control, Selection, and Executive Processes
	A12 - A13	Grammar: Morphology
	A14 - A22	Grammar: Syntax
	A23, A35, A56	Language Therapy
	A24 - A34, A53	Language Disorders
	A36 - A44	Meaning: Lexical Semantics
	A45, A69	Meaning: Prosody, Social and Emotional Processes
	A48 - A52, A54	Methods
	A58	Perception: Orthographic and Other Visual Processes
	A59 - A68	Multilingualism
	A70 - A73	Perception: Auditory
	A75 - A78	Phonology and Phonological Working Memory
	A79	Speech Motor Control and Sensorimotor Integration
	A80	Writing and Spelling
Poster Session B Wednesday, November 8 3:00 – 4:15 pm *Harborview and Loch Raven Ballrooms* Setup Begins: 12:30 pm Teardown Complete: 4:45 pm	B1 - B10	Control, Selection, and Executive Processes
	B11 - B12, B68 - B69	Writing and Spelling
	B13 - B14, B45	Grammar: Morphology
	B15 - B24	Grammar: Syntax
	B25, B35 - B36, B66	Language Therapy
	B26 - B34	Language Disorders
	B37 - B44	Meaning: Lexical Semantics
	B46, B59 - B65	Perception: Orthographic and Other Visual Processes
	B47 - B50	Perception: Auditory
	B51	Language Genetics
	B52 - B54, B56 - B57	Phonology and Phonological Working Memory
	B55, B70 - B77	Perception: Speech Perception and Audiovisual Integration
	B58	Speech Motor Control and Sensorimotor Integration
	B67	Meaning: Prosody, Social and Emotional Processes
	B78	Signed Language and Gesture
	B79	Computational Approaches
Poster Session C Thursday, November 9 10:00 - 11:15 am *Harborview and Loch Raven Ballrooms* Setup Begins: 8:00 am Teardown Complete: 3:30 pm	C1, C14	Computational Approaches
	C2 - C11	Grammar: Syntax
	C13, C70	Signed Language and Gesture
	C15 - C25	Language Development
	C26 - C34, C37	Language Disorders
	C35, C59	Meaning: Prosody, Social and Emotional Processes
	C36	Writing and Spelling
	C38 - C43	Meaning: Combinatorial Semantics
	C44 - C48	Meaning: Discourse and Pragmatics
	C49 - C57	Meaning: Lexical Semantics
	C58	Grammar: Morphology
	C60	Speech Motor Control and Sensorimotor Integration
	C61 - C69	Multilingualism
	C71 - C79	Perception: Speech Perception and Audiovisual Integration

Poster Session D Thursday, November 9 6:15 – 7:30 pm *Harborview and Loch Raven Ballrooms* Setup Begins: 3:45 pm Teardown Complete: 8:00 pm	D1, D64	Animal Communication
	D3 - D13	Grammar: Syntax
	D14, D72	Language Therapy
	D15 - D22	Language Development
	D23	Signed Language and Gesture
	D24 - D32	Language Disorders
	D34 - D39	Meaning: Combinatorial Semantics
	D40 - D43	Meaning: Discourse and Pragmatics
	D44, D52	Meaning: Prosody, Social and Emotional Processes
	D45 - D51	Meaning: Lexical Semantics
	D53	Computational Approaches
	D54, D74 - D78	Speech Motor Control and Sensorimotor Integration
	D55 - D63	Perception: Speech Perception and Audiovisual Integration
	D65 - D68	Perception: Auditory
	D69 - D71	Phonology and Phonological Working Memory
	D73	Control, Selection, and Executive Processes
Poster Session E Friday, November 10 10:00 – 11:15 am *Harborview and Loch Raven Ballrooms* Setup Begins: 8:00 am Teardown Complete: 11:45 am	E1 - E9	Language Development
	E10	Language Genetics
	E11, E55 - E56, E70	Perception: Orthographic and Other Visual Processes
	E12, E47 - E52, E80	Methods
	E13 - E22	Language Disorders
	E23, E54	Language Therapy
	E24, E46, E57, E79	Speech Motor Control and Sensorimotor Integration
	E25 - E29	Meaning: Combinatorial Semantics
	E31 - E34	Meaning: Discourse and Pragmatics
	E35, E45	Meaning: Prosody, Social and Emotional Processes
	E36 - E43	Meaning: Lexical Semantics
	E44, E53, E69	Computational Approaches
	E58 - E67	Multilingualism
	E68	Signed Language and Gesture
	E71 - E78	Perception: Speech Perception and Audiovisual Integration

NATIONAL SCIENCE FOUNDATION FUNDING

The National Science Foundation funds research related to the neurobiology of language through its Cognitive Neuroscience, Linguistics, Perception-Action-and-Cognition, Developmental Sciences and newly-created Science of Learning program.

During SNL 2017, Program Officers for the Linguistics and Cognitive Neuroscience programs will be on site. Attendees are welcome to contact them in advance to arrange meetings (Dr. William Badecker; wbadecke@nsf.gov; Dr. Uri Hasson; uhasson@nsf.gov).

Poster Sessions

Poster Session A

Wednesday, November 8, 10:30 – 11:45 am, Harborview and Loch Raven Ballrooms

Computational Approaches

A1 Alpha and theta power are sensitive to semantic but not syntactic retrieval interference *Ashley Lewis[1], Julie Van Dyke[1]; [1]Haskins Laboratories*

According to cue-based retrieval parsing (Lewis, Vasishth, & Van Dyke, 2006) grammatical heads give rise to a retrieval probe, which incorporates retrieval cues associated with critical features (e.g., semantic properties, thematic role, grammatical case) of a constituent that needs to be retrieved from memory for argument integration. Retrieval interference can occur when alternative constituents in the intervening sentence region between a to-be-retrieved constituent and a head share features with the retrieval probe. We used EEG and neural oscillations to investigate the timing of neural events related to syntactic and semantic retrieval interference. Memory retrieval has been linked to alpha, theta, and gamma oscillations (Spitzer et al., 2009). In non-interfering contexts, beta and gamma oscillations have been implicated in semantic and syntactic integration (Lewis, Wang, & Bastiaansen, 2015). Participants' (n=23) EEG was recorded while they read relative clause sentences (RSVP) in one of four conditions, varying the level of syntactic and semantic interference in the region intervening between the animate matrix clause subject and the matrix clause verb. Semantic (animate vs inanimate) and syntactic (potential grammatical subject vs not) feature overlap between an intervening referent and the desired antecedent was used to create high compared to low semantic and syntactic interference respectively. A time-frequency analysis of power in both a low (2-30 Hz) and a high (32-100 Hz) frequency range (multitaper approach; Mitra & Pesaran, 1999) was conducted at the matrix clause verb (target word). Statistical significance was assessed for comparisons of high and low interference using cluster-based permutation statistics (Maris & Oostenveld, 2007). For semantic interference, right centroparietal alpha power (6-13 Hz) at the target word decreased when interference was low ($p = 0.01$) but not when interference was high. Frontal theta power (5-8 Hz) at the target word increased for high compared to low semantic interference ($p = 0.004$). There were no statistically significant differences in alpha or theta power for comparisons between high and low syntactic interference. No other frequency bands showed sensitivity to the level or type of interference. We argue that the alpha power effect is related to the allocation of attention (more pronounced alpha power desynchronization = more attention) to the linguistic input stream (Jensen & Mazaheri, 2010). Low retrieval interference results in successful integration of the target word, after which the parser can shift its full attention to the next word in the input, resulting in a pronounced alpha power desynchronization. High retrieval interference on the other hand results in a greater reliance on more deliberate processing (less attention allocated to the linguistic input stream) in order to resolve the interference, resulting in a temporary reduction in alpha desynchronization. Frontal theta power has been linked to increased working memory load (Jensen & Tesche, 2002), which is consistent with the need to select between multiple potential antecedents when interference is high. Behavioral work has suggested that syntactic interference is easier to identify and recover from (Van Dyke, 2007), which may explain why we only observe oscillatory effects when comparing high and low semantic interference.

Control, Selection, and Executive Processes

A2 Verbal and Nonverbal Fluency Predicts Volume of the Anterior Cingulate Gyrus *Jennifer E. Schlak[1], Hannah L. Travis[1], Andrew E. Molnar[1], Ruchi Brahmachari[1], George W. Hynd[2], Michelle Y. Kibby[1]; [1]Southern Illinois University-Carbondale, [2]Oakland University*

Objective: Children with dyslexia may have deficits in verbal fluency compared to typically developing children (Cohen et al., 1999). Researchers suggest that verbal fluency is related to frontal lobe functioning (Frith et al., 1991). The anterior cingulate gyrus is not as commonly associated with dyslexia compared to various regions in the frontal lobes, although the anterior cingulate is part of some frontal lobe networks (Bonelli, & Cummings, 2007). Less is known about fluency in relation to the anterior cingulate. Therefore, the purpose of this study was to perform an exploratory analysis between fluency measures and bilateral anterior cingulate volumes to determine if fluency is related anterior cingulate volume in a mixed sample. Method: Data was collected during a study focused on dyslexia (NIH/NIHCD R01, HD26890). Brain tracing was conducted during a separate grant (NIH/ NICHD R03 HD048752). Forty-two children from ages 8 to 12 years completed a neuropsychological battery and an MRI scan. About half had dyslexia (52%). The sample was largely Caucasian (84%) and male (67%). Fluency was measured though NEPSY Design Fluency, as well as the Semantic and Phonemic portions of NEPSY Verbal Fluency. The TONI-3 and CTOPP RAN were included as two non-"executive" measures that may be related to frontal lobe functioning. Not all participants had all measures. Three-dimensional, T1 weighted images were collected via a 1.5T GE Sigma scanner. The cingulate was traced on every slice in the sagittal plane using Crespo-Facorro et al. (1999) as a guideline. Then, the cingulate was

separated into three regions, and the anterior region ran from the anterior commissure through the termination of the anterior portion of the cingulate. Inter-rater reliability was > 0.90. Results: Two Backward regressions were used to examine the relationship between Design Fluency, Semantic and Phonemic Fluency, the TONI-3, and RAN with anterior cingulate volume (for both the left and right hemispheres). We found that the TONI-3 (β=-.32, p=.079) and semantic fluency (β=.36, p= .047) predicted right anterior cingulate volume (adjusted R2=-.15, F(2, 26)=3.51, p=.045) in the final equation. No independent variables predicted left anterior cingulate volume. Conclusion: Semantic fluency and the TONI-3 were the only predictors of right anterior cingulate volume. Concerning semantic fluency, some research suggests that this task uses bilateral frontal lobes (Zajac-Lamparsaka et al., 2016). However, there is some evidence to suggest that semantic fluency occurs more often in the left hemisphere (Jones-Gotman & Milner, 1977), even though our study suggests significance for the right hemisphere, This could be due to the nature of our study, as approximately half of the participants had dyslexia. These children could have been compensating for left hemisphere dysfunction by using their right hemisphere more. In terms of the TONI-3, our results show an inverse relationship between right hemisphere volume and nonverbal intelligence. This could be because approximately three-quarters of the population had a clinical diagnosis, which may lead to different results compared to when only controls are used. It also could be spurious, as it was only a trend.

A3 Reduced Stroop competition between tool action "neighbors" in left hemisphere stroke

Harrison Stoll[1], Tamer Soliman[1], Laurel Buxbaum[1]; [1]Moss Rehabilitation Research Institute

Producing a word or action requires selection from among a set of competing alternatives. Response competition strongly affects action errors in left hemisphere stroke patients with limb apraxia. Apraxics pantomiming the use of tools make more errors with tools associated with conflicting actions for use versus grasp-to-pick-up (e.g., TV remote; i.e. "conflict" tools) than tools having a single action for both use and grasp (e.g., hammer; i.e. "non-conflict" tools) (Watson & Buxbaum, 2015). This susceptibility to competition from grasp actions is associated with weakness of 'automatic' activation of use actions, and reduced competition from use 'neighbors' that share sensory-motor attributes such as hand posture (Lee et al., 2014). A predicted consequence of weakened automatic activation of use representations and reduced competition between action 'neighbors' is relatively good performance when neighbors are directly pitted against one another in a Stroop-like task requiring inhibition of a typically pre-potent use action. We tested this hypothesis in a group of 21 left hemisphere stroke patients. In each of 6 blocks, a picture of one of 2 tools was shown over 24 trials. Within each block, the 2 tools were either Action neighbors (e.g., key and lightbulb), Function neighbors (e.g., axe and saw), or Unrelated. On Congruent trials in each block, subjects produced the action appropriate to the tool. On Incongruent trials they produced the action appropriate to the other tool in the block. The Stroop cost was relative performance on Incongruent versus Congruent trials. Patients also performed a simple pantomime task requiring them to gesture the use of both conflict and non-conflict tools. We computed overall scores and a use conflict score (relative performance with conflict versus non-conflict objects) -- an index of use activation strength. Conflict scores were uncorrelated with overall scores (p > .1). Data were analyzed with mixed-effects models with condition (Action-related, Function-related, Unrelated) and Congruence as within-subjects factors. On the action Stroop task, Incongruent actions were less accurate than Congruent actions. More interestingly, higher effects of conflict on the simple pantomime task were associated with lower Stroop costs in the Action condition (p = < .05), but not in the Function or Unrelated conditions (p's > .5) (see Figure 1). Moreover, the relationship between the pantomime conflict effect and Stroop costs was stronger in the Action condition than in the other two conditions (p's < .01). Consistent with our hypothesis, reduced activation of use information in a pantomime task is specifically associated with reduced Stroop costs from close action neighbors, but not from close function neighbors. There are at least two possible accounts of these data. Less precise activation of tool use actions may lead to spreading activation in the action "neighborhood", priming close Incongruent actions and making them easier to produce. Alternatively, weakened automatic activation of use actions may be associated with weaker "lateral" inhibition of neighboring (in this case, Incongruent) actions, rendering them easier to produce. Computational modeling of the observed effects may be useful in disentangling these possibilities.

A4 Depression alters limbic-sensorimotor brain interactions during implicit emotional speech production

Kevin Sitek[1,2], Gregory Ciccarelli[1,3], Mathias Goncalves[1], Thomas Quatieri[1,3], Satrajit Ghosh[1,2]; [1]MIT, [2]Harvard University, [3]MIT Lincoln Laboratory

Speech communication requires the precise coordination of language, motor, and sensory processes in the brain. Because speech is largely used to communicate thoughts, feelings, and internal states, additional cognitive and affective brain networks are likely involved in producing meaningful speech. We investigated the interaction between affect and speech production in participants with major depressive disorder (MDD). MDD is associated with emotional processing difficulties. In addition, depressed episodes affect speech production in individuals with MDD. Due to altered affective processing and speech production in depression, we hypothesized that sensorimotor and limbic brain activation would differ between MDD and non-depressed participants when

producing implicitly emotional speech. Twenty-three participants with MDD and twenty-two non-depressed controls participated in an MRI experiment at MIT which included T1-weighted anatomical scans, diffusion-weighted imaging, resting-state functional imaging, and task functional imaging. For task fMRI, five slices were acquired simultaneously (SMS-5), allowing for quick whole-brain coverage at 2 mm isotropic resolution. A rapid sparse acquisition scheme alternated each 1.1 s acquisition with a 2.9 s silent gap. During these runs, participants saw a short sentence on the screen, which they then produced out loud during the silent period between acquisitions. Sentences were either sad, happy, or neutral, as rated by an independent sample, and were ordered pseudorandomly. Participants were not instructed to produce the sentences in any particular way with any explicit emotional prosody. Participants' speech was recorded with an MRI-compatible microphone. Functional imaging data were preprocessed with Nipype. Overall, implicitly emotional speech production activated the canonical speech network, as well as medial prefrontal limbic regions, more strongly than neutral speech. However, the speech network was hyperactivated in MDD participants. Within the MDD group, depression severity was correlated with right insular activity when producing implicitly sad (compared to neutral) sentences. In resting state functional connectivity analysis, this right insular region was less connected with the speech production network but more connected with the default mode network in depressed participants compared to controls. Using psychophysiological interactions (PPI), we investigated functional connectivity between brain regions while performing the speech production task. We found that the amygdala, a structure involved in affective processing, was more functionally connected with right hemisphere insular and auditory cortices as well as regions associated with the default mode network in depressed (vs. control) participants. Compared to neutral speech, sad sentences showed less functional connectivity between the amygdala and posterior cingulate, another default mode region. In this study, we found that speech and limbic brain networks are activated differently between participants with MDD and non-depressed controls. In particular, the right insula, which has been implicated in both emotional processing dysfunction in depression as well as speech processing, is hyperactivated in the most depressed participants during implicitly sad speech and is functionally more strongly connected with both speech-motor and default mode regions. The right insula may play a crucial role in speech production changes that occur in depression.

A5 Brain and Clinical Predictors of Unique Brain Connectivity for Adjacent Levels of Language in the Reading Brain: Managing a Complex, Multi-Leveled System

Virginia Berninger[1], Todd Richards[1], Robert Abbott[1]; [1]University of Washington, Seattle

Introduction: Our programmatic research has shown that referring to language and reading, as many literacy researchers and clinical neuropsychologists do, is inaccurate. Language teams with sensory or motor systems in language by ear (listening), language by mouth (oral expression), language by eye (reading), and language by hand (written expression), and in each system cascades from subword to word to syntax to text levels. In this study we extended prior research on common and unique fMRI connectivity at adjacent subword, word, syntax, and text levels for the reading system in typical readers to reading disabilities—dyslexia (impaired word reading/decoding) and oral and written language learning disability (impaired syntactic reading comprehension). To understand how a complex, multi-leveled system is managed, focus was on connectivity with brain regions known to be involved in executive functions and clinical measures of executive functions. Methods: Students in grades 4 to 9 (4 males, 5 females with no reading disability; 10 males, 6 females with dyslexia; 2 males, 3 females with OWL LD) completed diagnostic assessment and then four multi-leveled fMRI reading tasks: judgments about permissible grapheme-phoneme correspondences, correct word-specific spellings versus homonyms, meaningfulness of sentences with and without homonym foils, and correct choice for answering question about multi-sentence text. These were programmed, timed, and coordinated with scanner triggers using E-prime and in-house LabView software. Participants had to complete tasks outside the scanner with 90% accuracy to enter the Philips 3 T Achieva scanner (release 3.2.2 with 32-channel head coil). fMRI connectivity maps, corrected for motion using FSL MCFLIRT, were generated for individuals from four seeds: left precuneus, left occipital temporal cortex, left supramarginal, and left inferior frontal gyrus. For each task, after controlling for multiple comparisons, unique brain connectivity for each adjacent level of language was identified in the controls without reading disability; then we examined that connectivity for those brain regions shown in prior research to involve executive functions or language regulation (left and right cingulate, left and right inferior frontal cortex, secondary somatosensory/operculum, insula, and cerebellum V or vermis) for the control, dyslexia, and OWL LD groups. We also correlated clinical measures of executive functions with those regions. Results and Discussion: For the controls without reading disability significant unique connectivity was found for each leveled language fMRI task with one or more of the brain regions known to be involved in executive functions for at least one seed and often more. From the same seeds, the dyslexia group did not differ from the controls where controls showed connectivity unique for a level of language, but differed in showing over-connectivity to other regions where controls did not. The OWL LD group did not always show connectivity where the controls did and tended to show under-connectivity compared to controls. Rapid Automatic Switching (Wolf & Denckla,

2003) was significantly correlated with magnitude of connectivity with the fMRI word-level and text-level tasks and with number of significant connections from at least one but not always the same seed point for the subword-, word-, syntax-, and text-level fMRI tasks.

A6 Fluent Speech in the Presence of Severe Verbal Working Memory Dysfunction

Christopher Barkley[1], Zhenhong Hi[2], Angela Birnbaum[1], Ilo Leppik[1], Susan Marino[1]; [1]University of Minnesota, [2]University of Florida

It has been well established that verbal working memory (VWM) processes play a central role in language production (Daneman, 1991; Acheson, 2009), though the nature of the VWM mechanisms necessary for production has yet to be fully characterized. Here we describe the results of a clinical protocol that utilizes the tools of pharmacology to generate findings that constrain accounts of the interactions between VWM and production processes. Topiramate (TPM), a broad-spectrum anti-seizure drug used to treat conditions ranging from epilepsy to migraine, frequently causes cognitive deficits, the most common being severe word-finding difficulties (Mula et al., 2003). Lorazepam (LZP), a benzodiazapene used to treat anxiety and sleep disorders, is also associated with cognitive impairments but, in contrast to TPM, there is no evidence in the literature that LZP disrupts language. Due to the tight link between VWM and language production, we predicted that subjects on TPM would show VWM impairments. As LZP appears to spare the language system, we predicted that performance on a VWM task would remain intact after taking LZP. Twenty-nine healthy subjects received either 100, 150, or 200 mgs of TPM, 2mg of LZP, and PBO in a randomized, double-blind, crossover study design. Four hours after drug administration, they completed a Sternberg VWM task (three memory loads: 1, 3, and 5 syllables). Reaction time and accuracy were recorded, and the extent of drug-induced impairment was calculated by comparing each treatment to PBO ((drug-PBO)/PBO), thus normalizing across individual accuracy rates. Working memory capacity (WMC) was assessed by using data collected during the PBO session to calculate Cowan's k scores, averaged across memory loads (Cowan, 2001). Subjects also completed a neuropsychological battery at 3 time points during each session. The battery included multiple tests of executive function, as well as the timed phonemic and semantic controlled oral word-association tasks (COWA) to assess verbal fluency. Compared to PBO, TPM caused pronounced deficits on all neuropsychological tests, including both COWA tasks (all $p < .05$). In contrast, while LZP affected all non-language tasks (all $p < .05$), performance on the COWAs did not differ from PBO. On the VWM task, TPM administration led to decreases in accuracy for all three memory loads (all $p<.005$). The magnitude of these accuracy decreases was correlated with subjects WMC ($r=-.49$, $p=.011$). Intriguingly, performance on the VWM task during the LZP session declined even more severely. Accuracy again decreased for all loads (all $p<.005$), but reaction times also increased significantly compared to both PBO and TPM (all $p<.005$). However, the severity of these performance deficits was not correlated with WMC ($r=-.18$,$p=.33$), suggesting that LZP impaired a VWM process distinct from the one crucial to production that was negatively impacted by TPM. These data suggest that individuals can produce normal language in the face of at least some severe disruptions of the VWM system, a finding not predicted under most descriptions of the architecture of the language production system. This underscores the utility of using pharmacological probes to understand the structure of the language system.

A7 Task difficulty affects language production: Behavioral and fMRI evidence

Haoyun Zhang[1], Anna Eppes[1], Anne Beatty-Martínez[1], Christian Navarro-Torres[2], Michele Diaz[1]; [1]Pennsylvania State University, [2]University of California, Riverside

Language production involves a largely left-lateralized network including temporal, frontal, premotor and motor cortices (Indefrey & Levelt, 2000, 2004; Price, 2010). The CRUNCH model (Reuter-Lorenz & Cappell, 2008) has proposed that task difficulty affects the relationship between performance and brain activation, which has not been fully examined in language production. Therefore, this study manipulated task difficulty to explore how difficulty affects language production behaviorally and neurally. 20 individuals (10 females; 18-34 years) participated in a phonological Go-No-Go picture naming task. We manipulated language production difficulty via the proportions of Go trials and No-Go trials across three runs: All Go (named all the pictures), Go Bias (75% Go trials, named pictures whose name started with a consonant, e.g., nose), and No-Go Bias (75% No-Go trials, named pictures whose name started with a vowel, e.g., ear). A lower proportion of Go trials should elicit greater demands in production (Go trials). On the contrary, a higher proportion of Go trials should elicit greater demands in executive function (No-Go trials, inhibition to withhold responses). Behaviorally, participants failed to inhibit responding (No-Go trials) significantly more often in the Go Bias run than the No-Go Bias run ($t(19) = 3.73$, $p = .001$), consistent with increased inhibition difficulty during the Go-Bias run. Moreover, participants were slower to name pictures in the No-Go Bias run compared to the other two conditions (ps < .001), suggesting that naming was most difficult in the No-Go Bias run. In the fMRI analysis, we used a linear trend analysis to compare brain activation to Go trials across the three runs to examine effects of naming difficulty (No-Go Bias > Go Bias > All Go). Results revealed that Go trials in the No-Go Bias run elicited greater activation than Go trials in the other runs in right inferior frontal gyrus (pars triangularis, pars opercularis) which extended into posterior superior and middle temporal gyrus and orbitofrontal cortex, and also in left supramarginal and angular gyri. Similarly, we examined inhibition demands across No-Go trials

and found that No-Go trials in the Go Bias run elicited greater activation than No-Go trials in the No-Go Bias run in bilateral orbitalfrontal cortex, which extended to superior and inferior frontal gyri, and anterior cingulate cortex. Combined with our behavioral results, these findings confirm that the more difficult conditions (for both naming and inhibition) elicited more extensive activation. Moreover, we found negative correlations between reaction times and brain activation to Go trials across all runs in bilateral precentral and postcentral gyri, extending to superior frontal gyrus, which suggests that greater recruitment of motor regions facilitated naming. Positive correlations were found in left inferior frontal gyrus and fusiform gyrus. Consistent with the CRUNCH model, our results indicate that task difficulty affects language production behavior and fMRI activation and that in younger adults, increased naming difficulty was associated with increased recruitment of inferior frontal regions. Moreover, increased recruitment of bilateral premotor, motor, and superior frontal regions facilitate naming performance.

A8 Tracking the time course of associative and categorical context effects in spoken word production

Andus Wing-Kuen Wong[1], Ho-Ching Chiu[1], Jie Wang[2], Siu-San Wong[1], Jinlu Cao[2], Hsuan-Chih Chen[2]; [1]City University of Hong Kong, [2]Chinese University of Hong Kong

A key issue in the production literature concerns the mechanism of lexical selection in speech production. The Lexical Selection by Competition (LSC) view assumes that lexical selection involves competition among multiple co-activated lexical units. Supporting evidence comes from picture-word interference (PWI) studies. In a PWI task, participants are asked to name individually presented picture and ignore a word distractor. Participants' naming latencies were slower if the target (DOG) and distractor (cat) were from the same semantic category, relative to an unrelated control (pen). This categorical interference effect has been taken to support the LSC view as only the categorically related distractor, but not the unrelated distractor, would intensify the competition during lexical selection. Dissimilarly, the Response Exclusion Hypothesis (REH) assumes a late locus of the categorical interference effect. According to REH, longer time is required to exclude a categorially related response from the response buffer due to its response relevance. Furthermore, null or facilitation effects have been reported if the distractor was associatively related to the target (bone and DOG). The REH assumes that the associative effect arises from an early conceptual stage and the categorical interference from a late post-lexical stage. Conversely, the LSC view assumes a lexical locus for both associative and categorical effects. To verify the above two accounts, this study was conducted using the PWI paradigm with concurrent ERP recording. Thirty-four native Mandarin speakers participated. Each picture stimulus was paired with three word distractors, namely categorically related, associatively related, or phonologically related. Three corresponding unrelated conditions were constructed by re-pairing the targets and distractors in each condition. Participants' naming latencies were submitted to linear mixed-effect modeling. The differences in naming latencies between related and unrelated conditions were significant for categorical distractors (b = -45.62, SE = 14.13, p = 0.002), marginally significant for phonological distractors (b = 21.72, SE = 12.68, p = 0.092), and not significant for associative distractors (b = -11.12, SE = 11.97, p = 0.357). The ERP signals were analyzed using a stimulus-locked approach (i.e., time-locked to the picture onset) and a response-locked approach (i.e., time-locked to the response onset). For the stimulus-locked analysis, mean ERP amplitude values were calculated in the time windows of 0-275, 275-450, and 450-600 ms post-target. For the response-locked analysis, mean ERP amplitudes were calculated within the 300 ms to 150 ms time window prior to the response onset and within the 150-ms time window preceding the response onset. Significant ERP effects were obtained in categorical and associative conditions in the time window between 275 and 450 ms post-target. Furthermore, significant ERP effects of target-distractor relatedness were observed only in the associative condition within the 300-ms pre-response period. The classical categorical interference was replicated in the present study. By combining stimulus-locked and response-locked approaches, this study showed relatively early ERP effects in categorical and associative conditions and late ERP effects only in the associative condition. These results are consistent with the LSC view that the categorical interference effect is due to competition during lexical selection.

A9 Auditory attention and predictive processing co-modulate speech comprehension in middle-aged adults

Sarah Tune[1], Malte Wöstmann[1], Jonas Obleser[1]; [1]University of Lübeck, Germany

In real-life communication, speech comprehension requires the dynamic engagement of a complex set of perceptual, executive control and prediction processes. This challenge becomes exacerbated by the gradual declines in sensory acuity and cognitive functioning that are typically associated with healthy aging starting in middle adulthood. Here, we present results from a study focused on healthy middle-aged human adults (40-70y) who performed a novel dichotic listening task. The paradigm called for adaptive control of cognitive strategies by varying the degree to which auditory spatial attention and predictive processing support comprehension. Participants were presented with two competing, dichotically presented speech streams uttered by the same female speaker. Participants were probed on the last word in one of the two streams. Crucially, auditory presentation was preceded by two visual cues. First, a spatial-attention cue either indicated the to-be-probed side, thus invoking selective attention, or it did

not provide any information about the to-be-probed side, thus invoking divided attention. The second cue specified a general or a specific semantic category for the target word (and was valid for both utterances). This semantic cue therefore facilitated semantic and sensory prediction of the upcoming input. Behavioral results (n=29) show a general increase in performance for informative compared to uninformative cues. Participants responded faster in selective attention trials and following a specific semantic cue. Accuracy was co-modulated by the joint effect of both cues, as reflected by a benefit from specific (vs. general) semantic cues but only under selective auditory attention. Moreover, reliance on the spatial-attention cue varied with age: Older adults performed better under selective attention and worse under divided attention than younger adults. Analysis of electroencephalography (EEG) data (n=16) revealed a lateralization of 8–12Hz alpha power during spatial attention cue presentation, but also and even more pronounced during the dichotic speech streams in selective-attention but not in divided-attention trials. Specificity of the semantic cue on the other hand modulated oscillatory power in the beta frequency band (15–30Hz), with a decrease in power for specific cues. In sum, our results provide evidence for the interplay of attentional control and predictive processes in difficult listening situations. Crucially, providing two distinct types of cues prompted changes in behavioural performance correlated with qualitatively different neural signatures, and highlights changes in cognitive strategies with age.

A10 Semantic context reverses the polarity of P200 effects during word planning

Daniel Kleinman[1], Kara Federmeier[1]; [1]University of Illinois at Urbana-Champaign

How long does it take to retrieve a word's representation in long-term semantic memory when preparing to speak? Recent EEG studies using language production tasks have found that the P200 component has a greater amplitude when lexical selection is more difficult. This relationship holds across several different manipulations: Larger P200s are evoked when bilinguals name pictures in their L2 (vs. in their L1), or when speakers name pictures with lower-frequency (vs. higher-frequency) names or pictures with recently named semantic competitors (Costa, Strijkers, Martin, & Thierry, 2009; Strijkers, Costa, & Thierry, 2009). Strikingly, P200 amplitude in these tasks positively correlates with picture naming latencies on a trial-to-trial basis. Collectively, these findings have led researchers to suggest that speakers initiate lexical access within 200 ms, and that the P200 component (particularly in occipital regions) indexes the difficulty of this retrieval process. However, to our knowledge, all such reports have used a picture naming task, which affords only a single correct response that must be produced in the absence of a broader context – factors that may limit the generality of these findings. Here, we investigated the relationship between P200 amplitude and lexical selection difficulty using a sentence completion task, which affords many acceptable responses that are generated within a semantically rich context. METHOD: We recorded participants' EEG (n=38) as they read RSVP sentences that varied in constraint (how strongly the context predicted a particular final word). On 50% of trials, the last word of the sentence was omitted and participants instead saw a blank, prompting them to overtly produce their own completions. To permit comparison with standard effects of context on comprehension, the other 50% of sentences were completed with a final word that was either expected or unexpected. RESULTS: On production trials, single-trial analyses revealed a significant relationship between response latencies and P200 amplitudes in occipital regions. However, in contrast to previous studies, this relationship was negative – that is, a larger P200 was associated with a faster RT (which was in turn associated with higher sentence constraint and higher cloze probability of participants' productions). CONCLUSIONS: The relationship between P200 amplitude and word production difficulty (as indexed by production latencies) is task-dependent. As there are many differences between picture naming and our sentence completion task that could account for the polarity of this effect, this inconsistency may help to reveal what exactly P200 amplitude signifies. If P200 amplitude scales with the amount of activation injected into the production system, for instance, then that extra activation could lead to different RT effects when spread among a set of close competitors (as during picture naming) vs. when concentrated on a single response (as during sentence completion for a strongly constraining sentence). Alternatively, P200 amplitude during production may reflect attention-related and pre-lexical effects that differ between tasks. Until further research reveals how (and not just when) P200 effects reflect word production processes, using that component as a barometer of lexical selection difficulty may be premature.

A11 Transcranial 10-Hz stimulation but also eye closure modulate auditory attention

Malte Wöstmann[1], Lea-Maria Schmitt[1], Johannes Vosskuhl[2], Christoph S. Herrmann[2], Jonas Obleser[1]; [1]Department of Psychology, University of Lübeck, Germany, [2]Department of Psychology, Oldenburg University, Germany

When humans focus attention to auditory events, neural alpha oscillations (~10 Hz) in the Magneto-/Electroencephalogram (M/EEG) increase in power. Here we test whether experimentally induced increases in alpha power modulate auditory attention. In two studies, healthy human participants attended to spoken target digits against distractors. Alpha power was increased exogenously through transcranial alternating current stimulation (tACS), or endogenously through eye closure. In study I (n = 20), participants were cued to attend to a stream of four spoken digits presented to one ear, while ignoring a distracting (same-talker) stream of digits presented to the other ear. Previous M/EEG studies have shown that such dichotic tasks increase alpha power in auditory and parietal cortex

ipsilateral to the focus of attention. To manipulate this alpha lateralization, we applied continuous 10-Hz tACS to temporal and parietal scalp regions in the left hemisphere (1 milliamp; stimulation sites FC5 and TP7). To control for the effect of stimulation frequency, each participant also received sham and gamma-tACS (47.1 Hz). Compared to sham, left-hemisphere alpha-tACS enhanced the recall of target digits in 'attend-left' versus 'attend-right' trials, while the opposite was found for gamma-tACS. This suggests that an exogenous increase in lateralized alpha power relatively suppresses auditory spatial attention to the side opposite to stimulation. In study II (n = 22), we sought to invoke an endogenous increase of alpha power instead while presenting participants with two alternating (different-talker) streams of five spoken digits. On each trial, participants were instructed to attend to one stream and to ignore the other. In blocks where they closed their eyes (in a dark room; compared to keeping their eyes open), participants induced a baseline increase in parieto-occipital EEG alpha power. During a trial, baseline-corrected alpha power fluctuated rhythmically, with alpha peaks preceding onsets of attended digits by ~100 ms. This attentional modulation of alpha power strongly increased with closed compared to open eyes, demonstrating that eye closure boosts the neural difference in auditory attending versus ignoring. However, eye closure did not enhance participants' ability to afterwards tell attended from ignored digits, which contradicts the widely held belief that eye closure per se enhances the behavioral outcome of attentive listening. In sum, the observed impact of eye closure and alpha-tACS on neural alpha dynamics and behavioral corollaries suggest that alpha power is more than a mere epiphenomenon but neurally and behaviorally relevant to auditory attention.

Grammar: Morphology

A12 Language impairment and improvement in Parkinson's disease: what, when, and why

Karim Johari[1], Jana Reifegerste[2], Matthew Walenski[3], Farzad Ashrafi[4], Roozbeh Behroozmand[5], Michael T Ullman[6]; [1]University of South Carolina, USA, [2]University of Potsdam, Germany, [3]Northwestern University, USA, [4]Shahid Beheshti University of Medical Sciences, Iran, [5]University of South Carolina, USA, [6]Georgetown University, USA

Introduction and Methods. Although Parkinson's disease (PD), which is linked to the degeneration of dopaminergic neurons in the basal ganglia, has long been associated with motor deficits, language has also been implicated. We comprehensively investigated language in PD by testing multiple aspects of language within-subjects, and by examining different factors that might negatively or positively impact language deficits. To expand the literature beyond the usual investigation of English, we probed Farsi, in Farsi-speaking patients and healthy controls. We examined patients with moderate-to-severe PD, in whom degeneration may extend to frontal/basal-ganglia circuits implicated in language. We focused on regular vs. irregular inflectional morphology, which directly contrasts grammatical vs. lexical processing, but also examined syntactic and lexical-semantic processing. Based on a well-developed neurocognitive theory, the declarative/procedural model, which has tied grammar to procedural memory and frontal/basal-ganglia circuits and lexical memory to declarative memory, we predicted impairments at grammatical more than lexical aspects of language. Matched male and female patients and controls were tested, since female patients might compensate for their grammatical deficits by memorizing regular forms in lexical/declarative memory, which shows female advantages. Results. We found that male but not female PD patients showed greater deficits at regular than irregular past-tense production. Indeed, the females' impairment was mildest for regulars, apparently due to compensatory storage, as revealed by regular past-tense frequency effects only in females. Reflecting both sexes' underlying dysfunction, right-side hypokinesia (tied to left frontal/basal-ganglia degeneration) correlated negatively with accuracy of regulars but not irregulars, while left-side hypokinesia correlated with neither. Similarly, the levodopa equivalent dose of patients' last medication correlated with only regulars. The patients showed deficits at both syntactic judgment and syntactic comprehension, which also correlated with levodopa equivalent dose. Additionally, the patients were impaired at naming commonly-manipulated objects (linked to frontal/basal-ganglia circuits), but not non-manipulated items, indicating that lexical retrieval remained relatively spared. Conclusion. Overall, the findings, which support and further elucidate the declarative/procedural model, suggest that PD is associated with grammatical deficits but relative sparing of lexical memory, with the grammatical deficits linked to left frontal/basal-ganglia circuits and dopaminergic processes. More generally, the results suggest that language is impaired in PD, but that the impairments are modulated by multiple interacting factors, including type of linguistic knowledge, degree of left frontal/basal-ganglia degeneration, dopamine levels, and sex. Moreover, the data suggest a potential for significant improvement of the language deficits, both from dopaminergic medication and compensation by lexical/declarative memory.

A13 The brain differentiates between known and unknown word compositions but not between transparent and opaque meaning composition: ERP-evidence from the processing of German nominal compounds and pseudo-compounds

Carsten Eulitz[1], Eva Smolka[1]; [1]University of Konstanz, Department of Linguistics

This study investigated whether lexical representations of German compounds incorporate the constituent structure, and whether this is affected by the semantic transparency of the whole-word compound. To this end, we compared

compound triplets that held the same head such as /auge/ ("eye"): (a) semantically transparent compounds such as /Hundeauge/ ("dog's eye"), (b) semantically opaque compounds such as /Hühnerauge/ ("corn"; literal: "hen's eye"), and (c) pseudo-compounds that were neologisms consisting of legal noun constituents such as /Hosenauge/ ("trousers' eye"). Pseudo-compounds were possible but non-existent word formations. We measured event-related potentials while participants read the compound stimuli and made nonword decisions to (d) nonword compounds with scrambled constituents such as /Hosenegaug/ (nonwords had a rate of 25%). Among the 35 recorded subjects, 24 participants showed a good nonword detection with d primes larger than 2. ERP-results of good performers showed an interaction of condition and electrode position. This effect was driven by a more negative amplitude of the pseudo-compound-condition compared to both semantically transparent and opaque compound conditions. This relative negativity started at 400 ms post-stimulus onset and had a central maximum that can be interpreted as an N400 effect, indicating that the brain differentiates between known (semantically transparent and opaque compounds) and unknown (pseudo-compounds) word combinations. By contrast, there were no reliable ERP effects differentiating between the semantically transparent and opaque compound conditions. This latter finding replicates our previous behavioral findings on German compounds where we observed equivalent priming effects regardless of the semantic transparency of modifiers or heads. The present ERP findings indicate that the lexical representation of German compounds refers to their constituent structure, and this occurs regardless of the semantic transparency of the whole-word compound. Different from other Indo-European languages, constituent structure thus needs to be incorporated in the lexical representation and processing of German. Altogether, these findings stress the importance of cross-language comparisons to understand the representation and processing of morphologically complex words.

Grammar: Syntax

A14 An ALE-based meta-analysis of neuroimaging studies of sentence comprehension

Matthew Walenski[1], Eduardo Europa[1], David Caplan[4], Cynthia K. Thompson[1,2,3]; [1]Department of Communication Sciences and Disorders, Northwestern University, Evanston, IL, USA, [2]Cognitive Neurology and Alzheimer's Disease Center, Northwestern University, Evanston, IL, USA, [3]Department of Neurology, Northwestern University, Evanston, IL, USA, [4]Massachusetts General Hospital, Department of Neurology, Harvard Medical School, Boston, MA, USA

Introduction. Comprehending a sentence is a complex endeavor that requires the coordinated activity of multiple brain regions. Our goal in this project was to merge findings from imaging studies of sentence comprehension to summarize regions shown to be engaged in language comprehension in healthy individuals. We expect that these would largely involve perisylvian regions of the left hemisphere. We also examined the contrast between non-canonical and canonical sentence structures. Non-canonically ordered sentences subvert the dominant agent-verb-theme order of arguments in English, such that the theme precedes the verb. For example, in an object relative clause (The boy that the girl saw [gap] is …), the theme argument (boy) is extracted from the [gap] position, preceding its verb (saw) and the agent argument (girl). In a subject relative clause (The girl that [gap] saw the boy is …), the dominant order is preserved. For non-canonical sentences, we anticipated involvement of left inferior frontal regions that putatively subserve the complex syntactic processing required for these structures. Method. Literature searches revealed 443 imaging studies (FMRI, PET) of sentence comprehension published between 1992 and 2016. Of these, studies were considered eligible for inclusion in our analyses if they reported whole-brain 3-D coordinates for two or more activation foci in a standard space (Talairach, MNI) from healthy, right-handed, monolingual adults. Of the eligible studies, we first examined those that reported contrasts for sentence comprehension (auditory or visual) against a perceptual baseline (e.g., backwards speech, nonsense fonts). Additionally, we identified studies that reported a contrast of sentences with non-canonical order against those with canonically ordered arguments. Studies with these contrasts were included only if the participants were required to perform a task while comprehending the sentences. We performed an automated estimation likelihood analysis on the published coordinates using the GingerAle software package, with a cluster level inference thresholding method and false discovery rate correction for multiple comparisons. Results. In comparison against the perceptual baseline, 36 contrasts met all criteria for inclusion. The results indicated significant clusters with extrema in left perisylvian regions (temporal pole, anterior and posterior middle temporal gyrus, angular gyrus, inferior frontal gyrus) as well as in the right temporal lobe (temporal pole, anterior and posterior middle temporal gyrus). A follow-up conjunction analysis comparing auditory and visual modalities found areas of common activation in left middle temporal gyrus and left inferior frontal cortex. Thirty-four contrasts between non-canonical and canonical sentences met criteria for inclusion. The results showed significant clusters in left inferior frontal, middle frontal, paracingulate, middle temporal, and angular gyri. No significant clusters were found in the right hemisphere. Follow-up analyses of auditory vs. visual modality differences reveal substantial overlap in left inferior frontal gyrus. Conclusions. The results revealed a set of bilateral regions activated in response to sentence comprehension relative to perceptual baseline conditions, consistent with our expectations. A more

restricted subset of left-hemisphere regions was implicated in the comprehension of non-canonical sentence structures, indicating specialized syntactic processing for these structures.

A15 Neural Correlates Modulated by the Word Category Information During Complicated Hierarchical Syntactic Structure Processing: An fMRI study

Luyao Chen[1], Yongben Fu[1], Huntae Kang[1], Liping Feng[1]; [1]Beijing Normal University

The essence of human language faculty has been recently assumed to be the competence of labeling which gives two merged syntactic objects an syntactic identity, e.g. 'the apple' is labeled as a DP after the merge of 'the' (D) and 'apple' (N). And theoretically, the labeling competence based on the word category information is crucial to generate hierarchical syntactic structures. Thus we assumed that the word category information might be important for hierarchical syntactic structure processing, and the neural correlates modulated by it might be essential for human language processing. Hence, an fMRI experiment was conducted to investigate the neural mechanisms modulated by word category information during hierarchical syntactic structure processing. we adopted the artificial grammar learning paradigm adapted from Opitz & Friederici (2007), and created a Chinese-like artificial language containing 4 nouns (N), 9 verbs (V1/2/3) with 3 in every subcategory, 2 relativizers (R1/2) and 1 adverb/ verb modifier (M) on the basis of the Chinese phonetic alphabet. The center-embedding structure, e.g. [N V1/2 [[V3 N] R1/2] N], was used avoiding the mere transition probability problem of processing, and it was considered to contain the syntactic long-dependencies (e.g. between V1/2 and the last N, and between V1/2 and R1/2) that may better reflect the function of the word category information. The dependencies between V1/2 and R1/2 were set to be principal in the present study. 30 Korean native speakers were randomly separated into 2 groups. One group acquired the word category information before the artificial language learning, and the other did not. The learning session consists of 6 blocks with one part of training and the other testing in every block. Participants needed to extract the syntactic rules during training and to judge the syntactic correctness in testing. The participants without acquiring the word category information before should take the extra artificial word categorization test. The scanning session only required the participants to make the syntactic judgment. The behavioral results showed that the participants with word category information could successfully acquired the principal syntactic rules more accurately and quickly, but the other group failed in both the rule acquisition and the word categorization. FMRI results revealed that processing such the complicated hierarchical syntactic structures with the word category information could evoke the stronger activation of the Broca's area including BA 44 and BA 45, the superior temporal gyrus (STG) and the (superior and inferior) parietal lobe. Further correlation analysis of the functional connectivity strength between the related ROIs indicated that the word category information might result in a much closer collaboration between the sub-parts of the Broca's area, and the group without the word category information might resort to more brain areas for processing the syntactic structure. Our present experiment has provided the direct evidence to the importance of the word category information in language learning and processing, and has made the first try to explore the labeling hypothesis in the field of neurolinguistics.

A16 EEG responses to two A-movement phenomena: unaccusatives and passives

Jon Sprouse[1], Susi Wurmbrand[1]; [1]University of Connecticut

The intransitive verb constructions in (1) are superficially distinct from the transitive verb constructions in (2). (1a) The package arrived after the deadline. (intransitive: unaccusative) (1b) The singer coughed after the song. (intransitive: unergative) (2a) The plane was flown during the storm. (transitive: passive) (2b) The pilot was flying during the storm. (transitive: active) Nonetheless, many syntactic theories predict that the sub-members of these constructions will pattern together: (1a) with (2a) and (1b) with (2b). This sub-patterning is manifest in the semantics of the subjects (the (a) subjects are patients, the (b) subjects are agents), and has been argued to be encoded by a syntactic mechanism called A-movement (e.g., Levin and Rappaport-Hovav 1995). If we take these analyses seriously, there are two potential sentence processing predictions. First, there should be a difference in the processing profiles between the (a) and (b) sentences: the (a) sentences involve the integration of a patient and a verb; the (b) sentences involve the integration of an agent and a verb. This prediction has been of particular interest recently, especially in the fMRI literature, but typically for only one construction at a time (Shetreet et al. 2010, VanDyke and Hall 2012, Agnew et al. 2014, Aya Meltzer-Asscher et al. 2015). Second, these theories predict that the difference between the (a) and (b) sentences should be (at least partially) the same for both constructions, as they both involve the same grammatical mechanisms, and therefore plausibly the same sentence processing mechanisms. Our goal in this project is to explore this latter claim by testing all four of these constructions in the same set of participants using EEG, so that we can explore both the ERP and time-frequency responses across the sentences. We have conducted two experiments. Experiment 1 (N=33) tested the four conditions above, using pure intransitive verbs in (1a-b), optional transitives in (2a-b), 40 items per condition, RSVP (SOA 500ms, ISI 200ms), mixed with 140 fillers to eliminate processing biases based on the animacy of the subject and the continuation at "was". Experiment 2 (N=28) was identical, except that we used optional intransitive verbs like "froze" and "sang" in (1a) and (1b), and "had flown" in (2b). In experiment 1, the ERP responses to (1a) vs (1b) were roughly opposite

in polarity to the ERP responses to (2a) vs (2b). (1a) and (1b) revealed a sustained positivity from the verb until the end of the sentence (baselined to the first 50ms of the verb). The positivity was broadly distributed, but larger at posterior electrode sites. The difference between (2a) and (2b) revealed phasic negativities in the 300-500ms window of the auxiliary ("was" for both, but always preceded by an inanimate noun in (2a) and an animate noun in (2b)), and in the 300-500ms window of the verb itself. The ERP responses for experiment 2 were roughly similar. Time-frequency analyses have revealed no significant differences in power, though we have not exhausted the analysis types yet. These results fail to confirm the classes predicted by syntactic theories.

A17 Noun and verb processing in French during sentence comprehension – an event-related potential study

Lauren Fromont[1,2], Phaedra Royle[1,2], Karsten Steinhauer[2,3]; [1]Université de Montréal, [2]Centre for Research on Brain, Language and Music, [3]McGill University

Syntactic and semantic processing are essential to sentence comprehension: syntactic categories (SCs) and lexical semantic information help integrate each incoming word into the sentence context. How these two processes interact is still under debate. Serial accounts such as Friederici's (2002, 2011) extremely influential "syntax-first" model posit that SCs are analyzed first. SC violations were shown to elicit early left-anterior negativities (ELANs) and appeared to 'block' semantic N400 effects, suggesting that SC analysis is instrumental to semantic processing (Friederici et al., 1999). However, some studies in other languages (Yang et al., 2015 in Mandarin), could not replicate either the ELAN or the semantic blocking effect. The authors suggested that SC analysis is not automatic in languages with poorer morphological marking. In addition, Steinhauer and Drury (2012) argued that most previous ELAN studies involved pre-target context differences that may have caused ELAN-like artifacts as well as the absence of N400s. To avoid context effects, we created a balanced design that controls for both the context and the target word (verb or noun). In French, definite articles le/la/les (= the in (1)) and accusative clitics le/la/les (= him/her/them in (2)) are homophographs and appear before a noun or a verb, respectively. We selected verbs in (1) and (2) that subcategorize specifically for either noun or verb complements. In our design, only target verbs bear inflection. (1) Elles ôtent le crapeau. 'They remove the toad' (2) Elles osent le plaquer. 'They dare tackling him' Syntactic category violations (3) and (4) are created by cross-splicing the two sentences before the target word. (3) Elles ôtent le *plaquer. 'They remove the *tackling' (4) Elles osent le *crapeau. 'They dare *toad him' All experimental sentences (1-4) were preceded by a lead-in sentenc" that a) licensed clitics and definite determiners with a referent noun (e.g., "Mary and Jane are playing hockey with their friend" for sentence (2)), and b) established degrees of semantic priming, allowing us to study semantic N400s in the presence of SC violations. Event-related potentials across sub-conditions (1-2 vs. 3-4) revealed no ELAN for SC violations, suggesting that there is no early automatic stage of syntactic processing, and that previous ELAN findings may be context-driven artifacts. Instead, we found an N400 and a late P600, showing that lexical semantic processing is not blocked but takes place in parallel to syntactic processes. N400 responses were still present when the target was primed, suggesting that the two processes take place in parallel. Comparing between sub-conditions (1 vs 2, 3 vs. 4) revealed no difference between the violation conditions, but additional N400 effects on the correct noun (1) versus verb condition (2). Such differences may be attributed to the absence of inflection in the noun condition. Friederici (2002) TiCS 6 (2):78-84. Friederici, Steinhauer & Frisch (1999) Memory and Cognition 27 (3):438-53. Steinhauer & Drury (2012). Brain and Language. 120 (2), 135-162. Yang, Wu & Zhou (2015) PLoS ONE. 10(6)

A18 Syntactic Constituent Rate Effects in EEG

Ellen Lau[1], Mina Hirzel[1], Natalia Lapinskaya[2], Jeffrey Lidz[1]; [1]University of Maryland, College Park, [2]McMaster University

Recent findings using MEG suggest that the phase reset of neural oscillations encodes hierarchical linguistic structure in the brain [1]. In two experiments, we demonstrate this entrainment manifests regardless of stimulus presentation rate. Our data suggest that further work with EEG could provide insights into the mechanisms that give rise to these effects (e.g. lexical vs. syntactic, [2]). In experiment 1, eight adults listened to lists of simple sentences with identical syntactic structure. One-syllable English words were synthesized independently using Neospeech. Each word was truncated or padded with silence at the end to a duration of 320ms. Sixty unique sentences were formed with the sentence structure [[Adj Noun][Verb Noun]] (e.g., 'sick-Adj ducks-N hate-V pools-N') by concatenating each syllable with no acoustic gaps added. Participants listened to 30 blocks (22 test blocks, 8 filler blocks) of 12 sentences each. Their task was to indicate at the end of each block whether they heard an ungrammatical sentence within that block, and eyes were kept closed to minimize blink artifacts. Following [1], we predicted that cortical tracking of abstract linguistic structure would manifest as high amplitude peaks at frequencies corresponding to sentence (1Hz), phrase (2Hz) and word (4Hz) presentation rates. For each participant, epochs were extracted spanning the length of each of the 22 12-sentence trials and averaged. As in [1], we observed peaks at the sentence ($t(7) = 2.0$, $p < .05$) and syllable rates ($t(7) = 7.2$, $p < .01$) in the frequency domain. However, the expected peak at the phrasal rate ($t(7) = 1.7$, $p = .07$) was not as prominent. The syllable rate activity had a central distribution, while the sentence rate activity had a frontal distribution. If this effect reflects the encoding of syntactic constituency, we would expect to observe it independent of presentation rate. In experiment 2, we slowed the presentation rate to

520ms per syllable by padding 200ms after each syllable; experiment 2 was otherwise identical to experiment 1. In the frequency domain, we observe clear frequency peaks at the syllable rate ($t(7) = 6.0$, $p < .01$) and phrasal rate ($t(7) = 2.6$, $p < .05$), but the sentence rate peak was somewhat diminished in strength ($t(7) = 1.0$, $p = .16$). The slower presentation rate makes it easier to examine correlates of the frequency effects in the time-locked evoked response. Here we observed after each word a positive deflection followed by a negative deflection peaking at about 500ms. The amplitude of this negative peak appeared larger after words 2 and 4 (the nouns), a potential correlate of the phrasal rate. In a potential correlate to the sentence rate, frontal responses were more positive between 150-450ms after word 1, which could reflect either early processes related to beginning a sentence, or late processes related to completing a sentence (670-970ms after word 4).
References: [1] Ding, N., Melloni, L., Zhang, H., Tian, X., & Poeppel, D. (2016). Nature neuroscience. [2] Frank, S. & Yang, J. (2017). CUNY Sentence Processing Conference.

A19 ERP responses to active versus "passive" gap filling

Laura Snider[1], Jon Sprouse[1]; [1]University of Connecticut

The goal of this project is to compare the ERP correlates of active gap filling – the processing of a gap that is predicted by the grammar, and "passive" gap filling – a gap that is not predicted by the grammar (and presumably identified using bottom-up information). The hope is that this information could be instrumental in resolving debates about the presence or absence of dependency constraints in various languages. To create syntactic contexts that allowed for the manipulation of active versus passive gap filling, we adapted the design of Wagers and Phillips 2009, and compared two types of multiple-gap constructions: across-the-board (ATB) constructions ("and" in 1), and parasitic gap (PG) constructions ("before" in 1). (2) are control conditions. (1) Target: Who was the announcer presenting __ energetically on the show {and/before} discussing __ cheerfully during the segment? (2) Control: Who was energetically presenting the guest on the show {and/before} discussing the guest cheerfully during the segment? PG and ATB constructions each have two gaps: one in the first clause, and one in the second clause. Wagers and Phillips demonstrated with reading times that the second gap in ATB and PG differ in terms of gap processing: the second gap of ATB is actively filled (because the gap is required by the grammar); the second gap of PG is not actively filled (because the gap is not required). The question is to what extent the ERP correlates of gap filling differ at the second gap for ATB and PG. We recorded continuous EEG over 32 channels, for 300 sentences (40 each of the 4 conditions, plus 140 fillers to eliminate processing biases), RSVP, 500ms SOA, 200ms ISI. The analysis includes 19 subjects with accuracy ratings over 70% for grammaticality judgments (following 25% of items). We believe the participants processed the two structures differently because we observed an increased frontal-central negativity between 300 and 500ms for PG versus ATB at the critical structural word (and vs before/during/after). However, we found no differences between ATB and PG constructions at the second gap. For the 500ms at the second verb, we found no effects for either ATB or PG target conditions versus their controls. For the 1000ms window containing the preposition and determiner, we found identical effects for ATB and PG targets versus controls: a more negative N1 peak for controls, a more positive P2 peak for controls, a posterior positivity for targets from 300 to 700ms, and a left anterior negativity for targets from 700 to 1000ms. We also compared ATB target to PG target conditions (without controls) at the adverb, and found no differences. Our results suggest that classic ERP responses do not distinguish active versus passive gap filling (at least for this sample size). This suggests that we need to look beyond classic ERP responses to study gap filling in detail. Future work will look at neuronal oscillations in this data set, and a follow-up study will look for differences in sustained anterior negativities in ATB and PG.

A20 Tracking the dynamics of wh- dependency resolution inside and outside of islands: An ERP investigation

Lauren Covey[1], Alison Gabriele[1], Robert Fiorentino[1]; [1]University of Kansas

Wh-dependencies involve a long-distance relationship between a fronted wh-word (who) and the position in the sentence where it originated, called a gap site. Researchers have suggested that the processing of wh-dependencies involves at least two distinct processes, a predictive process in which the parser searches for a potential gap site upon encountering the wh-element, and an integrative process, when the dependency is successfully resolved at the gap site. The broader literature has linked these qualitatively different processes to distinct components: N400 for prediction (Federmeier, 2007; Lau et al., 2013; Michel, 2014; Van Berkum et al., 2005), and P600 for syntactic integration (Felser et al., 2003; Gouvea et al., 2010; Kaan et al., 2000; Phillips et al., 2005). Previous ERP studies have examined these processes independently, and few studies have tracked the dynamics of wh-dependency resolution across the sentence. The present study examines both prediction and integration and investigates whether these processes are indexed by unique components, focusing on the processing of wh-dependencies at three critical regions across the sentence: two associated with prediction and one with integration. The study also examines the extent to which prediction is grammatically constrained, investigating whether the parser avoids predicting a gap in positions that are not licensed by the grammar. 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 (Clifton & Frazier, 1989; Hestvik et al., 2007, 2012; Lee, 2004; Stowe, 1986). We also investigate whether the parser avoids predicting a gap

in a position that is not licensed by the grammar, called 'islands' (e.g., Dave Campbell in 1c vs. 1d) (Johnson et al. 2016; Stowe, 1986). [Examples: (1a-b) Jamie wondered if/ who the editor interviewed Dave Campbell with __ from the department. (Non-Island). (1c-d) Jamie wondered if/ who the editor [that interviewed Dave Campbell] kissed __ after the meeting. (Island).] Effects of gap prediction were examined at a filled pre-verbal subject position (the editor in 1a/b and 1c/d) and a filled post-verbal object position (Dave Campbell), both inside (1c/d) and outside (1a/b) of an island. Dependency resolution was examined at the actual gap site (1a/1b with; 1c/1d kissed). Results from 26 native English speakers were analyzed using linear mixed-effects models for the following time windows: 300-500ms for N400 and 500-900ms for P600. At the subject position, a significant N400 emerged, with wh-extraction sentences yielding larger negativities than no-extraction sentences. For the object position, a significant N400 emerged only for the non-island conditions (1a/1b); no significant effects emerged for the island conditions (1c/1d). At the actual gap site, significant P600s emerged in both conditions, with wh-extraction sentences yielding increased positivities compared to no-extraction sentences. The fact that filled-gap effects (N400) emerged only at grammatically licit positions suggests that gap prediction is grammatically guided. P600s at the actual gap site indicate that the wh-dependency was ultimately resolved, even in sentences with islands. The study provides evidence for distinct neurophysiological responses associated with gap prediction and dependency completion during wh-dependency resolution.

A21 EEG tracking of grammatical structures with different cloze probabilities in connected speech

Adria Rofes[1,2], Giovanni Di Liberto[1], Emily Teoh[1,3], Robert Coen[4], Sonja Kotz[5], Edmund Lalor[1,3], Brian Lawlor[1,4], Paul Dockree[1]; [1]Trinity College Dublin, Ireland, [2]Johns Hopkins University, USA, [3]Rochester University, USA, [4]St James's Hospital, Ireland, [5]Maastricht University, Netherlands

Introduction: The processing of grammatical structures in connected speech has been tracked with MEG (Ding et al. 2015, 2016). However, it is unknown whether the indices are only a marker of grammatical processing or can be modulated by semantic processing. This is a relevant issue as some theories argue that grammar happens first (Frazier & Rayner, 1982) while other theories that grammar and semantics occur in parallel (MacDonald et al., 1994). First, we study whether Ding et al.'s results can be replicated with EEG. Second, we assess whether the indices are modulated by semantic cloze probability in young and older healthy individuals. Methods: EEG signals were recorded from 16 healthy young adults (age 18-30) and 11 healthy older adults (age 61-72) using a 128-channel system. All participants heard sequences of monosyllabic words and were asked to indicate whether or not the words made sentences. Individual words were presented at a frequency of 2.5Hz and were independently synthesized to avoid prosodic cues. The experiment contained 32 trials repeated in 3 separate runs. Each trial, consisting of 12 sentences, tested one semantic probability condition (high cloze= top chefs cook steak; low cloze= top chefs buy steak; no cloze= #top chefs jump steak) or a condition with 48 scrambled words (e.g., chefs steak top cook). To build the high and low probability conditions we asked 79 healthy participants (age 18-69) to write the first and second verb that occurred as a likely completion of a sentence missing a verb (top chefs ___ steak). A frequency analysis was conducted on the EEG data following Ding et al. Fourier transforms were derived for individual conditions to extract cortical indices of sentence, phrase, and word structure. We also studied the topographical distribution of these indices. Results: Mean percentage of correct behavioral responses was above chance level in young (86, sd=11) and older adults (68, sd=12). For young adults EEG tracks sentence structure (indexed by a frequency domain peak at 0.625Hz for sentences vs scrambled words) as well as semantic processing (differences between semantic probabilities). The topographies show a rhythmic component in central-posterior areas that we associate to a N400. For older adults EEG tracks sentence structure similarly to younger adults. The index is modulated by cloze probability (higher magnitude for higher cloze probability). However, the data does not show the central-posterior component. Conclusion: EEG tracks brain processes that correlate with sentence comprehension. Cloze probability modulates indices of sentence processing. This indicates (1) the signal is a marker of grammatical and semantic processing, in line with theories of parallel processing; (2) the paradigm has the potential to detect grammatical and semantic problems in people with neurological etiologies. Further analyses and pilot results on people with semantic impairments will be presented.

A22 Using ERPs to investigate the comprehension of passive versus active sentences in English

Carrie N. Jackson[1], Heidi Lorimor[2], Janet G. van Hell[1]; [1]Pennsylvania State University, [2]Bucknell University

Behavioral research shows that adult native English speakers have greater difficulty comprehending passive than active sentences, because in passive sentences the subject does not play the prototypical "agent" role (e.g., Ferreira, 2003). However, less is known about the cognitive and neural mechanisms that underlie the processing of passives, as previous studies have not compared active and passive sentences directly, focusing instead on the processing of semantic and syntactic anomalies within passive constructions (e.g., Kim & Osterhout, 2005; Kuperberg, 2007). In two experiments, we address this gap by comparing ERP responses for active versus passive sentences among college-aged monolingual English speakers in two visual event-related potential (ERP) experiments. We also investigated whether the presence of ungrammatical filler items changes ERP responses to a grammatical—yet less-preferred—structure (i.e.,

passives). In Experiment 1, we presented active and passive sentences alongside ungrammatical filler items, while in Experiment 2, all fillers were grammatical. In Experiment 1, 25 participants read 36 sentences in conditions (1) – (4), along with 72 additional filler items. (1) The man was annoying the lady in the grocery store. (active) (2) The man was annoyed by the lady in the grocery store. (passive) (3) The nurse should confront the friend who lied to her. (grammatical filler) (4) The nurse should confronting the friend who lied to her. (ungrammatical filler). Thus, 20% of all sentences involved passive constructions. Y/N comprehension questions followed one-third of the sentences, with eight passive and eight active questions focusing on thematic-role assignment (e.g., Did the man annoy the lady?). Comprehension accuracy was higher for active than passive sentences (88.0% vs. 73.0%). ERPs timelocked to the thematic verb (e.g., annoying/ annoyed) revealed a frontal positivity in the 500-700 ms time window for passive versus active sentences. This late frontal positivity contrasted with the posterior-distributed P600 effect (500-700ms time window) for ungrammatical versus grammatical fillers, replicating the typical P600 effect obtained in previous research (e.g., Osterhout & Nicol, 1999). In Experiment 2, 22 participants read the same sentences, but ungrammatical filler sentences were replaced with their corresponding grammatical version. Comprehension accuracy was again higher for active than passive sentences (85.8% vs. 78.4%). ERPs revealed a positivity (500-700ms time window) for passive versus active sentences that was strongest in the left hemisphere, and descriptively stronger in frontal versus posterior electrodes. Comparing effect sizes across experiments revealed smaller effect sizes for ERP responses to passive sentences in Experiment 2 versus Experiment 1, and smaller effects sizes for passive sentences in both experiments than ungrammatical fillers in Experiment 1. Together, these results reveal ERP response profiles for passive versus active sentences that are similar in size and distribution to frontal positivities associated with the revision of previous expectations when confronted with unexpected input (e.g., Federmeier, 2007), and that are markedly different from P600 effects traditionally associated with processes of syntactic reanalysis (e.g., Osterhout & Holcomb, 1992). Further, differences across experiments raise important methodological issues regarding the ways in which ERP responses to grammatical sentences are modulated by the experimental design and stimulus list composition.

Language Therapy

A23 Impact of aging and aphasia on incremental sentence production: eye-tracking while speaking

Jiyeon Lee[1], Grace Man[1], Jennifer Frederick[1]; [1]Purdue University

The normal sentence production system opportunistically uses both word- and structure-level information to ease lexico-syntactic integration processes (Bock & Ferreira, 2014). In word-driven production, speakers incrementally plan sentence structures as they speak based on the relative ease of retrieving individual words (e.g., attentional saliency of characters, lexical accessibility). In structure-driven production, in contrast, the availability of a larger relational structure among elements (e.g., verb argument structure) drives speakers' choice of sentence structures. Little systematic research is available on how different types of information accessibility influence syntactic production in individuals with aphasia (IWA). Recent eye-tracking sentence production studies have shown that encoding verb argument structure information before speech onset is facilitative of sentence production in IWA, in line with structure-driven production (Lee & Thompson, 2011a; 2011b; Lee, Yoshida, & Thompson, 2015). However, it remains unknown if the aphasic production system also follows word-driven incremental production. This study examines the effects of attentional (Experiment 1) and lexical priming (Experiment 2) on speakers' choice of alternating sentence structures during off-line (accuracy) and on-line (eyetracking) sentence production. Sixteen young adults, 14 older adults, and 7 IWAs participated in the study so far. In Experiment 1, production of sentences with perspective verbs (e.g., buy/sell) and those with conjoined noun phrases was examined. Attentional saliency of alternating characters in a scene (e.g., agent/ theme) was manipulated by presenting a brief attention capture cue (a red dot, r = 25 pixels) for 100 ms at the position of the primed character before the target picture was presented. In Experiment 2, production of sentences with dative and transitive alternations was examined under lexical priming. The relative ease of lexical retrieval for the critical nouns was manipulated based on the 'givenness' of the nouns in the auditory probe sentence (e.g., what is happening with the man? vs. what is happening with the boy? for the active (the man kicked the boy) vs. passive (the boy was kicked by the man) targets respectively). For off-line production, young and older adults showed significant attentional and lexical priming effects, producing preferred (primed) characters earlier in the sentence more frequently under preferred than non-preferred priming conditions (p's < .01). However, for IWA, only lexical primes ($p < .05$) but not attentional primes successfully modulated aphasic speakers' production of sentence structures. For eye fixation data, all three groups made earlier fixations to the primed than non-primed character in both experiments (p's < .01), suggesting that both attentional and lexical primes were effective in successfully drawing visual attention to different characters, thus activating the primed word earlier than the non-primed word. These findings suggest that older and aphasic speakers have preserved ability to incrementally plan sentences, taking advantage of relative accessibility of lexical items (Slevc, 2011; Gleitman et al., 2007). However, the aphasic production system may not be as radically incremental as the sentence production system in healthy speakers, as evidenced by greater priming effects

with linguistic (lexical in the current study; structural in previous studies) compared to non-linguistic (attentional) cues (cf. Saffran et al., 1980).

Language Disorders

A24 Is the Middle Frontal Gyrus Implicated in Reading?

Maria Stacy[1], Sarah Dyer[1], Michelle Kibby[1]; [1]Southern Illinois University-Carbondale

Objective: Despite recent growth in our understanding of the neurobiological basis of reading, much of this research has focused upon single-word reading, while higher-level reading skills, like reading comprehension, have received less attention. Hence, this study investigated the relationship between middle frontal gyrus volume (MFG) and basic reading skills, like single word reading and reading fluency, and more complex reading skills, like reading comprehension, to ascertain whether volume in this region is equally related to differing aspects of reading ability. This study focused on MFG volume because previous research has indicated that this region is involved in working memory (Narayanan, et al, 2005; Tor & Edward, 2003), and that working memory contributes to both single word reading (decoding) (Messer, Henry & Nash, 2016) and reading comprehension (Cain, Oakhill & Bryant, 2004; Tighe & Schatschneider, 2014). Method: Data were collected as part of larger, NIH funded studies on a community sample (R03 HD048752, R15 HD065627). Children, ages 8 to 12 years, with reading disability (n=19), ADHD (n=42), both disorders (n=20), or typically developing controls (n=28) were administered subtests from the Woodcock-Johnson III including Passage Comprehension (PC), Reading Fluency (RF) and Letter-Word Identification (LWI). In addition, all participants completed a T1 weighted MRI scan using a 1.5T Phillips Intera scanner. Results: Two hierarchical multiple regressions were performed to statistically predict left, then right, middle frontal gyrus volume (MFG), with the three reading measures as predictors. The regression predicting left MFG volume was significant: adjusted R2=.06, $F(3, 102) = 3.21$, $p = .03$. In addition, the regression predicting right MFG volume was significant: adjusted R2= .08, $F(3, 102) = 3.92$, $p = .01$. Passage Comprehension was a significant predictor for both left ($\beta = .22$, $p = .03$) and right ($\beta = .32$, $p = .001$) hemispheres, but Letter Word Identification and Reading Fluency were not ($ps > .10$). Conclusion: Reading comprehension ability predicted bilateral middle frontal gyrus volumes. In contrast, word recognition and reading fluency did not significantly predict either left or right middle frontal gyrus volume. It is logical that a reading comprehension task, which requires more working memory than single word reading, would be a better predictor of middle frontal gyrus volume than basic reading, as the MFG is implicated in cognitive executive functioning, including working memory. However, it is surprising that PC better predicted right hemisphere volume than left hemisphere volume. Traditionally, the left hemisphere has been more closely associated with verbal processing than the right. However, researchers have reported that the kind of working memory task being completed by each hemisphere may affect which hemisphere is more involved. Tsukiura, et al (2001) asserted that while the left hemisphere is more involved in maintenance of information, the right hemisphere is more involved in manipulation of information held in mind. Updating and synthesizing of information is required when comprehending written text, and it may be these aspects of reading that are reflected in the relationship with right MFG volume.

A25 Semantic control does not relate to domain-general components of executive function.

Curtiss Chapman[1], Randi Martin[1]; [1]Rice University

Theories of semantic memory sometimes claim a distinction between stored semantic representations and mechanisms for accessing those representations. For individuals with aphasia, researchers have claimed multi-modal (i.e., both verbal and nonverbal) semantic deficits (i.e., semantic aphasia, SA) arise from damage to the semantic access mechanism, called 'semantic control' (Jefferies & Lambon Ralph, 2006). Supporting this claim are findings showing correlations between semantic and executive function (EF) performance. However, these correlations rely on small samples and use of global executive tasks (e.g., Raven's Progressive Matrices; WCST: Wisconsin Card Sort Task) that prevents determination of which aspect of EF is related to semantic deficits. Our goals were to 1) validate the correlations between semantics and EF by combining data from the published SA literature, 2) to explore which component of EF (updating, shifting, inhibition) is related to semantic access. We identified 20 unique patients from the semantic control literature and examined correlations between semantic and executive measures. Sample sizes varied depending on which patients completed which tasks. To address specific components of EF, we tested a new group of 9 SA patients on semantic tasks and tasks tapping specific aspects of EF. Semantic tasks included: picture and word versions of the Camel and Cactus Test of associative relations; environmental sound–picture matching; auditory word-picture matching with within-category distracters; and picture naming. Executive tasks included: 1) updating (phonological working memory; pWM): digit and word span, N-back, 2) shifting: cued task-set shifting, a trail-making task, 3) inhibition: verbal and non-verbal Stroop, picture-word interference, 4) global: WCST and Raven's. For SA patients from the published literature, the semantic composite correlated significantly ($p < .05$) with Raven's ($r(18)=.44$) and an executive composite (Raven's & WCST; $r(10)=.73$) and marginally with a pWM composite (digit span forward & backward; $r(18)=.40$, $p=.08$). When partialling out the influence of pWM, the executive composite remained predictive of semantics ($r(9)=.68$, $p=.02$), whereas Raven's

did not (r(17)=.38, p=.11). For our 9 SA patients, the semantic composite did not correlate significantly (ps > .58) with the shifting composite (r(7)=-.17), Raven's (r(5)=.15), WCST (r(6)=.15), or an EF composite containing all EF measures (r(5)=.10). (An inhibition composite was not calculated, as inhibition measures were uncorrelated). There was a moderate correlation with the phonological WM composite, (r(6)=.54), which was non-significant (p=.17) with this sample size. Using the published data, we confirmed significant correlations between semantics and performance on global EF tasks. For our new group, we failed to replicate the correlations with global EF and did not find correlations with specific aspects of EF. Some prior case study results suggest that semantic control depends on EF specific to semantics, rather than on domain-general executive abilities (Hoffman et al., 2013). If so, the lack of convergence between the findings from the published literature and ours may result from a greater overlap of domain-general EF deficit with the critical semantic EF deficit in the published cases than in our sample. Future work will address whether a specific semantic EF deficit can be demonstrated in our patients.

A26 Analysis of executive and attentional (dys)function in chronic stroke aphasia

Rahel Schumacher[1], Matthew A. Lambon Ralph[1]; [1]Neuroscience and Aphasia Research Unit, School of Biological Sciences, University of Manchester

There is growing awareness that aphasia following a stroke co-occurs with deficits in other cognitive functions (such as memory, attention and executive functions). Such additional deficits have been shown to influence recovery from aphasia and to affect the potential to profit from therapeutic interventions. Even though it is becoming more common to include measures of cognitive functioning in studies with aphasic patients, these additional measures are often either only at a screening level or tap only one specific aspect (e.g., working memory). To date, no systematic analyses covering a broad spectrum of attentional and executive (dys)functions in patients with aphasia have been completed. We administered a substantial number of computerized as well as paper-and-pencil tests measuring language, attentional and executive functions to our database of more than forty aphasic patients. All the patients had a single stroke and were at least one year post-stroke at the time of testing. The group deliberately covers the full range of severity and types of aphasia. Performance in a simple attentional task, measuring their alertness level, was within normal range in the vast majority of patients. However, a quarter of the patients showed reduced selective attention performance, in a third of the patients distractibility was increased, and nearly half of the patients performed below normal range in a test of divided attention. Furthermore, our analysis yielded deficits in non-verbal tests of executive functioning in thirty to fifty percent of the patients, with some notable dissociations between tests. Correlational analyses with language tests yielded significant associations across domains, for instance between a test of semantic matching and several nonverbal tests of executive functioning. Our results allow a deeper understanding of the interrelation between language and other cognitive functions in stroke patients. We show that a broad assessment of attentional and executive functions by means of widely available standardized neuropsychological tests is not only feasible but also highly informative with respect to potential therapeutic targets and a patient's cognitive resources.

A27 Lexical Selection and Multiword Speech in Acute Stroke

Tatiana Schnur[1], Randi Martin[2]; [1]Baylor College of Medicine, [2]Rice University

Selecting a word for production is generally understood to be competitive, where the word to be produced is selected by comparing its activation to other activated words that are not the intended target (Levelt, Roelofs, & Meyer, 1999). Although some deficits in multiword speech because of stroke are caused by damage to the meanings, phonological representations, and articulation of individual words, we hypothesize that beyond these factors, a deficit in the ability to reduce interference from competing words during selection (decreased selection capacity) causes poorly formed sentences. We predicted that decreased selection capacity should create increased semantically inappropriate word substitutions, omissions, and the omission or substitution of function words (decreased proportion of closed-class words) resulting in grammatically ill-formed sentences (decreased proportion of well-formed sentences). We also predicted decreased selection capacity should correlate with decreases in general measures of discourse productivity (numbers of words per minute and narrative words) under the hypothesis that failures in word selection result in general word-finding difficulties. Methods. As part of an ongoing project, we recruited 74 monolingual English speakers from multiple hospital stroke units in the Houston area who were diagnosed with acute left hemisphere ischemic cerebrovascular accidents. Subjects named 15 high-name agreement (low selection conflict; e.g., FORK) and 15 low-name agreement pictures (high selection conflict; e.g., COINS/MONEY; one item removed due to visual confusability and >50% error; Kan & Thompson-Schill, 2004). We measured selection capacity as the proportion correct naming difference between high- and low-name agreement conditions, where the more positive the NA difference score, the larger the assumed selection deficit. Subjects' narrative production was scored per the Quantitative Production Analysis of the freely recalled Cinderella story (Rochon et al., 2000). Forty-six subjects confirmed with a unilateral left hemisphere stroke and no previous stroke or other neurological disorder completed name agreement and 36 subjects completed narrative story-telling within eight days after stroke (mean= 3 days, range= 1-8 days). Subjects named an additional set of unrelated pictures (n=47), where 12 subjects could only complete 17 items. Results. Consistent with predictions, as NA difference scores

increased, accuracy of picture naming on the unrelated list decreased (r= -.40, p = .01) and the number of semantically related and description errors increased (144 errors; r= .53, p < .001). Subjects produced other error types too infrequently for statistical comparisons. As predicted, as NA difference scores increased, the proportion of well-formed sentences decreased during narrative story telling (r= -.38, p= .02). However, correlations with other QPA measures were not significant (p's > .28). Conclusion. Selection deficits as measured in single word production contribute to semantically related and description picture naming errors and failures to produce grammatically well-formed sentences in spontaneous speech, but not to general discourse measures. This discrepancy may be because general discourse relies more heavily on the ability to generate message-level representations, while our selection task reflects processing at a lexical-grammatical encoding level of language production. We need to further explore the lack of relationship between selection deficit magnitude and production of closed-class words during narrative production.

A28 (Morpho)syntactic production in agrammatic aphasia: Testing three hypotheses within a cross-linguistic approach

Valantis Fyndanis[1,2], Gabriele Miceli[3], Carlo Semenza[4,5], Rita Capasso[6], Paraskevi Christidou[7], Serena de Pellegrin[4], Marialuisa Gandolfi[8], Helen Killmer[1,2], Lambros Messinis[9], Panagiotis Papathanasopoulos[9], Eugenia Panagea[9], Nicola Smania[8], Frank Burchert[2], Isabell Wartenburger[2]; [1]University of Oslo, Norway, [2]University of Potsdam, Germany, [3]University of Trento, Padua, [4]University of Padua, Italy, [5]Fondazione Ospedale San Camillo, Italy, [6]SCA Associates, Italy, [7]Evexia Rehabilitation Center, Greece, [8]University of Verona, Italy, [9]University of Patras, Greece

INTRODUCTION Impaired (morpho)syntactic production is the hallmark of agrammatic aphasia. Several hypotheses have been proposed to account for agrammatic patterns of (morpho)syntactic production. Within a cross-linguistic approach, this study tests three recent hypotheses that have not been tested adequately thus far: Distributed Morphology Hypothesis (DMH) (e.g., Wang, Yoshida, & Thompson, 2014); Tense Underspecification Hypothesis (TUH) (Wenzlaff & Clahsen, 2004, 2005); and Interpretable Features' Impairment Hypothesis (IFIH) (e.g., Fyndanis, Varlokosta, & Tsapkini, 2012). According to the DMH, categories involving inflectional alternations (e.g., Tense, Agreement) are impaired in agrammatic aphasia; moreover, such categories are expected to be similarly affected. The TUH states that what is impaired in agrammatic aphasia is Tense; Agreement and Mood are well-preserved. The IFIH posits that categories involving integration processes (e.g., Tense, Mood, Polarity) are more impaired than categories that do not involve integration processes (e.g., Agreement). Given the inherent properties of these categories and the way they are encoded in the languages of interest here (Greek, Italian, German), the above hypotheses make the following predictions: the DMH expects Agreement, Tense and Mood to be comparably impaired in German and Italian agrammatic aphasia, and Agreement and Tense to be comparably impaired in Greek agrammatic aphasia. The TUH expects Agreement and Mood to be better preserved than Tense in all three languages. According to the IFIH, Agreement should be better preserved than Tense, Mood and Polarity in all three languages. METHODS Nine German-, 10 Italian- and 8 Greek-speaking persons with agrammatic aphasia (PWA), as well as 14 German-, 11 Italian- and 8 Greek-speaking age- and education-matched healthy controls, were administered a sentence completion task tapping subject-verb Agreement and Tense (similar to that employed by Fyndanis et al., 2013), a sentence completion task tapping Mood (based on Wenzlaff & Clahsen, 2005), and an anagram task tapping Polarity (based on Rispens et al., 2001). Individual data were analysed using Fisher's exact test for count data. To analyze data at the group level, mixed-effect models were fitted to the German, Italian and Greek datasets. RESULTS & DISCUSSION In all three languages, the control groups fared significantly better than the three PWA groups. At the individual level, of the 27 PWA, only 4 lend support to the DMH (Wang et al., 2014) and only 5 lend support to the TUH (Wenzlaff & Clahsen, 2004, 2005). None of 27 PWA lends support to the IFIH (Fyndanis et al., 2012). The patterns of performance exhibited by the German, Italian and Greek groups of PWA were Polarity>Mood>Agreement>Tense, Polarity>Agreement/Tense>Mood, and Agreement/Mood>Polarity>Tense, respectively. Therefore, only the Greek group lends support to only one of the three hypotheses tested here: TUH (Wenzlaff & Clahsen, 2004, 2005). Thus, none of the three hypotheses gains cross-linguistic empirical support. The results suggest that a unitary account of agrammatic aphasia is unlikely to succeed. A number of factors such as subject-specific characteristics, language-independent and language-specific properties of (morpho)syntactic categories, and task-specific features of linguistic materials may interact in determining the way in which (morpho)syntactic impairments manifest themselves across PWA and languages. REFERENCES Fyndanis, V., Manouilidou, C., Koufou, E., Karampekios, S., & Tsapakis, E. M. (2013). Agrammatic patterns in Alzheimer's disease: Evidence from tense, agreement, and aspect. Aphasiology, 27, 178–200. Fyndanis, V., Varlokosta, S., & Tsapkini, K. (2012). Agrammatic production: Interpretable features and selective impairment in verb inflection. Lingua, 122, 1134–1147. Rispens, J. E., & Bastiaanse, Y. R. M. (2001). Negation in agrammatism: A cross-linguistic comparison. Journal of Neurolinguistics, 14, 59–83. Wang, H., Yoshida, M., & Thompson, C. K. (2014). Parallel functional category deficits in clauses and nominal phrases: The case of English agrammatism. Journal of Neurolinguistics, 27, 75–102. Wenzlaff, M., & Clahsen, H. (2004). Tense and agreement in German agrammatism. Brain and Language, 89, 57–68.

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A29 Abnormal cortical folding and neurite architecture during brain maturation in children with developmental dyslexia

Eduardo Caverzasi[1,2,7], Maria Luisa Mandelli[1], Christa Watson[1], Marita Meyer[1], Fumiko Hoeft[3], Claudia A Gandini Wheeler-Kingshott[4,5,6], Elysa J Marco[7,8,9], Bruce L Miller[10], Robert Hendren[1], Kevin Shapiro[1], Maria Luisa Gorno-Tempini[1,7]; [1]Dyslexia Center, Department of Neurology, University of California, San Francisco, San Francisco, CA, USA, [2]Biomedical Sciences PhD, Department of Brain and Behavioral Sciences, University of Pavia, Pavia, Italy, [3]Langley Porter Psychiatry Institute Langley Porter Psychiatric Hospital and Clinics, Department of Psychiatry, University of California, San Francisco, CA, USA, [4]Queen Square MS Centre, Department of Neuroinflammation, UCL Institute of Neurology, Russel Square House, London, United Kingdom, [5]Department of Brain and Behavioral Sciences, University of Pavia, Pavia, Italy, [6]Brain MRI 3T Mondino Research Center, C. Mondino National Neurological Institute, Pavia, Italy, [7]Department of Neurology, University of California, San Francisco, San Francisco, CA, USA, [8]Department of Psychiatry, University of California, San Francisco, San Francisco, CA, USA, [9]Department of Pediatrics; University of California, San Francisco, San Francisco, CA, USA, [10]Memory and Aging Center, Department of Neurology; University of California, San Francisco, San Francisco, CA, USA

There is increasing recognition of a relationship between regional variability in cerebral gyrification and differences in cognition and neurodevelopment. Recent neuroimaging data suggests that cortical folding changes are associated with neurodevelopmental disorders such as autism spectrum disorder, attention-deficit hyperactivity disorder, and dyslexia. However, regional patterns of folding are not fixed at birth, and recent work in morphometric MRI has shown that the local gyrification index generally decreases with age in adolescence and young adulthood. Little is known about how these changes in brain maturation interact with neurodevelopmental differences. In this study, we analyzed local gyrification index using Freesurfer in 39 children with developmental dyslexia and 56 typically developing children between the ages of 7 and 15. We also investigated the microstructural changes underlying gyrification differences, specifically the relationship between gyrification and neurite architecture, by using neurite orientation dispersion and density imaging (NODDI), an advanced diffusion MRI model. NODDI provides two key metrics, the neurite density and the orientation dispersion index, which characterize the microstructural organization of dendritic projections and axons. We found significant differences in gyrification between dyslexic and typically developing children in left mid-frontal and left lateral temporal regions. Specifically, children with developmental dyslexia failed to show an age-related decrease in local gyrification index in this region, which was seen (as expected) in typically developing children. This was not explained by differences in cortical thickness, but did correlate with measures of neurite architecture. Our findings suggest that gyrification changes in developmental dyslexia are related to abnormal neurite architecture, likely due to an interaction between genetic factors, experience-dependent plasticity, and pruning.

A30 Distinct spatiotemporal patterns of neuronal functional connectivity in primary progressive aphasia variants

Kamalini Ranasinghe[1], Leighton Hinkley[1], Alexander Beagle[1], Danielle Mizuiri[1], Susanne Honma[1], Ariane Welch[1], Isabel Hubbard[1], Maria Luisa Mandelli[1], Zachary Miller[1], Coleman Garret[1], Alice La[1], Adam Boxer[1], John Houde[1], Bruce Miller[1], Keith Vossel[1], Maria Luisa Gorno-Tempini[1], Srikantan Nagarajan[1]; [1]University of California San Francisco

Primary progressive aphasia (PPA) is a syndrome characterized by progressive loss of language abilities with three main phenotypic clinical presentations, including logopenic (lvPPA), non-fluent/agrammatic (nfvPPA), and semantic (svPPA) variants. Previous imaging studies have shown unique anatomic impacts within language networks in each variant. However, direct measures of spontaneous neuronal activity and functional integrity of these impacted neural networks in PPA are lacking. The aim of this study was to characterize the spatial and temporal patterns of resting state neuronal synchronizations in PPA syndromes. We hypothesized that resting state brain oscillations will show unique deficits within language networks in each variant of PPA. We examined 39 PPA patients including lvPPA (n = 14, age = 61±9), nfvPPA (n = 12, age = 71±8) and svPPA (n = 13, age = 65±7) using magnetoencephalographic imaging, compared to a control group that was matched in age and gender to each PPA subgroup (n = 20, age = 65±5). Each patient underwent a complete clinical evaluation including a comprehensive battery of language tests. We examined the whole-brain resting state functional connectivity as measured by imaginary coherence in each patient group compared to the control cohort, in three frequency oscillation bands—delta-theta (2 - 8 Hz); alpha (8 - 12Hz); and beta (12 - 30Hz). We found that within the left hemisphere, each PPA variant shows a distinct pattern of functional connectivity deficits in alpha and beta frequency oscillations. Specifically, we found significant reductions of neuronal synchrony within the left posterior temporal and occipital cortices in lvPPA patients, within the left inferior frontal cortex in nfvPPA patients, and within the left temporo-parietal junction in svPPA patients. lvPPA patients further showed significant hypersynchrony of delta-theta frequency band within bilateral medial frontal and posterior parietal cortices. Importantly, the

distinct spatiotemporal characteristics of MEGI-derived functional connectivity patterns reliably discriminated PPA variants (linear discriminant function analysis, overall correct classification of 95%). We also found distinct patterns of regional spectral power in each PPA variant. The functional connectivity deficits showed consistently robust effects when corrected for cortical volumes loss. In contrast, the spectral power differences showed partial dependencies on cortical volumes. Collectively, these results demonstrate neural signatures of network specific, regional, neuronal dysfunction in each PPA variant. The unique spatiotemporal patterns of neuronal synchrony in subgroups signify diverse neurophysiological disruptions and pathological underpinnings of the language network in each PPA variant.

A31 The role of executive functions in anaphora resolution in non-fluent variant Primary Progressive Aphasia *Eleni Peristeri[1], Ianthi-Maria Tsimpli[2], Kyrana Tsapkini[3]; [1]Department of English Language and Liguistics, Aristotle University of Thessaloniki, Thessaloniki, Greece, [2]Department of Theoretical and applied linguistics, University of Cambridge, UK, [3]Department of Neurology, Johns Hopkins University, Baltimore, USA*

Syntactic processing theories suggest that executive functions (EF) play a critical role in sentence parsing and comprehension (Novick, etal. 2005). For individuals with Primary Progressive Aphasia (PPA), verbal EF deficits have been claimed to reflect the patients' language deficits. However, findings supporting this claim are still inconclusive (Wicklund etal., 2004). One possible reason for the controversial results is that we may be missing some important EFs that may affect language processing, such as the attentional demands of verbal and non-verbal tasks. The present study examines for the first time the global-local attentional dimension in nfv-PPA patients' performance in sentence parsing. We employed an anaphora choice task that allowed us to isolate effects of global language context as well as local parameters of referential processing. The performance of the same patients in the referential processing task was correlated to their performance on a visual attention task tapping the ability to shift attention from the global to the local level as well as in other EF tasks (e.g., digit span). Data were collected from 8 Greek-speaking patients with nfv-PPA (Mean age: 62;9) along with 8 age-matched healthy controls. The anaphora resolution task was a self-paced picture-selection task during sentence listening, in which participants had to pick an antecedent for an ambiguous subject pronoun that was either a null or an overt pronoun. The candidate antecedents could be either the syntactic subject or the object of the sentence, which was closer to the critical pronoun than the subject. Co-indexing null pronouns to syntactic subjects in null subject languages has been claimed to be subject to global discourse constraints, while linking the overt pronoun to the object requires integration of local discourse cues. Executive abilities were assessed with the global-local task (Navon, 1977). Participants also completed a Digits Backward task to measure their working memory capacity. Given the sample size, correlation analyses were used to examine the relationship between these two EF measures and performance in anaphora resolution. One-way ANOVA analyses showed that for controls, object preference rates were significantly higher when the pronoun was overt ($p=.04$), while subject preference was stronger in null pronoun trials ($p=.05$). This suggests that controls could integrate both global and local discourse constraints during anaphora resolution. On the other hand, PPA patients systematically picked the object across all trials irrespective of whether the pronoun was null or overt ($p<.001$). This finding reflects PPA patients' preference to resolve the pronoun to the closest antecedent, rather than an interpretive preference guided by the form of the pronoun. In controls, subject and object referent rates were correlated with the cost (in RTs) they have experienced when switching attention from the global to the local level and vice versa, in the global-local task ($r=.75$), while PPA patients' object referent rates were negatively correlated with their performance in the Digits Backward task ($r=-.90$). Taken together, PPA patients' preference for the object referent may be attributed to working memory limitations, rather than to global and local attention parameters that regulated controls' referential preferences.

A32 A quick bedside language assessment *Sarah M. Schneck[1], Dana K. Eriksson[2], Jillian Lucanie[1], Stephen M. Wilson[1]; [1]Vanderbilt University Medical Center, [2]University of Arizona*

In this presentation, we describe a new aphasia battery: the Quick Bedside Language Assessment (QBLA), which aims to evaluate language function in adults with acquired aphasia as comprehensively as possible in about a quarter of an hour. The QBLA is intended to fill a gap between existing comprehensive batteries and rapid screening instruments, and to optimize assessment of aphasia in the many clinical and research contexts in which time is limited for one reason or another. Moreover, it has multiple forms for repeated administrations, requires no props, and is freely available to clinicians and researchers. The battery is comprised of eight subtests: Level of consciousness, Connected speech, Word comprehension, Sentence comprehension, Picture naming, Repetition, Reading aloud, and Motor speech. Each subtest contains between 5 and 12 items. To maximize the informativeness of each item, items were carefully chosen to span a wide difficulty range, so that mild as well as severe deficits can be quantified effectively, and a graded scoring system and set of error codes were developed so that information can be gleaned from responses that are neither completely correct nor completely incorrect. After completion of the eight subtests, nine summary measures are derived: Word comprehension, Sentence comprehension, Word

finding, Grammatical construction, Selection and encoding, Speech motor programming, Repetition, Reading, and Overall. Together these yield a multidimensional profile of an individual's strengths and weaknesses across core language domains. To obtain reference data, the QBLA was administered to 28 individuals with acute stroke and aphasia, 25 individuals with acute stroke but no aphasia, 16 individuals with chronic post-stroke aphasia, and 14 healthy controls. The 16 individuals with chronic post-stroke aphasia were tested 3 times each and scored independently by 2 raters to establish inter-rater reliability and test-retest reliability. The Western Aphasia Battery (WAB) was also administered to these patients to assess concurrent validity. The inter-rater reliability of all nine summary measures was excellent, with intraclass correlation coefficients (ICC) ranging from 0.81 to 0.99 (0.99 for the Overall summary measure). Test-retest reliability was good to excellent over the nine measures (0.72 to 0.98; 0.97 for the Overall summary measure), and can be increased by stacking multiple forms for individual subsections when needed. With respect to clinical impression of aphasia, the sensitivity of the QBLA was 0.91 and the specificity was 0.95. Seven of the nine summary measures have related measures on the WAB, and correlations between QBLA and WAB measures ranged from 0.79 to 0.95, demonstrating strong concurrent validity. The specific profiles of summary measures were studied in the 16 individuals with chronic aphasia and were found to effectively capture clinical impressions. In sum, despite taking less than a quarter of an hour to administer to the majority of patients, the QBLA is a reliable and valid aphasia battery that is capable of characterizing spared and impaired language functions across multiple domains. It promises to be a useful tool for clinical and research applications.

A33 White matter matters in the recovery of language in post-stroke aphasia

Erin Meier[1], Jeffrey Johnson[1], Yansong Geng[1], Swathi Kiran[1]; [1]Boston University, Sargent College of Health and Rehabilitation Sciences

Research has shown that lesion volume is a significant predictor of language outcomes in persons with aphasia (PWA) (e.g., Lazar et al., 2008). However, recent evidence suggests that lesion site, and in particular, the integrity of white matter (WM) in specific regions of interest (ROIs) is a better indicator of language skills like fluency and semantics (Basilakos et al., 2014; Pani et al., 2016). However, the impact of damage to left hemisphere (LH) WM regions and the potential compensation by right hemisphere (RH) homologues has not been explored in the context of naming abilities in PWA. Therefore, this study addressed two research questions (RQs): (1) To what extent does integrity of LH WM regions differ from RH regions? (2) What is the relationship between the integrity of bilateral WM ROIs and language skills? Fifteen PWA (9M, mean age=61.7 years) underwent a high-resolution, whole-brain DTI scan. Regions implicated in semantic and phonological stages of naming (Indefrey & Levelt, 2004) were selected as ROIs from the Harvard-Oxford atlas, including superior and middle frontal gyri (SFG, MFG); inferior frontal gyrus pars triangularis (IFGtri) and opercularis (IFGop); anterior and posterior middle temporal gyri (aMTG, pMTG), anterior and posterior superior marginal gyri (aSMG, pSMG), and angular gyrus (AG). An FA template thresholded at .20 was superimposed over the aforementioned bilateral cortical ROIs to ensure the extraction of WM only. Fractional anisotropy (FA) in these ROIs was extracted from patient data. To address RQ1, a one-way MANOVA was used to determine if the integrity of LH WM ROIs differed from their RH homologues. For RQ2, linear regression models were conducted, predicting aphasia severity or naming skills from FA, while controlling for lesion volume. Only homologous regions that significantly differed in FA per RQ1 were analyzed in RQ2. For RQ1, the main effect of hemisphere approached significance ($F=2.51$, $p=.056$). The univariate results revealed that FA was significantly higher in specific RH versus LH ROIs, including MFG ($p=.016$), IFGtri ($p=.001$), IFGop ($p<.001$), pMTG ($p=.005$), pSMG ($p=.004$), and AG ($p=.018$). For RQ2, when controlling for LH lesion volume, FA in LH regions did not significantly predict aphasia severity ($F=2.187$, $p=.234$) or naming skills ($F=2.73$, $p=.174$). However, the model predicting aphasia severity from FA in RH ROIs approached significance ($F=3.728$, $p=.065$). RH FA values significantly predicted naming skills ($F=5.67$, $p=.025$) and lesion volume was a significant factor in this relationship ($t=-3.792$, $p=.009$). Univariate results demonstrated different effects by ROI: PWA with greater FA in RIFGtri ($t=2.843$, $p=.029$) and RIFGop ($t=2.653$, $p=.038$) had better naming abilities while PWA with greater FA in RMFG ($t=-2.051$, $p=.086$) and RAG ($t=-2.214$, $p=.069$) trended towards poorer naming skills. As expected, FA in the undamaged RH was significantly greater than the LH in several WM ROIs central to language processing in general and naming specifically. Heightened RH FA appeared to be beneficial for naming in certain ROIs but maladaptive in others. These findings expand upon theories regarding potential compensation of specific RH regions in the neural reorganization of language in post-stroke aphasia.

A34 White Matter Connectivity and Lexical Access in Aphasia

William Hula[1,2], Juan Fernandez-Miranda[3], David Fernandes-Cabral[3], Michelle Gravier[1], Michael Walsh Dickey[1,2], Fang-Cheng Yeh[3], Sandip Panesar[3], Vijay Rowthu[3], Sudhir Pathak[2], Patrick Doyle[1,2]; [1]VA Pittsburgh Healthcare System, [2]University of Pittsburgh, [3]University of Pittsburgh Medical Center

INTRODUCTION: Neurolinguistic models have coalesced around the view that two distinct pathways support different kinds of processing (Hickok & Poeppel ,2004; Saur et al., 2008): A ventral stream (VS) maps sound to meaning, while a dorsal stream (DS) maps sound to articulation. Dell, Schwartz, Nozari, Faseyitan, & Coslett (2013) found correspondences between this framework and

the interactive two-step model of lexical access (Foygel & Dell, 2000) such that integrity of VS cortical areas predicted the semantic (s) connection weight parameter and DS areas predicted phonological (p) weight. However, there is evidence that the arcuate fascicle (AF), a major component of the DS, also contributes to semantic processing (Glasser & Rilling, 2008; Fernandez-Miranda et al., 2014). We present updated results from an ongoing study (Hula Fernandez-Miranda, et al., 2014) applying High Definition Fiber Tractography (Fernandez-Miranda, Pathak, Engh, et al., 2012) to investigate white matter correlates of word production in aphasia. We hypothesize that both left DS and VS connectivity predict s-weight, while only the former predicts p-weight. METHOD: Thirty-three participants with aphasia of at least six months post-onset due to unilateral left hemisphere stroke were given the Philadelphia Naming Test (mean %correct = 64, sd = 23). Error-type counts were used to estimate the s-weight and p-weight weight parameters of the two-step model. Diffusion spectrum imaging data were reconstructed by generalized q-sampling (Yeh, Wedeen, & Tseng, 2010). Orientation distribution functions (directional probability of diffusion) were used to calculate quantitative anisotropy (QA) values for each tract using whole-brain seeding and defined ROIs for each tract. We estimated two regression models using Bayesian methods with s-weight and p-weight as dependent variables and QA values for the left VS (VSQA; inferior fronto-occipital fascicle, uncinate fascicle) and DS (DSQA; AF, superior longitudinal fascicle) as predictors. RESULTS: Markov chain Monte Carlo convergence and model fit were acceptable. VSQA and DSQA were not significantly correlated (r = 0.083, 95%CI: -0.25, 0.39). VSQA and DSQA were both significant positive predictors of s-weight (both ps < 0.02; VSQA beta = 0.39, 95%CI: 0.09, 0.62; DSQA beta = 0.44, 95%CI: 0.11, 0.67; multiple r-squared = 0.35, 95%CI: 0.132 0.56) Only VSQA was a significant predictor of p-weight (p = 0.026; VSQA beta = 0.38, 95%CI: 0.05, 0.61; r-squared = 0.14, 95%CI = 0.004, 0.37). DISCUSSION: As predicted, we found significant relationships between VS and DS white matter connectivity and semantic word production ability in aphasia, consistent with involvement of the AF in semantic processing (Glasser & Rilling, 2008; Fernandez-Miranda et al., 2014). Contrary our hypothesis, we found that only VS connectivity predicted phonological ability. One potential explanation is related to prior reports that recruitment of perilesional cortex may be associated with better recovery (Saur, Lange, et al, 2006; Szaflarski, Allendorfer, et al., 2013). It is possible that in this sample of persons with chronic aphasia who have recovered to varying degrees, neuroplastic recruitment of perilesional areas that include cortical terminations of the ventral stream may be associated with increased connectivity of these tracts and better phonological function.

Language Therapy

A35 Increased connectivity with right hemisphere homologues of language areas following melody-based intervention in a patient with aphasia

Tali Bitan[1,2], Cristina Saverino[3], Tijana Simic[2,3,4], Cheryl Jones[2], Joanna Glazer[3], Brenda Colella[3], Catherine Wiseman-Hakes[3], Robin Green[2,3], Elizabeth Rochon[2,3,4]; [1]University of Haifa, Israel, [2]University of Toronto, Canada, [3]Toronto Rehabilitation Institute, Canada, [4]Canadian Partnership for Stroke Recovery, Heart and Stroke Foundation, Canada

The role of the right hemisphere (RH) in compensating for left hemisphere (LH) damage during language processing in patients with aphasia has been called into question lately. Although melody-based treatments, assumed to rely on the preserved musical abilities of the RH were shown to be effective [1], there are still open questions regarding the role of the RH in this outcome. While structural imaging studies show changes in white-matter volume and connectivity in right frontal areas [2, 3], functional imaging studies, measuring treatment-related changes in local activation are less consistent [4, 5]. The current study measured changes in resting state functional connectivity following melody-based intervention, to identify lateralization of treatment-related changes. A 50 year-old female, with extensive left fronto-temporal damage following two temporally proximal events of moderate-severe traumatic brain injury (TBI), was examined 3.2 years after her injury. Her language assessment showed moderate-severe non-fluent aphasia with severe naming impairment, moderate comprehension deficits, and mild impairments in all other cognitive domains. She received 45 sessions of melody-based intervention, 30 min each, which included intoned repetition or completion of phrases and left-hand tapping. Treatment lasted for 15 weeks, and performance on treated and untreated phrases was tested pre- and post-treatment, and 8-weeks following the end of treatment. Resting state fMRI data were collected at three time points: T1- baseline, T2-immediately before treatment and T3-immediately after treatment. A case-matched control TBI patient was also scanned at the same intervals. Behavioral results show improvement on repetition of long treated phrases, but not untreated phrases. However, sentence completion and answering question probes improved for both treated and untreated phrases and was maintained during follow-up. Resting state connectivity was measured between areas associated with speech motor control (bilateral supplementary motor area-SMA, precentral gyri and insulae) and frontal language areas associated with production (bilateral inferior frontal gyri-IFG opercularis, triangularis and orbitalis). Changes during the treatment interval (T3-T2) were compared to changes during the baseline interval (T2-T1) for each patient separately. The treated patient showed a greater increase in connectivity between bilateral SMA and RH language areas (R.SMA-R.IFG triangularis; L.SMA-R.

IFG opercularis) during the treatment period, compared to the baseline interval. LH language areas showed only decreases in connectivity during treatment. Furthermore, connectivity changes in the control patient occurred only for LH language areas. This study is the first to show changes in functional connectivity following melody-based treatment. The results support a compensatory role for RH language areas following melody-based intervention. The emphasis on musical elements, and the left hand tapping, which typically recruit the RH, may have strengthened the connections between RH language areas and speech motor control areas necessary for language production. 1. van der Meulen, I., et al., Archives of Physical Medicine and Rehabilitation, 2012. 93: p. S46-S52. 2. Wan, C.Y., et al. Brain and Language, 2014. 136: p. 1-7. 3. Zipse, L., et al. Neurosciences and Music Iv: Learning and Memory, 2012. 1252: p. 237-245. 4. Schlaug, G., et al. Music Perception, 2008. 25: p. 315-323. 5. Jungblut, M., et al. Neural Plasticity, 2014.

Meaning: Lexical Semantics

A36 The mental lexicon across the lifespan: Word associations from L1 and L2 speakers of Norwegian with and without dementia

Pernille Hansen[1], Ingeborg Sophie Ribu[1], Malene Bøyum[1]; [1]University of Oslo

Results from word association tasks may shed light on theories on the mental lexicon, on integration of L2 items into the lexicon, on changes in lexical access due to ageing and age-related cognitive decline, and on the influence of specific variables on lexical access. The current study touches on all of these aspects by investigating word associations in Norwegian from 213 participants across five groups: Young neurologically healthy L1 speakers of Norwegian (aged 20-30, n=122), elderly neurologically healthy L1 speakers of Norwegian (over 60 years old, n=51), elderly neurologically healthy L2 speakers of Norwegian (n=20), elderly L1 speakers of Norwegian diagnosed with dementia (n=10) and elderly L2 speakers of Norwegian diagnosed with dementia (10). A word association test with 100 cue words was developed, based on the methodology of Fitzpatrick et al. (2015). The cue words were nouns, verbs and adjectives randomly selected from the 2 k and 3 k bands of the NoWaC (Guevara, 2010), in order to control for the impact of word class and frequency. This list was administered on paper to the two cohorts of neurologically healthy L1 speakers of Norwegian, who were instructed to write the first word that came to mind for each of them. A short version of the test with 30 cue words was created based on the response patterns among these two groups, and administered both orally and on paper to the L2 speakers of Norwegian and the two groups of participants diagnosed with dementia. Response patterns were analysed within and across the five participant groups. Comparisons of the word associations show clear group differences both in the response frequency lists, and in the response category patterns. Differences were found between the two cohorts of neurologically healthy L1 speakers, as well as between the neurologically healthy elderly speakers and the participants diagnosed with dementia. Whereas the younger speakers mostly responded with single words, multi-word responses and blank responses were common across all four groups of elderly speakers. Responses were given on all levels of representation (i.e. related to meaning, position, and form), and there was much individual variation in the responses. These findings support a non-modular view of language, where linguistic knowledge is organised in a network. The findings also support the role of experience in usage-based theory. Further, significant differences were found between noun cues and verb cues, supporting the fundamental difference between nouns and verbs that is postulated in cognitive grammar. The results support previous findings of difficulties in the retrieval of and production of words as a result of age and age-related cognitive decline. References: Fitzpatrick, Playfoot, Wray & Wright (2015). Establishing the reliability of word association data for investigating individual and group differences. Applied Linguistics 36:1, 23-50. Guevara (2010). "NoWaC: a large web-based corpus for Norwegian". Proceedings for the NAACL HLT 2010 Sixth Web as Corpus Workshop. Association for Computational Linguistics, 1-7.

A37 No evidence for semantic predictions? Inability to decode predictable semantic categories from EEG during silent pauses in spoken language

Edvard Heikel[1], Jona Sassenhagen[1], Christian J. Fiebach[1]; [1]Goethe University Frankfurt

Predictive coding has rapidly become a prevailing theory of neuronal processing. It proposes that the brain continuously predicts incoming sensory information in a probabilistic, Bayesian-like manner, based on mental models of the external (and internal) sources of sensory information. These predictions are utilized to minimize information processing requirements by 'explaining away' predictable input, which is highly compatible with the assumption of incremental parsing. If sensory input is incompatible with these internally generated predictions, a prediction error signal is generated to update these models thereby optimizing their predictions. Recently theories of language processing have made steps towards incorporating predictive coding into their frameworks. However, while many neural correlates of language processing seem to be plausibly associated with the prediction error (such as, e.g., the N400 component of the ERP), the neural signatures of linguistic predictions themselves have so far remained elusive. One plausible approach to identifying neural correlates of top-down predictions during perception is to abolish bottom-up sensory information, for example through omissions or the occlusion of sensory stimuli. In a strict interpretation of predictive coding, the resulting prediction error should in this situation represent the prediction – which should

thus be decodable from the neural prediction error signal. We aimed to investigate the neurophysiological realization of linguistic predictions during the perception of spoken sentences, by using EEG and multivariate pattern analysis (MVPA) to decode the semantic category of a predictable word from brain activity during a 1 second pause preceding the word itself.. If predictive coding operates in speech processing, we should be able to decode above chance the upcoming word's semantic category during the brief period of silence preceding the actual perception of the word. In a first study (N=39), pauses were inserted prior to target words occuring in sentence contexts that were constraining towards (and therefore, allowing prediction of) either an animate or an inanimate noun. In the second study (N=39), the predictable target words were either abstract or concrete nouns. The constraining (prediction licensing) nature of the sentences was verified on the basis of cloze ratings. Analysing EEG activity during the pre-target word pause with a multitude of MVPA approaches (Generalization Across Time – King & Dehaene, 2014; XDAWN – Rivet et al, 2009; Common Spatial Patterns – Zoltan et al, 1991) and machine learning algoritms, we found no evidence for above-chance decoding, neither for animacy nor for concreteness (all $p > .05$; accuracies ~50%). Experiment 2 was designed after obtaining the null-result in Experiment 1, with the hypothesis that concreteness entails a clearer difference in neurophysiological response than animacy, and thus should increase the chances of decoding linguistic expectations prior to word onset. We conclude that either 1. our manipulation was insufficiently strong to induce a semantic category-level prediction, 2. there was such a prediction maintained by the subjects, but (at least our) EEG data does not contain enough information to decode this prediction, or 3. at least some aspects of language processing are not captured by the predictive coding framework.

A38 Investigating the Behavioral and Physiological Effects of Acute Exercise on Novel Word Learning in Older Adults: Feasibility and Preliminary Data

Amy D. Rodriguez[1], Kyle Hortman[1,2], Jeffrey H. Boatright[1,2], Monica Coulter[1], Joe R. Nocera[1,2], Kevin Mammino[1], Susan Murphy[1,2], Paul Weiss[1,2], Bruce A. Crosson[1,2,3]; [1]VA RR&D Center for Visual and Neurocognitive Rehabilitation, [2]Emory University, [3]Georgia State University

Physical exercise is a potent modulator of cognition that may improve learning. Studies have demonstrated that acute bouts of exercise can enhance immediate and long-term retention of new words in healthy young and older adults (Rodriguez, in prep; Salias, 2013; Schmidt-Kassow et al., 2013; Winter et al., 2007), suggesting an effect on acquisition and/or consolidation. However, task-related differences across learning paradigms exist, and the underlying mechanisms of effect remain unclear. To identify an optimal learning paradigm and better understand the physiological effects of acute exercise in older adults, we are: 1) comparing Study Only (SO) vs. Retrieval Practice (RP) learning paradigms; 2) examining changes in serum brain derived neurotrophic factor (BDNF); and 3) exploring the relationship between novel word learning and BDNF levels. In a 2x2 within-subjects cross-over design, healthy older adults (65-89 y/o) undergo cognitive and physical function assessments and four conditions each comprising three sessions of training [30 minutes of moderate-intensity cycling or gentle stretching (control)] followed by a learning task [15 familiar object-novel word pairs presented in an SO or RP paradigm]. Word recall and recognition testing is conducted immediately after each learning task (three acquisition testing points) as well as before training in sessions 2 and 3 and one week after session 3 (three consolidation testing points). At sessions 1 and 3, four blood draws are taken: immediately before training (baseline), immediately after training, immediately after learning and 15 minutes after learning. Feasibility: Nine participants have been enrolled. Two have withdrawn (22% attrition), three are in progress, and four (3F, 1M; 67-87 y/o) have completed the study. Barriers to recruitment/retention are exclusionary medications, discomfort with exercise and multiple blood draws. No adverse events have been reported. Behavioral data: Raw score accuracy for word recall and recognition was averaged across participants and analyzed descriptively. In the SO condition, accuracy was higher after exercise than stretching for word recall [difference scores= 1, 3.25 and 2 words (immediate); .75, 1.5, and 2.5 words (consolidation)] and for word recognition [difference scores= 1.5, 2 and 1 words (immediate); 2.25, 2.5, and 1 words (consolidation)]. In the RP condition, word recall and recognition accuracy was higher after exercise than stretching at all but the first consolidation testing point; however, the range of difference scores (.33- 1.33 words) was smaller than in the SO condition. Physiological data: Serum BDNF levels (pg/mL) were averaged across participants at the four time points and analyzed descriptively. A similar pattern was observed for exercise and stretching, with BDNF levels increasing from baseline to immediately after training and remaining above baseline 15 minutes after word learning. Preliminary data are not sufficient for describing the relationship between word learning and BDNF levels. Our approach to investigating the behavioral and physiological effects of acute exercise on novel word learning in older adults appears feasible. Preliminary findings are at least partially consistent with previous research suggesting that: 1) exercise may improve acquisition and/or consolidation of new words; and 2) serum BDNF levels increase with exercise. Data collection is ongoing.

A39 Semantic similarity effect for written words in left perirhinal cortex: influence of type of property retrieved, visual versus nonvisual

Antonietta Gabriella Liuzzi[1], Patrick Dupont[1], Ronald Peeters[2], Simon De Deyne[3], Gerrit

Storms[3], Rik Vandenberghe[1,4]; [1]Laboratory for Cognitive Neurology, Department of Neurosciences, KU Leuven, Belgium, [2]Radiology Department, University Hospitals Leuven, 3000 Leuven, Belgium., [3]Laboratory of Experimental Psychology, Humanities and Social Sciences Group, KU Leuven, Belgium, [4]Neurology Department, University Hospitals Leuven, 3000 Leuven, Belgium

INTRODUCTION: An increasing number of studies have demonstrated that left perirhinal activity patterns code for semantic similarity between concrete written words. Here we examine how these effects are influenced by the type of property retrieved, visual versus nonvisual, and by the input-modality, picture versus written word. METHODS: An event-related fMRI study was run on a Philips Achieva dstream 3T equipped with a 32-channel head coil in 18 subjects. Twelve animate (mammals, birds, insects) and 12 inanimate entities (kitchen tools, clothes, music instruments) (De Deyne et al.,2008) were presented as either a written word or a picture. From the concept-feature matrix 52 properties were evaluated online by 11 healthy volunteers who judged on a 1-7 rating scale the degree to which each property was visual or nonvisual. Four visual and 4 nonvisual properties for each subcategory were selected. From the word association matrix (De Deyne et al.,2016), the pairwise semantic cosine similarity was calculated for each pair of items (semantic matrix). During fMRI, subjects performed a property verification task. fMRI data were modelled using a General Linear Model (GLM). By calculating the pairwise cosine similarity between every pair of trials, 10 fMRI matrices in perirhinal cortex were generated: for written words, pictures, written words and pictures pooled, crossmodal effect, visual properties, nonvisual properties, visual properties for written words, nonvisual properties for written words, visual properties for pictures, nonvisual properties for pictures. A representational similarity analysis between the semantic matrix and each fMRI matrix was conducted by using one-tailed statistical threshold of $P < 0.05$. RESULTS: A 3-way repeated measures ANOVA with reaction times as outcome showed a main effect of input-modality (written words: 1.7s pictures: 1.63s) ($F(1,15)=31.9$ $p=.000$) and property (non-visual: 1.69s; visual: 1.63s) ($F(1,15)=17.60$ $p=.001$). The accuracy of responses was 70.8%. The correlation between semantic similarity and the similarity of activity patterns in left perirhinal cortex was significant for written words (Pearson correlation (r) = 0.15 p=0.0086), written words and pictures pooled (r=0.20 p=0.001), for crossmodal word-picture pairs (r=0.20 p=0.0002) and for the retrieval of visual properties for written words (r=0.14 p=0.013) but not for nonvisual properties (r = -0.03 p = 0.7) and neither for visual or nonvisual properties of pictures (r= -0.0058 p =0.52, r = 0.07 p = 0.13). CONCLUSION: The effect of type of property and input-modality leads us to hypothesize that left perirhinal cortex mediates mnemonic retrieval of properties of referents of concrete written words.

A40 Lexical access in inferential naming

Raphael Fargier[1], Giulia Krethlow[1], Eric Ménétré[1], Marina Laganaro[1]; [1]Faculty of Psychology and Educational Sciences, University of Geneva, Geneva, Switzerland

The neural dynamics of speech planning processes have been mainly investigated with picture naming. Although it has been useful to test various properties of language production, it might not be the best option to study semantic retrieval since early processes of conceptual preparation are constrained by visual properties of objects. In a recent study, we sought to shed a light on this issue by comparing the dynamics of neural processes underlying referential (picture) naming and inferential naming (naming from definition). We revealed that word-form encoding was underpinned by similar neural processes in both tasks but that early lexical-semantic processes were different (Fargier & Laganaro, 2017). Inferential naming thus offers promising perspectives to study language production and lexical-semantic retrieval but the underlying neural processes need to be further detailed. In the present study, we used a psycholinguistic variable that has been taken to reflect the onset of lexical selection in picture naming: lexical frequency. Strijkers et al. (2010) notably reported lexical frequency effects on the P2 component arising around 200 ms after picture onset on posterior sites. Here, high-density electroencephalograms (EEG) were recorded while participants overtly produced low-frequency vs. high-frequency words in response to oral definitions. A significant effect was found on production latencies with faster responses for high-frequency words (823 ms) compared to low-frequency words (856 ms). Significant modulations of waveform amplitudes were observed on stimulus-aligned epochs, around 300 ms, on centro-posterior and anterior sites. These effects corresponded to a right posterior positivity. No effects were found on response-aligned epochs. These results confirm our previous observation of lexical frequency effects around 300 ms in naming from written definitions (Fargier & Laganaro, 2017) although they were found when lexical frequency was used as a continuous variable and definitions were presented visually. Our results thus suggest that lexical selection is engaged around 300 ms in inferential naming, which is later than what is observed in picture naming. This favors the idea that inferential naming requires deeper managing of the semantic network to extract the correct name, which is probably mediated by integration processes that not necessary in referential naming. References Fargier R, Laganaro M. 2017. Spatio-temporal Dynamics of Referential and Inferential Naming: Different Brain and Cognitive Operations to Lexical Selection. Brain Topogr. 30:182–197. Strijkers K, Costa A, Thierry G. 2010. Tracking lexical access in speech production: electrophysiological correlates of word frequency and cognate effects. Cereb Cortex N Y N 1991. 20:912–928.

A41 Furry hippos & scaly sharks: blind individuals' knowledge of animal appearance

Judy Sein Kim[1], Giulia Elli[1], Marina Bedny[1]; [1]Johns Hopkins University

We learn about the world through many channels, including observing with our eyes and hearing linguistic descriptions. For example, we might learn about giraffes by seeing them or hearing people talk about them. Studying the concepts of blind individuals provides insight into the role of vision in knowing what we know. Previous studies suggest that blind individuals have surprisingly rich knowledge about categories which at first glance seem 'visual', such as verbs of perception (e.g., look and see) and colors (Landau & Gleitman, 1985; Shepard & Cooper, 1992). One hypothesis is that such information is gained through language. Are there types of knowledge that are uniquely or preferentially acquired through vision? To investigate this question, we tested blind people's knowledge about animals. Prior neuropsychological and imaging work suggests that visual information may be particularly important for the category of living things (Martin & Caramazza, 2003; Warrington & Shallice, 1984; Farah et al., 1989). 20 congenitally blind and 20 matched sighted control participants made judgments about the physical properties of common animals. For shape, texture, and color, participants sorted animals into groups based on each dimension separately (n=30 animals, Braille or print). Similarity matrices were generated for each sorting rule and participant. For shape, participants additionally performed an odd-one-out task with triplets of animals. For texture, participants judged whether each animal had feathers, scales, skin, or fur (n=33 animals). Finally, participants performed a rank-ordering task with 15 animals based on their size and height. As controls, participants sorted objects based on where they are stored and animals based on where they live. Similarity matrices from objects and animal habitat sortings were indistinguishable across groups (sighted-subject-to-sighted-group (S-S) correlations vs. blind-subject-to-sighted-group (B-S) correlations, t-tests over rho's: $p>0.3$). For shape, despite significantly correlated group average matrices (rho=0.83, $p<0.0001$), blind participants made less distinctions in the sorting (S-S vs. B-S correlations, $t(37)=1.71$, $p=0.09$) and triplets tasks (blind vs. sighted accuracy: $t(37)=6.06$, $p<0.0001$). With texture, group differences were even more pronounced both for sorting (S-S vs. B-S, $t(36)=4.16$, $p=0.0002$) and feature choice tasks (e.g., 42% of blind chose fur for hippo). Blind individuals tended to rely on taxonomy for shape and texture. For color, blind participants' ratings were entirely uncorrelated with the sighted (group matrices correlation: rho=0.34, $p=0.25$; S-S vs. B-S, $t(37)=11.66$, $p<0.0001$). Unlike shape and texture, color may not be well predicted by taxonomy. When ordering animals based on their size or height, blind participants were less reliable in fine-grained size distinctions. Notably, a few blind individuals' answers came close to those of the average sighted in all tasks except color. We find that unlike some other types of visual information, knowledge about the appearance of animals is different in blindness, and certain features are more affected than others. These results suggest that some knowledge about physical attributes are learned predominantly through vision and are not captured in linguistic communication. One possibility is that language is less able to capture continuous as opposed to categorical information (Pinker 2007).

A42 Context and prediction in spoken word recognition: Early left frontotemporal effects of lexical uncertainty and semantic constraint

Anastasia Klimovich-Smith[1], Barry Devereux[1], Billi Randall[1], William Marslen-Wilson[1], Lorraine K. Tyler[1]; [1]University of Cambridge

Processing spoken words in isolation evokes the activation of multiple word candidates consistent with the early sensory input. Competition between these continues until only one candidate is consistent with the bottom-up auditory input (uniqueness point UP), at which point the word is recognised (Marslen-Wilson & Welsh, 1978; Marslen-Wilson, 1987). Recent research shows that these processes of activation and competition involve multiple, primarily left lateralised, regions in inferior frontal, temporal and parietal cortex (Kocagoncu et al., 2016), and confirms the importance of the UP in marking a shift from competitive processes to identification of the unique target word. In everyday speech, however, words are rarely heard and processed without a prior semantic and syntactic context. While many studies have shown that the presence of a constraining context facilitates word recognition, the neuro-computational mechanisms underlying these effects are not clear, and models differ in the claims they make about the influence of contextual constraints. Some models claim prior constraints do not directly affect the upcoming speech (Marslen-Wilson,1987), whereas others (Friston & Frith, 2015) claim that a prior context generates contextually constrained predictions about the properties of upcoming words, thus reducing uncertainty about the incoming bottom-up input. In the present study, using a combination of EMEG and Representational Similarity analysis (RSA), we were able to decode specific predictions generated by the semantic context, and their spatiotemporal neural coordinates. Participants listened to two-word English phrases ('yellow banana'; 'peeled banana') that varied in the degree of semantic constraint that the first word exerted on the second. In a pre-test we obtained gating responses from participants who produced guesses about word 2 (W2) after only hearing word 1 (W1). We used a corpus-based Distributional Memory (DM) database (Baroni and Lenci, 2010) to derive two computational models capturing different properties of the gating responses. One model, Lexical Competition, captured the degree of uncertainty about the lexical identity of W2 on the basis of the word candidates generated by hearing W1. The second model, Semantic Blend, captured the semantic content

of participant guesses. We derived Representational Dissimilarity Matrices (RDMs) from each model and tested these using the source-localised activity estimates and multivariate RSA to determine which areas within an extended bilateral fronto-temporo-parietal language network encoded these aspects of the processing of the two-word phrases. We found a strikingly early effect of Lexical Competition in LBA45 which started -50ms before W1 offset and persisted for 10 ms into W2, with a later effect at 75 to 90 ms. Semantic Blend effects, encoding semantically-constrained predictions, emerged in LMTG later (100 to 160 ms after W2 onset) and just before the UP of W2. These results suggest that listeners are sensitive to the overall lexical uncertainty of upcoming words in advance of hearing any sensory input (early BA45 effects), while the semantic properties of contextual constraints only become computationally relevant once minimal sensory input associated with W2 has been heard (later MTG effects).

A43 Dissociating the roles of ventral versus dorsal pathways in language production: an awake language mapping study

Stephanie Ries[1], Vitoria Piai[2,3], David Perry[4], Sandon Griffin[5], Kesshi Jordan[6,7], Robert Knight[5], Mitchel Berger[4]; [1]School of Speech, Language, and Hearing Sciences & Center for Clinical and Cognitive Neuroscience, San Diego State University, San Diego, CA, USA., [2]Donders Centre for Cognition, Radboud University, Nijmegen, The Netherlands., [3]Department of Medical Psychology, Radboud University Medical Centre, Nijmegen, The Netherlands., [4]Department of Neurological Surgery, University of California, San Francisco, CA, USA., [5]Helen Wills Neuroscience Institute and Department of Psychology, University of California at Berkeley, Berkeley, CA, USA., [6]Department of Neurology, University California, San Francisco, CA, USA., [7]UC Berkeley - UCSF Graduate Program in Bioengineering, San Francisco, CA, USA.

The neural basis for human language is thought to be organized along two main processing streams connecting the posterior temporal cortex to the inferior frontal cortex in the left hemisphere: one travelling dorsal, and the other travelling ventral to the Sylvian fissure. The roles of these two streams have been subject to debate. Some views propose a perception/production division (Hickok & Poeppel, 2007), and others propose a division along different types of combinatorial mechanisms (the dorsal stream being associated with the ability to combine elements into a sequence, the ventral with the formation of dependencies independent of sequential order and thus associated with semantics, Bornkessel-Schlesewsky, Schlesewsky, Small, & Rauschecker, 2015). However, the causal roles of dorsal and ventral white matter pathways associated with language production have yet to be specified. Here, we present data acquired through direct cortical electrical stimulation and subcortical resection during awake language mapping in 18 neurosurgical patients prior to and during tumor resection. Of the 18 patients, 17 were stimulated cortically and 10 were tested during subcortical resection in one or both of our tasks. Our 2 language tasks were designed to test the roles of the ventral and dorsal streams in language production. We used a picture-word interference (PWI) task manipulating semantic interference (the picture to be named and the superimposed distractor word were either semantically-related or semantically-unrelated); and a sentence generation task testing the ability to form sequential dependencies. We analyzed accuracy rates using logistic mixed effect models and deviance table analysis to test for fixed effects of Task, Stream (ventral or dorsal), and their interaction. There was no effect of Task, Stream (dorsal vs. ventral), nor interaction between Task and Stream during cortical stimulation. During subcortical testing, there was a main effect of Task: the sentence generation task elicited more errors than the PWI task. Critically, there was also an interaction between Task and Stream: when tumor resection was performed in the territory of dorsal stream pathways (i.e., the superior longitudinal fasciculus or the arcuate fasciculus), the sentence generation task elicited more errors compared to the PWI task. Whereas when tumor resection was performed in the territory of ventral stream pathways (i.e., the inferior fronto-occipital fasciculus or the uncinate fasciculus), there was no significant difference between tasks. Our results support a dorsal/ventral role division for white matter pathways involved in language production. In agreement with the model proposed by (Bornkessel-Schlesewsky et al., 2015), our results support that dorsal stream pathways are critical for organizing elements in a sequence, which is particularly needed in the generation of sentences, and that ventral stream pathways are critical for the processing of meaning dependencies, involved in both the picture-word interference and sentence generation tasks.

A44 Different contextual effects modulate the representation of word meaning in the human brain

Christine Tseng[1], Leila Wehbe[1], Fatma Deniz[1], Jack Gallant[1]; [1]University of California, Berkeley

Context crucially affects how the human brain processes words. Neuroimaging studies have shown that words in sentences elicit more brain activity than isolated words or meaningless sentences [1], and that brain activity elicited by narratives is more widespread than activity elicited by isolated words [2]. However, it is unclear whether these contextual effects reflect semantic context or linguistic structure. For example, consider the brain representation of the word "apples" presented in isolation, versus in the sentence "She preferred unripe apples to juicy oranges." The sentence clearly provides a richer semantic context than the word presented alone, and this might affect how the brain represents the concept, "apples." Alternatively, the linguistic structure of the sentence confers a particular meaning on "apples" that is not present when the words are in a different order, and this might also affect the brain

representation of "apples." To characterize the effects of semantic context and linguistic structure, we designed an fMRI experiment with four stimulus conditions: Single Words: randomly sampled words from ten narratives from [2]; Blocks: groups of 114 conceptually similar words sampled from 12 clusters (created by projecting the narrative words into a word co-occurrence space); Sentences: 231 factual sentences; and Narratives: ten narratives from [2]. The Blocks condition is crucial because it provides semantic context without linguistic structure. Thus, comparison of activity elicited by Blocks to Single Words reveals how semantic context affects the brain representation of words. Analogously, comparison of brain activity elicited by Blocks to Sentences and Narratives reveals the effect of linguistic structure. Before data collection we constructed a semantic feature space based on word co-occurrence statistics calculated over a large text corpus, and we projected all stimulus words into this space. Then we collected six hours of fMRI data for each subject. (In all conditions, words were presented one-at-a-time using RSVP.). Finally, for each condition, we modelled every voxel in every individual subject as a linear sum of weighted features. We used these models to predict voxel responses in a separate validation dataset using a different set of words. Prediction performance was quantified as the correlation between predicted brain responses and measured responses. This voxel-wise modeling approach identifies semantically selective voxels across the entire cerebral cortex for each individual subject and experimental condition. We find that most voxels in bilateral temporal, parietal and prefrontal cortex are semantically selective in the Narratives, Sentences, and Blocks conditions. In contrast, very few voxels show semantic selectivity for the Single Words condition. Prediction performance is significantly higher for Blocks in comparison to Single Words. Because the Single Words condition does not have semantic context, we conclude that semantic context affects how the brain represents word meaning. However, prediction performance for Blocks was overall lower than for Sentences, which in turn had worse prediction performance than Narratives. Because the Blocks condition does not have linguistic structure, we conclude that linguistic structure also modulates the brain representation of word meaning. REFERENCES: [1] Fedorenko et al., Neuropsychologia, 2012; [2] Huth et al., Nature, 2016

Meaning: Prosody, Social and Emotional Processes

A45 The cognitive and neural oscillatory mechanisms underlying the facilitating effect of rhythm on speech comprehension

Xiaoqing Li[1], Jinyan Xia[1]; [1]Key Laboratory of Behavioral Science, Institute of Psychology, Chinese Academy of Sciences (Beijing, China)

One of the most fascinating abilities of the human brain is that it can recognize the temporally regular patterns in the dynamically changing auditory or visual stimuli. Quite a lot of studies have demonstrated that temporal prediction derived from the rhythm regularity plays an important role in auditory/visual perception and language comprehension as well. Although the existing studies provide some insights on how temporal prediction affects auditory/sensory perception, the mechanism by which temporal regularity influences language comprehension remains to be explored. The aim of the present study was to use the EEG (electroencephalograph) technique to examine the effect of rhythm regularity on Mandarin Chinese speech comprehension and the internal mechanisms underlying this effect. Specifically, this study aimed to explore, during speech comprehension, how the different stages of language processing (early sensory stage and late semantic stage of information processing) are affected by temporal predictions generated from rhythm regularity, and what's the neural oscillatory mechanism underlying this rhythm regularity effect. Participants listened to Mandarin Chinese sentences that had a regular or irregular rhythm context and that contained critical nouns that were congruent or incongruent with the sentence contexts. The results revealed that: 1) relative to congruent nouns, incongruent nouns elicited a larger complex of N1+N400+residual N400 in the context of regular rhythm, but elicited only a larger later P600 in the context of irregular rhythm, which suggests that regular rhythm speeds up speech comprehension; moreover, the reduced N1 and N400 indicates that rhythm regularity affects speech comprehension by modulating both the later semantic stage of processing and the early sensory/phonological stage of processing. 2) as compared to irregular rhythm, regular rhythm induced power increases in beta band immediately preceding the critical nouns and power increases in alpha band immediately following the critical nouns; this alpha-power-increase rhythm regularity effect was positively correlated with the N1 enhancement effect (incongruent vs. congruent noun) and the beta-power-increase rhythm regularity effect negatively correlated with the N400 and residual-N400 enhancement effect (incongruent vs. congruent noun) in the regular rhythm context. These correlation effects indicated that the facilitating effect of rhythm regularity on speech comprehension relies at least in part on the beta- and alpha-bands of neural oscillatory activities, and that rhythm regularity facilitates speech comprehension both by enhancing neural excitability associated with early sensory/phonological processing and by reducing cognitive costs associated with later semantic processing. In summary, the present study provides further experimental evidence for the dynamic attending theory by showing that, even during complex spoken sentence comprehension, both the later semantic processing and the very early sensory/phonological processing is modulated by the relatively long-distance rhythm structure of speech

sequences. Moreover, the present results also permit us to gain some understanding of the neural oscillatory mechanisms by which rhythm regularity affects speech comprehension. Key words: rhythm regularity; speech comprehension; brain oscillations; dynamic attending theory

Computational Approaches

A46 Episodic and semantic components of lexical knowledge: a computational model

Alvaro Cabana[1], Emilia Flo[1], Camila Zugarramurdi[1], Juan C. Valle-Lisboa[1]; [1]Facultad de Psicología, Universidad de la República, Montevideo, Uruguay

The role and structure of the lexicon have been the subject of recent debate in psycholinguistic theories. Empirical evidence shows that early semantic processing integrates semantic and pragmatic or "world knowledge" information. Some theoretical approaches account this stating that meaning is computing by integration of contextual cues from different sources, implying there may be no "meaning" of words independent of context. Other views support the interaction between a semantic lexical store and event knowledge representations to explain these effects. With the intention to test the plausibility of this dual-route approaches, here we expand a previous attempt to build a computational model with two components: a WordNet-based lexical store and a set of documents related to different types of events. We tested our model simulating the results of priming experiments in which the relationship between prime and target either "semantic" or "episodic" (for instance, category coordinates or nouns denoting typical participants of events). We used spreading activation functions to account priming effects: activation in the "semantic" (WordNet) module spreads to all elements of a given synset, whereas activation in the "episodic" module spreads to all words that appear in a given document. Using this approach to explore two different priming experiments, we show that there are instances in which priming can be explained mainly by activation from the semantic or the episodic modules. In most of these latter cases, clusters of event-related words are strongly represented in the "episodic" documents, whereas in the latter cases, words are represented in a wide set of unrelated documents, rendering their event-activations low. That is, when words are spread over many different types of events, the event knowledge is not relevant; in contrast, as in event nouns, event knowledge is more important. These results suggest, using a computational model, that dual-store accounts of lexical knowledge are compatible with priming patterns of event-related words.

A47 Neuro-computational modelling of parallel incremental prediction and integration during speech comprehension

Hun Choi[1], Billi Randall[1], Barry Devereux[1], Lorraine Tyler[1]; [1]University of Cambridge

Spoken sentence comprehension is a rapid, incremental process which involves anticipating and integrating upcoming words into a developing representation. We use state-of-art computational models of verb subcategorization information and semantic selectional preferences to explore the dynamic neurocomputational processes involved in incremental integration of the semantic and syntactic properties of words in sentences. Our models measured prediction: information about syntactic and semantic properties of subsequent input, given the preceding context; and integration: the difficulty of integrating this subsequent input, given these predictions. We aimed to determine how quickly syntactic and semantic information is reflected in the dynamics of neural activity, and to distinguish whether information relevant to processing the subsequent input is activated early, or becomes active only when needed to facilitate integration of subsequent input. In an EMEG study, participants listened to 200 sentences which varied in complement structure following subject and verb (e.g. ['The student (subject NP) designed (verb) the experiment (complement)']). To model verb syntactic preferences, we used VALEX, a corpora-derived database providing syntactic frames for 6,397 English verbs (Korhonen et al., 2006). For the semantic preference model, we used the Latent Dirichlet Allocation (LDA) approach of topic-modelling (O'Seaghdha & Korhonen, 2014). This model combined topic distributions associated with direct object continuations given in a pre-test. We also modelled syntactic and semantic prediction error as the difference between the actual continuation and prior belief reflected in the syntactic and semantic prediction distributions. Representational similarity analysis (Kriegeskorte et al., 2008) related our computational models to the spatio-temporal dynamics of source-space signals in the language network. Consistent with claims that syntactic processing involves a left-lateralized fronto-temporal system (Tyler & Marslen-Wilson, 2008; Hagoort, 2013), verb subcategorisation information activated left fronto-temporal areas from 200ms after verb-onset. We found a significant subcategorisation prediction-error effect in L-BA45 150ms after the onset of the verb's complement reflecting the difficulty of syntactic integration. Activation of the semantic preferences of verbs occurred remarkably early in bilateral inferior frontal areas –soon after verb-onset and before the verb's complement structure had been determined. These early frontal effects may show how the subject NP constrains the verb such that the prediction of object nouns may begin before the verb is fully identified. Or the verb may be identified sooner given the context of the subject NP. Hence, this frontal activation may be related to the complexity of activating lexical-semantics by pre-activating a direct object frame. Finally, semantic prediction-error effects for the complement noun, reflecting integration difficulty for the noun, occurred in the left posterior middle and inferior temporal gyri around 300ms after complement noun onset. These results show that the left-syntactic and bilateral-semantic

networks in the brain rapidly activate relevant syntactic and semantic information, flexibly pre-activating likely verb complements (i.e. direct object) and incrementally integrating the syntax and semantics of the complement for faster and more accurate comprehension.

Methods

A48 Using Kinect technology to assess word learning

Andrés Méndez[1], Rossana Guerra[1], Leonel Gómez[1]; [1]Universidad de la República

Behavior has been often underestimated when it comes to understand complex cognitive functions, such as language acquisition. From an embodied and dynamic perspective, however, the structure of behavior and social interactions in space and time are key to understand how words become relevant to children. This does not mean that complex linguistic structures cannot emerge independent from experience, as classical cognitive theories describe. Recent evidence from embodied perspectives show the need to study how much variance and information there is in the interaction of infants with their environment, and therefore, how far we can go without the need to describe language as a symbolic-like process that happens all inside the child's head. This proposal demands the development of studies that analyzes behavior as a function of interaction and time, which usually result in large amount of data and time-consuming coding procedures. Kinect technologies are well suited to solve the demanding challenge of quantifying complex behavior with high temporal resolution. Our study assesses the power of the most recent Kinect to provide reliable data on infant´s behavior. This was done by comparing data from the Kinect to data obtained through manual coding. Of specific interest was the detection of hand and head movements while both parent and child interact freely in object-naming conditions. The results show that optimizing this technology is a potential road to the design of automatic, remote, non-invasive and reliable technology for the study of word learning - and cognitive development in general - from an embodied perspective.

A49 MrAnats: Magnetic Resonance-based Adaptive NeuroAnatomy Teaching Software

Paul Fillmore[1], Matthew Parham[1]; [1]Baylor University

The current work describes the creation of a software program (MrAnats: Magnetic Resonance-based Adaptive NeuroAnatomy Teaching Software) for teaching introductory neuroanatomy. With the advent of neuroimaging techniques such as magnetic resonance imaging (MRI), much has been learned about neuroanatomy and brain structure. However, many of these advances have occurred primarily in the realms of scientific research and clinical care, often without significant effect on the ways in which students learn about the brain. For example, most textbooks offer fairly simple two-dimensional views of neuroanatomy and do not make use of modern three-dimensional visualization methods common in scientific applications. Additionally, in learning about the brain, there are many different sets of terminology and labels used, making it especially difficult for the new learner to see how the different organizational systems fit together. There is no widespread framework in use for comparing and contrasting these systems. Lastly, current research in learning theory has highlighted the inefficiency of some of the most popular methods of studying (e.g. highlighting, re-reading), and has suggested specific learning methods (e.g. iterative self-testing) that are the most effective use of students' time. The availability of tools to make use of these insights, however, is still lacking. Thus, we describe a program which: 1) Leverages high-resolution MRI scans to visualize neuroanatomy interactively in three dimensions, 2) Presents the common labeling systems for human brain structure and allows for explorative comparing and contrasting, and 3) Uses current best-practices in learning theory to help students learn about the brain efficiently.

A50 Effects of laterality, handedness, and coil orientation on size and morphology of Motor Evoked Potentials (MEPs) recorded from lip muscles.

Patti Adank[1], Dan Kennedy-Higgins[1], Helen Nuttall[1,2]; [1]Department of Speech, Hearing and Phonetic Sciences, University College London, Chandler House, 2 Wakefield Street, London, UK, WC1N 1PF, [2]Department of Psychology, Lancaster University, Lancaster, UK, LA1 4YF

Recent research indicates that brain areas once believed to be exclusive to speech production are also recruited for speech perception. The role of speech production areas, specifically the lip area in primary motor cortex, has been studied by collecting Motor Evoked Potentials (MEPs) as a measure of relative cortical excitability through the application of single-pulse Transcranial Magnetic Stimulation (TMS) [1-3]. MEP acquisition procedures of speech MEP studies tend to be based on methodological studies conducted mostly in hand muscles, e.g., in the first interosseous dorsalis (FDI), which is innervated by the corticospinal tract [4]. Facial muscles, such as OO, are innervated by the corticobulbar tract and it is unclear to which extent specifics of the corticospinal tract can be extrapolated to the corticobulbar tract. This study aimed to address this issue by characterising effects of laterality, handedness, and coil orientation on the size and shape of MEPS collected from ipsi- and contralateral OO or FDI in left-handed (7) and right-handed (10) participants for eight orientations (0, 45, 90, 135, 180, 225, 270, and 315 degrees). MEPs from OO were evoked consistently in six out of eight orientations (0, 45, 90, 135, 270, and 315 degrees), with large inter-individual variability in optimal orientation. Similar-sized OO MEPs were also recorded from the ipsi- and contralateral sites after left-sided stimulation only. Hand MEPs were recorded consistently with lower inter-individual variability for the 45 degree orientation from the

contralateral hand only. We found no effects of handedness or effector on (standardised) MEPs. It is thus feasible to obtain lip MEPs using the 'standard' orientation of 45 degrees. Based on these results, it may be recommended that researchers adopt a modified thresholding procedure, where coil orientation, in addition to TMS intensity, is varied in order to detect similar populations of neurons that are oriented in potentially different directions across participants. This may promote a more accurate understanding of activation of the motor system for speech production, during speech perception. References: 1. Watkins, Strafella, and Paus, Seeing and hearing speech excites the motor system involved in speech production. Neuropsychologia, 2003. 41(8):989-94. 2. Nuttall, et al., The effect of speech distortion on the excitability of articulatory motor cortex Neuroimage, 2016. 128:218-226. 3. Murakami, Restle, and Ziemann, Observation-execution matching and action inhibition in human primary motor cortex during viewing of speech-related lip movements or listening to speech. Neuropsychologia, 2011. 49(7):2045-2054. 4. Rossini, et al., Non-invasive electrical and magnetic stimulation of the brain, spinal cord, roots and peripheral nerves: basic principles and procedures for routine clinical and research application. An updated report from an I.F.C.N. Committee. Clinical Neurophysiology, 2015. 126:1071-1107. 5. Adank, P., Nuttall, and Kennedy-Higgins, Transcranial Magnetic Stimulation (TMS) and Motor Evoked Potentials (MEPs) in Speech Perception Research. Language, Cognition & Neuroscience, 2016:1-10.

A51 Test-retest reliability comparison of RSA and GLM approaches in a language task

Ryan Staples[1], Einar Mencl[1,3], Jeffery Malins[1], Daniel Brennan[1], Ken Pugh[1,3,4], Robin Morris[2]; [1]Haskins Laboratories, [2]Georgia State University, [3]Yale University, [4]University of Connecticut

We examined the rest-retest reliability of representational similarity analysis (RSA) and a standard general linear model (GLM) approach in parallel, as applied to a language task. The purpose was to examine the differences between the GLM's smoothed, large-grained representation of neural information and RSA's more fine-grained, pattern based representation. The subjects are 14 adults who were scanned twice, approximately 3 weeks apart, on the same tasks and who had no reading or speech disabilities. Subjects were presented with a picture and then with either a written or recorded word that did or did not match the picture, though only the mismatch conditions were considered in our analyses. The GLM reliability was calculated as the voxel-wise correlation between time one and time two print-speech contrast maps. RSA reliability was calculated as the voxel-wise correlation between time one and time two RSA maps, which themselves were created by identifying, on a trial-wise basis and using a searchlight analysis, which voxels had a similar response within the auditory and visual conditions, and a different response in the opposite condition. Both approaches demonstrated broad reproducibility across perisylvian areas, with some differences appearing. Both analyses showed a great deal of reliability in bilateral fusiform, lingual, and middle occipital gyri. The GLM showed broader areas of bilateral middle and superior temporal gyri reliability, whereas the RSA was focused in the right middle temporal gyrus. Regions of the inferior parietal lobule showed strong reliability in both analyses, though the precise location differed. We also calculated the voxel-wise correlation between time one GLM results and time one RSA results and the same between time two GLM and RSA results. We again found broad positive correlation in the right and left fusiform, lingual, and middle occipital gyri, as well as in the left inferior frontal gyrus. Notably, no strong correlation was found in temporal regions. These results suggest that both analysis methods are highly reliable for language tasks. Additionally, both types of analysis are reliably correlated with each other in language areas. The RSA results additionally suggest that the response in visual areas to written words is highly stereotyped and differentiable from those same regions' response to auditory stimuli, but that the precise, local pattern of each response to an auditory word in temporal regions is more variable, more similar to those regions' responses to visual language stimuli, or both.

A52 ICA-based classifiers mitigate task correlated motion artifacts for overt-speech fMRI paradigms in aphasia

Venkatagiri Krishnamurthy[1,2], Lisa Krishnamurthy[2,3], Kaundinya Gopinath[4], Michelle Benjamin[5,6], Bruce Crosson[1,2,5,7]; [1]Dept. of Neurology, Emory University, Atlanta, GA, United States, [2]Center for Visual and Neurocognitive Rehabilitation, Atlanta VAMC, Decatur, GA, United States, [3]Dept. of Physics & Astronomy, Georgia State University, Atlanta, GA, United States, [4]Dept. of Radiology & Imaging Sciences, Emory University, Atlanta, GA, United States, [5]University of Florida, Gainesville, FL, United States, [6]Brooks Rehabilitation, Jacksonville, FL, United States, [7]Dept. of Psychology, Georgia State University, Atlanta, GA, United States

Overt-speech fMRI paradigms are very useful in aphasia research, but are also plagued by task-correlated motion (TCM). Several studies have developed methodologies to overcome TCM artifacts, but a relatively easy and computationally time-efficient technique that maintains the specificity-sensitivity balance in detection of task-related functional activity is still lacking. The goal of this study is to develop a novel ICA-based trained classifier that is optimized to capture spatio-temporally varying TCM, whose use can be cost-effective on large datasets. Four monolingual English speaking patients with aphasia (post-stroke >6 months) were recruited. We acquired high-resolution MPRAGE structural images and six task-fMRI runs. During the task-fMRI runs, patients heard and read a semantic category and attempted to overtly generate an exemplar of that category. Functional images were corrected for slice timing, global head motion, and

decomposed into temporal and spatial components using FSL MELODIC. Deconvolution on the IC components' time-series was used to obtain an impulse response function (IRF) that were visually inspected for TCM characteristics. TCM-like IRFs were further validated for its signature by using the designed task-specific periodicity and power spectral density at task frequency (0.03Hz). In parallel, a 3D deconvolution was applied on all fMRI runs to obtain a voxel IRF, which was further correlated with the TCM-like IRF. The result was masked by a 'TCM' mask that included major TCM-prone brain areas, and the correlation was thresholded at 0.7. Based on above criteria, the IC component was labeled as 'TCM-noise' component, and this step was carried out on 10 different data sets to obtain a trained-classifier, which was applied to the remaining datasets. The data sets were processed in 4 ways: (i) no application of any TCM correction (no ICA), (ii) novel TCM classifier (TCM), (iii) standard package, i.e., AROMA (AROMA), and (iv) TCM classifier followed by AROMA (TCM+AROMA). Finally, each denoised dataset was spatially smoothed excluding CSF, and deconvolved with the task stimuli to generate a HRF and statistical parametric activation map thresholded at R2 =0.16.TCM classifier out performs the other methods both in terms of specificity and sensitivity. In the process of cleaning-up TCM, the AROMA and TCM+AROMA methods removed BOLD signal from important language areas such as left Heschl's and angular gyrus, and right Superior Temporal gyrus, whereas the novel TCM classifier retained sensitivity in those areas. The TCM classifier also improved specificity by removing false positive activations from surrounding larger unrelated brain areas. We also noted that smoothing within grey and white matter (i.e. excluding CSF) increased specificity (i.e >R2).Our preliminary results show that TCM-specific ICA-based classifier is promising as evidenced by the improved sensitivity and specificity. Since speech-related motion has unique signatures, stock packages such as AROMA is not ideal for denoising TCM. Further, the advantage of semi-automated ICA classifier is that it requires a one-time front-end effort to hand label and train the classifiers thus reducing the burden of excessive computational and labor time to denoise each dataset. Future work will include extending this methodology to remove trial-by-trial variations in TCM.

Language Disorders

A53 Comparison between the effect of online and offline transcranial direct current stimulation on naming latency in healthy adults

Mohammed F. ALHarbi[1,2], Esther S. Kim[1]; [1]Faculty of Rehabilitation Medicine, University of Alberta, Edmonton, AB T6G 2G4, Canada, [2]College of Medical Rehabilitation Sciences, Taibah University, Madinah, Saudi Arabia

Purpose: Transcranial direct current stimulation (tDCS) is a non-invasive neuromodulation technique that can be used to boost language recovery in post-stroke aphasia and enhance language performance in healthy subjects. Although tDCS intervention studies for anomia have shown promising results, the optimal stimulation parameters are yet to be determined. One of the challenges with administering tDCS as an adjunct treatment for anomia is determining the best time to deliver the stimulation. In motor and cognitive domains, several studies have shown that the effect of tDCS differs when administered concurrently with a behavioral task that is related to the stimulated area (i.e., online stimulation) versus when the stimulation and the behavioral task are administered separately (i.e., offline stimulation). Specifically, some investigators have reported that online stimulation can interfere with motor or cognitive task performance, but this issue of interference has not been fully investigated with respect to naming performance. The purpose of this study is to examine the effect of tDCS on naming performance when tDCS is delivered concurrently(online) compared to sequential (offline) stimulation in healthy adult subjects. Methods: 21 healthy participants were included in the study. A double blinded within-subject crossover experimental design with two conditions (active anodal-tDCS, sham anodal-tDCS) and a 24 hour washout period between the conditions was used. Each participant was asked to name 20 pictures (2 x 10 items) of common objects five times (before, during, immediately post, 10 minutes post, and 20 minutes post-stimulation) in each condition. 1.5 mA A-tDCS was used over Broca's area with a return electrode over the contralateral supraorbital region for 10 minutes in each session. The participants were randomly allocated to conditions and the presentation of the stimuli was also random. Change in naming latency (in milliseconds) was the dependent variable. Results: Two-way repeated ANOVA with factors condition and time showed no significant differences between the two conditions (sham and active A-tDCS) (F=1.26, P=0.27) and no significant differences between the offline and online stimulations (F=1.82, P=0.13). Discussion: 10 minutes single tDCS session with 1.5 mA intensity and an active anodal electrode placed over Broca's area with a return electrode placed over contralateral supraorbital region might not sufficient to induce significant changes in naming latency in healthy subjects. The findings confirm the results of the recent studies where no effects of tDCS stimulation on naming ability have been found following a single session (Horvath et al., 2015; Westwood et al., 2017). Longer stimulation durations might be needed to detect the effect of tDCS and allow for accurate comparison between offline and online tDCS stimulation on naming latency.

Methods

A54 Gliosis+ for continuous lesion quantification in VLSM to map brain-language relationships

Lisa Krishnamurthy[1,2], Venkatagiri Krishnamurthy[2,3], Amy Rodriguez[2], Michelle Benjamin[4,5], Keith McGregor[2,3,5], Atchar Sudhyadhom[5], Kaundinya Gopinath[6], Bruce Crosson[2,3,5,7]; [1]Dept. of Physics & Astronomy, Georgia State University, Atlanta, GA, United States, [2]Center for Visual and Neurocognitive Rehabilitation, Atlanta VAMC, Decatur, GA, United States, [3]Dept. of Neurology, Emory University, Atlanta, GA, United States, [4]Brooks Rehabilitation, Jacksonville, FL, United States, [5]University of Florida, Gainesville, FL, United States, [6]Dept. of Radiology & Imaging Sciences, Emory University, Atlanta, GA, United States, [7]Dept. of Psychology, Georgia State University, Atlanta, GA, United States

Combining structural imaging with language behavior is emerging as a powerful clinical research tool to better understand stroke-related language deficits (aphasia). One method used for this purpose, Voxel-based Lesion Symptom Mapping (VLSM), is a simple yet elegant method used to define structure-behavior associations, but depends on binary "all-or-nothing" lesion masks. In 2005, Tyler et al. advanced VLSM by discarding the binary lesion masking step by means of correlating the continuous T1-weighted image signal intensity with continuous language measures, and demonstrated that T1-image signal intensity has high correlations with word processing abilities. Unfortunately, the T1-image normalization process is directly influenced by subject-specific lesion size, atrophy, and ventricle size, such that this normalization adds noise into the analysis. To address these issues, we have developed a VLSM-regression technique that relates a novel continuous MRI signal quantity (gliosis+) with continuous measures of behavior, but is free from MRI signal processing artifacts. Fourteen monolingual English speaking subjects were recruited >6 months post left-hemisphere stroke with evidence of non-fluent language output. The Western Aphasia Battery (WAB) and Boston Naming Test (BNT) were administered to assess verbal fluency, repetition, comprehension, and word retrieval in all subjects. High-resolution T1-weighted MPRAGE and T2SPACE structural images were acquired on each subject. The ratio of T1-MPRAGE to T2SPACE was calculated, and inverted to increase sensitivity to the lesion and surrounding structural changes. Images were spatially normalized to MNI space, and the anterior portion of the lateral ventricle and grey matter were segmented in the non-lesioned hemisphere to calculate upper and lower bounds of the gliosis+ maps. The T2/T1 ratio was then subdivided into ten compartments based on the upper and lower bounds, and automatically segmented, depicting the smooth and continuous transition from cavitation to surrounding glial and axonal damage. VLSM-regression with the behavioral score was calculated for all voxels that had a gliosis+ score for at least 4 or more subjects to ensure a good fit. Maps were thresholded at p=0.05, and clustered at 60 voxels to obtain regions of significant relationship with clinical measures of language behavior. All 14 subjects had quantifiable gliosis+ scores within the left hemisphere, and gliosis+ score location corresponded to the location of the lesion and surrounding structural damage. Linear regression revealed significant relationships between gliosis+ and WAB fluency, WAB repetition, WAB comprehension, and BNT. As an example, the gliosis+ score was related to WAB Repetition in a significant cluster of voxels in supramarginal gyrus and posterior arcuate fasciculus (R2=0.52). To the best of our knowledge, this work presents the first evidence that gliosis+ maps provide a measure that can be related to clinical measures of language behavior in patients with aphasia. The VLSM-regression results were sensitive to expected language areas of importance, and were able to account for a large variability in language behavior measures. These preliminary data show that we will be able to readily extend the gliosis+ VLSM-regression analysis to a larger cohort to obtain a robust comparison of gliosis+ VLSM-regression to standard VLSM.

Language Therapy

A56 Comparing Frontal and Parietal tDCS Montages for Reducing Anomia Symptoms in People with Dementia

Carlos Roncero[1], Erik Service[1], Alex Thiel[1], Stephan Probst[1], Howard Chertkow[1]; [1]Lady Davis Institute, Jewish General Hospital

INTRODUCTION: We evaluated whether transcranial direct current stimulation (tDCS) in two different montages could improve picture naming abilities in subjects with anomic Alzheimer or frontotemporal dementias. METHODS: Utilizing a double-blind cross-over design, twenty participants were trained on picture naming over a series of 10 sessions with e30 minutes of anodal (2 mA) tDCS stimulation to either the left inferior parieto-temporal region (P3), the left dorsolateral prefrontal cortex (F3), or sham stimulation. We evaluated performance on a trained picture naming list, an equivalent untrained list, and additional neuropsychological tasks. RESULTS: Regardless the montage, participants improved significantly more for trained items when they received real stimulation rather than sham stimulation, lasting at least two weeks post-stimulation. Whereas for the untrained items, improvement was only observed for the P3 montage, compared to a significant decrease when sham stimulation was given. For the F3 montage, there was neither a significant increase nor decrease for untrained items. Finally, as group, participants with semantic dementia showed the least improvement for untrained items. DISCUSSION: tDCS stimulation has promise as a treatment for anomia in demented individuals, but its effectiveness can vary depending on the montage given and participants' diagnosis.

Computational Approaches

A57 Verbal IQ is determined by brain health, which is modulated by cardiovascular risk factors

Barbara Khalibinzwa Marebwa[1], Robert J. Adams[1], Julius Fridriksson[2], Gayenell Magwood[1], Leonardo Bonilha; [1]Medical University of South Carolina, [2]University of South Carolina

The integrity of fiber connectivity in structural networks supports cognitive processing within the brain and can be used as a measure of brain health beyond current neuropsychological testing. We aimed to quantify the relationship between verbal IQ in older adults and the disruption of white matter network architecture using high resolution whole brain structural connectomes constructed from diffusion images of 60 participants either with no cardiovascular (CV) risk factors, or at least one CV risk factor. We measured white matter network organization using Newman's modularity algorithm and determined the effect of CV risk factors on the network architecture, and their relationship with verbal IQ. We hypothesized that verbal IQ in older adults is modulated by CV risk factors through the disruption of the white matter network architecture, which can be therefore understood as a biological measure of brain health. We found evidence of disruption via fragmentation of the community structure. Greater network fragmentation (high modularity) was significantly associated with decreased verbal IQ ($r = -0.3003$, $p = 0.0099$; $r = -0.3422$, $p = 0.0037$ for the left and right hemisphere respectively). Participants with CV risk factors had more modules, and significantly higher network modularity compared to healthy controls. We also investigated short-, mid- and long- range fibers and found evidence of mid- and long range fiber loss in participants with CV risk factors. Fiber loss was also significantly associated with participants with CV risk factors, and with decreased verbal IQ ($r = 0.4624$, $p < 10\text{-}4$; $r = 0.4704$, $p < 10\text{-}4$ for the left and right hemisphere respectively). Our findings show a pattern of network fragmentation and fiber loss in participants with cardiovascular risk factors, which is associated with lower verbal IQ. We propose that the disorganization of the community structure is a consequence of long range fiber loss, and demonstrate that white matter topological organization measured from the connectome could be used as a personalized biomarker to inform on individual brain health in relationship with language.

Perception: Orthographic and Other Visual Processes

A58 Sight or Sound? Individual Differences in the Neural and Cognitive Mechanisms of Single Word Reading

Simon Fischer-Baum[1], Jeong Hwan Kook[1], Yoseph Lee[1], Aurora Ramos-Nuñez[1], Marina Vannucci[1]; [1]Rice University

Most research on reading and its neural substrates has focused on a universal theory, identifying the common set of cognitive and neural processes shared across individuals. Within this framework, one area of debate has been the role of phonology in word reading – that is whether phonology is critical for mapping from written form to meaning. In the current study, we consider the possibility that there may be individual differences in the role that phonology plays in reading. Specifically, a group of thirty highly skilled adult readers participated in an experiment lasting two sessions, an fMRI study and a battery of behavioral reading tasks; a pseudohomophone lexical decision experiment that probes the role of phonology in reading (e.g. Rubenstein et al., 2001) and a set of standardized measures of reading skills (Nelson-Denny Reading Test, Brown et al., 1993; Test of Word Reading Efficiency, Torgesen et al., 2012). During the fMRI portion of the study, participants read aloud regular and irregular words and pronounceable pseudowords. We then applied a novel, data-driven approach to analyzing multi-subject, task-based fMRI data (Zhang et al., 2016) that clustered subjects into subgroups characterized by similar patterns of brain responses across the whole brain to written words. With this approach we identified two, roughly equally sized clusters of participants and a single outlier. We then compared these two groups on their performance on the behavioral reading tasks. Strikingly, the two groups differed in performance on the pseudohomophone lexical decision task. While there were no significant differences between individuals in Cluster 1 and 2 in the overall lexical decision time, the group by nonword-type interaction was significant ($F(1,26) = 6.50$, $p = .017$). Specifically, individuals in Cluster 2 showed a robust pseudohomophone effect (596 vs. 577, $t(15) = 4.58$, $p = .0004$), with slower reaction times for pseudowords that were pronounced like real words (e.g., BRANE) compared to matched pseudwords that were not pronounced like real words (e.g. BRAME). In contrast, Cluster 1 showed no pseudohomophone effect (625 vs 622, $t(11) = .85$, $p = .42$). The groups did not differ in their performance on any of the standardized measures of reading skill, from reading comprehension to vocabulary knowledge to decoding ability. The pseudohomophone effect has been used to argue that phonological information plays an important role in lexical access for visually presented words (e.g. Frost, 1998). Based on this logic, our results suggest hetereogeneity in the role of phonology during visual word recognition, with one group showing clear effects of phonology during reading and the other group not showing any effect. This heterogeneity can be interpreted in the context of dual-route theories of reading aloud, further assuming that some readers depend more on lexical/semantic processing while other readers depend more on sublexical/phonological processing, with no differences in overt reading skill between these different modes of reading. In general, cognitive neuroscience needs

to consider not only what tends to be true of group-average data, but also the patterns of variability that are observed across the population.

Multilingualism

A59 Lateralization differences on semantic processing between native speakers and proficient learners of Mandarin Chinese

Chia-Ho Lai[1], Shu-Kai Hsieh[1], Chia-Lin Lee[1], I-Wen Su[1], Te-Hsin Liu[1], Chia-Rung Lu[1], I-Ni Tsai[1], Tai-Li Chou[1]; [1]National Taiwan University

Mandarin Chinese is one of the language systems featured by orthographic characters. For alphabetic-based Indo-European language speakers, learning Mandarin Chinese as second language may take more efforts on processing orthographic information in order to achieve meaning comprehension. However, the neural changes or plasticity of brain lateralization in adult Chinese learners are not well understood. The present study aimed at exploring the hemispheric differences between native speakers (L1 group, N = 21, age = 24.5 years old, SD = 2.9) and proficient learners (L2 group, N = 10, age = 25.8 years old, SD = 3.8) of Mandarin Chinese on semantic processing of characters by using functional magnetic resonance imaging. In the scanner, participants were asked to make different relation judgments of Chinese character pairs corresponding to two conditions. One was to indicate whether the pairs were related in meaning, while the other was to identify whether the pairs were in the same orthographic form. Our results showed that, compared to orthographic form identification, semantic-related pairs had greater activation in the left hemisphere including the inferior frontal gyrus (IFG), middle temporal gyrus (MTG), superior frontal gyrus and caudate nucleus in the L1 group. While in the L2 group, the same comparison showed relatively weaker activation in the left IFG and greater activation in the right middle occipital gyrus. We further compared the semantically related pairs and semantically unrelated pairs of Chinese characters. The L1 group had more activation in the left-dominant regions including the inferior parietal lobule, superior frontal gyrus, MTG, IFG and caudate nucleus. In contrast, the L2 group showed bilateral activation in both angular gyrus and MTG. Previous findings in the literature have shown that after participating in the training of phonological learning of Chinese characters, English native speakers not only showed the activation in the left IFG but also had increased activation in the occipital regions related to visual processing in the right hemisphere. Furthermore, a recent study demonstrated that successful Chinese learners among the English native speakers tended to have stronger enhancement of white-matter connectivity in the right hemisphere. Therefore, our study indicated that for Chinese learners whose language systems are alphabetic-based, the right hemisphere has contributions to semantic processing which might due to the visual-spatial information loadings in understanding of Chinese characters or the recruitment of cognitive resources in processing second language which is genuinely different from their mother tongues.

A60 Right hemisphere contribution in syntactic category processing in L2 —ERP and fMRI data from learners of Mandarin Chinese

Chia-Ho Lai[1], Chih Yeh[1], Po-Heng Chen[1], Chia-Lin Lee[1], Shu-Kai Hsieh[1], I-Wen Su[1], Te-Hsin Liu[1], Chia-Rung Lu[1], I-Ni Tsai[1], Tai-Li Chou[1]; [1]National Taiwan University

Prior research has implicated greater right hemisphere (RH) involvement in second language (L2) processing, especially before native-like proficiency is obtained. To better understand the RH contribution in L2 syntactic processing, this study obtained functional magnetic resonance imaging (fMRI) and Event-Related Potential (ERP) data from native speakers and L2 learners of Mandarin Chinese during syntactic category processing. Experiment one used fMRI to investigate regions relevant for Chinese syntactic category processing from 20 native Chinese speakers and 10 intermediate-to-advanced learners of Chinese. In the scanner, participants viewed and judged the grammaticality of Chinese two-word phrases—a syntactic cue predictive of either a noun or a verb followed by a target word matching or mismatching the syntactic category expectancy. Data from 3 learners were excluded due to exceedingly low accuracy. Results comparing the ungrammatical versus grammatical conditions showed a left-lateralized response pattern for native speakers, with increased activation in the left superior frontal gyrus. L2 learners, in contrast, showed increased activation in the right anterior insula instead. This finding thus highlights the supportive role of the RH in L2 syntactic processing. Experiment two used ERPs in tandem with visual half-field presentation techniques to provide a multidimensional account of the processing biases of each hemisphere. Experiment two used a similar design and identical presentation timing, but focused on the more predictive noun context and laterally presented the grammatical and ungrammatical targets to either visual field (VF). 20 native Chinese speakers and 17 intermediate-to-advanced learners of Chinese participated. Target-locked ERPs showed, for native speakers, a P600 grammaticality effect with right-visual-field (RVF/LH) presentation only but a N400 grammaticality effect with both VF presentations. L2 learners as a group showed no N400 or P600 effects with either VF presentation. However, individual analyses showed a reliable negative correlation between LVF/RH P600 effects and self-report proficiency, indicating the benefits of suppressing RH P600 responses to achieve higher language ability. Together, our results provide support for the RH contribution in L2 processing and suggest that RH support may be dynamically modulated as L2 proficiency increases. Follow-up studies with designs appropriate for a wider range of proficiency levels would help to confirm these findings.

A61 Auditory and visual word processing in child and adult second language learners: Electrophysiological and behavioral evidence of cross-language interaction

Katharine Donnelly Adams[1], Fatemeh Abdollahi[1], Ping Li[1], Janet G. van Hell[1]; [1]The Pennsylvania State University

When cognates (words that share semantics, phonology, and orthography across languages) are presented to bilinguals, these words are processed faster than noncognates (for a review, see Van Hell & Tanner, 2012). This cognate facilitation effect occurs even when bilinguals read words in only one language. Studies reporting cognate facilitation effects have typically presented cognates and noncognates visually (but see Lagrou et al., 2011). Visual presentation of words activates orthographic codes more strongly than phonological codes and, likewise, auditory presentation activates phonological codes more strongly. Cognates, even orthographically identical cognates, nearly always have (slightly) different phonological forms across languages. These language-specific auditory cues may constrain lexical access to only one language. Auditory presentation of cognates and noncognates, therefore, may reduce or even eliminate a cognate facilitation effect that is present in visually presented words. To test whether cross-language lexical activation is different with auditory versus visual presentation, we presented cognate and noncognates in auditory and visual go-no go tasks to adult second language (L2) Spanish learners while measuring ERPs. Cognates and noncognates were presented in L2 Spanish and in L1 English to examine whether cross-language activation depends on relative proficiency in L1 and L2. In a second experiment, we tested child L2 Spanish learners aged 7-9 years (both adults and children were native English speakers and classroom learners of L2 Spanish). Research in our lab has shown that cognate facilitation effects pattern differently in children and adults (Brenders et al., 2011; Poarch & Van Hell, 2012). For example, testing child L2 learners, Brenders et al. (2011) found that the cognate facilitation effect turned into a cognate inhibition effect when interlingual homographs were added to the list of cognates and noncognates, whereas this list manipulation did not affect the cognate facilitation effect in adult proficient bilinguals. In the visual word recognition task in L2 Spanish, adult L2 learners demonstrated an N400 effect for cognate status (increased negativity for noncognates relative to cognates with English), and a smaller, nonsignificant N400 effect for cognate status in the visual word recognition task in L1 English. In contrast, no significant cognate effects were observed in the auditory tasks, and this was found in both the L2 and L1 tasks. Experiment 2 showed that performance of the child L2 learners patterned with that of the adults. Visual presentation of L2 Spanish cognates and noncognates showed a (delayed) N400 effect, and visual presentation of L1 English words showed a small and negligible N400 effect. In contract, auditory presentation yielded basically overlapping waveforms for cognates and noncognates, both for Spanish and English words. These findings indicate that mode of presentation (visual or auditory) modulates the co-activation of languages, and that both child and adult L2 learners employ phonological cues to constrain access to one language. Furthermore, for visual word recognition in L2, parallel activation of the nontarget L1 is stronger than vice versa, which reflects the difference in L1 and L2 proficiency in L2 learners.

A62 Speech perception in noise in a native and a second language: A functional magnetic resonance imaging (fMRI) investigation

Shanna Kousaie[1,3], Shari Baum[2,3], Natalie Phillips[3,4,5], Vincent Gracco[2,3,6], Debra Titone[3,7], Jen-Kai Chen[1,3], Xiaoqian J. Chai[1], Denise Klein[1,3,8]; [1]Neuropsychology/Cognitive Neuroscience Unit, Montreal Neurological Institute, McGill University, Montreal, QC, Canada, [2]School of Communication Sciences and Disorders, Faculty of Medicine, McGill University, Montreal, QC, Canada, [3]Centre for Research on Brain, Language and Music, McGill University, Montreal, QC, Canada, [4]Department of Psychology/Centre for Research in Human Development, Concordia University, Montreal, QC, Canada, [5]Bloomfield Centre for Research in Aging, Lady Davis Institute for Medical Research and Jewish General Hospital/McGill University Memory Clinic, Jewish General Hospital, Montreal, QC, Canada, [6]Haskins Laboratories, New Haven, CT, USA, [7]Department of Psychology, McGill University Montreal, QC, Canada, [8]Department of Neurology and Neurosurgery, Faculty of Medicine, McGill University, Montreal, QC, Canada

Language is an important aspect of social human behaviour, with speech processing forming an important part. Given that we are often in sub-optimal listening conditions (e.g., noisy restaurant) it is important to be able to perceive/comprehend speech in noise (SPiN). SPiN can be difficult, and in bilinguals it has been found that SPiN is more difficult in a second (L2) compared to a first language (L1). Previous research has focussed on the use of contextual information in L1 and L2 to support SPiN; however, little research has focussed on SPiN in informationally impoverished situations. We examined SPiN in both languages of highly proficient French/English bilinguals who varied in terms of when they learned their L2, with a focus on SPiN conditions where contextual information was absent. We hypothesized that age of L2 acquisition (AoA) would not impact SPiN in L1; however, in L2 we expected earlier AoA to be associated with better performance and patterns of brain activation suggestive of less effortful processing. Participants were 31 highly proficient French/English bilinguals comprising three groups matched in terms of demographic variables, but varying with respect to when they learned their L2. The groups included simultaneous bilinguals who learned both of their languages from birth (n=10; mean AoA=0

years), early sequential bilinguals who learned their L2 before the age of 6 years (n=13; mean AoA=4.7 years), and late sequential bilinguals who learned their L2 after age 6 (n=8; mean AoA=7.4 years). Participants were presented with sentences where the final word was of high vs. low predictability while they were in the fMRI scanner and were asked to repeat the final word of the sentence. Sentences were presented in English or French and in noise or quiet in a within subjects design. Behaviourally, late sequential bilinguals did not benefit from context in their L2 in noise. fMRI results showed no group differences in the brain regions recruited in L1; however, in L2, the three groups differentially recruited brain regions previously associated with difficult speech processing (i.e., the left inferior frontal gyrus; LIFG) in response to contextually and acoustically impoverished stimuli, with sequential bilinguals showing greater recruitment of this region for high than low predictability stimuli and the opposite pattern in simultaneous bilinguals. Our behavioural results show that SPiN is more effortful in an L2 compared to an L1 and unlike simultaneous and early sequential bilinguals, late sequential bilinguals are not able to benefit from contextual information in their L2. The neuroimaging data show that the LIFG is recruited differentially in an L2 as a function of AoA, with sequential bilinguals showing greater recruitment for high than low predictability stimuli. These findings suggest that early and prolonged exposure to an L2 is advantageous in terms of L2 SPiN processing, with bilinguals who learn their L2 early being better able to make use of contextual information to support SPiN.

A63 Effect of language context on accented words in bilinguals

Hia Datta[1], Arielle Mayer[1]; [1]Molloy College

It is clear from existing research that individuals who experience more than one language (multilingual, here bilingual individuals) during their lives, process and organize them differently from those who experience only one language (monolingual individuals) (Fabbro, 2001, for review). We wanted to understand how bilingual individuals organize their phonological systems, and how that interacts with their lexicons in the two different languages. Researchers argue that bilinguals either organize their two phonological systems as independent or composite systems (Peltola et. al, 2012). The organization of phonological systems in the bilingual brain can impact how words in two languages are processed and accessed, especially when the language context varies. Recent studies have demonstrated that changing the language context may change the perception of speech sounds common to both languages (Peltola 2010, 2012; Garcia-Sierra et al. 2012) but only in dominant and not balanced bilinguals. Conversely, Winkler et. al (2003) reported that language context does not affect speech processing in bilingual individuals. We are investigating how language context influences processing of English- and Spanish-accented words in late dominant and early balanced Spanish-English speaking individuals. To explore this, we designed a pilot study using Event Related Potentials (ERPs) in a picture-word priming task. The priming task is expected to elicit a larger ERP (N400) when the word and the picture mismatch compared conditions in which they match. Three Spanish-English bilingual individuals were tested in both Spanish and English language contexts, each on a different day. The desired context was created through instructions, conversation and a 10-minute video in each language. 60 picture-word pairs were tested in three conditions: a) the matching condition in which the picture and the words matched completely (/ʃip/-/ʃip/) b) the accented-mismatch category: in which the picture was paired with a Spanish accented-word (/ʃip/-/ʧip/) and c) a complete mismatch condition in which the picture was paired with a totally mismatched word (/ʃip/-/zip/). We predicted that if language context influenced the participants, they would elicit smaller N400s in the accented-mismatch condition compared to the complete mismatch condition. This would be true in the Spanish context rather than in the English context, since in the Spanish context, the Spanish accented English words would be perceived as legitimate matches for the paired pictures (e.g., the word ʧip would be perceived as ʃip). Preliminary results indicated that only the balanced bilingual individual was influenced by context, and performed as predicted, eliciting a smaller N400 in the accented-mismatch condition in Spanish relative to the English context. In contrast, the two dominant Spanish-English bilinguals, whose stronger language was English, were insensitive to the accented-mismatches in either language context. We are in the process of collecting more data to investigate whether language context influences lexical processing in early balanced but not late dominant bilingual individuals.

A64 Learning words from a new language changes processing of native language words

Gabriela Meade[1,2], Phillip J. Holcomb[1]; [1]San Diego State University, [2]University of California, San Diego

A number of studies have documented how learning novel words from a second language (L2) changes the N400 elicited by those words. Here, we focused instead on how learning novel L2 words changes the N400 response to native language (L1) English words. In Experiment 1, participants were tested in a language decision task (i.e., is this word from English or from the other language?) before and after they learned to associate a set of L2 (pseudo) words with pictures of familiar objects. Surprisingly, the N400s elicited by the L1 words increased from pretest to posttest. This effect is unlikely due to repeating the task, since N400 amplitude typically decreases across repetitions. Rather, we hypothesized that the increase in N400 amplitude after learning resulted from an increase in either lexicosemantic processing or task difficulty. Before learning the L2 words, only L1 words had lexical representations and reliable language decisions could easily be made based on superficial lexicosemantic information (i.e., have I seen this word before?). After learning, words from both

languages had lexical representations and completing the task likely required activating specific information about each word (e.g., semantics, language membership), which may have created a more challenging task environment. Experiment 2 was designed to dissociate between these two alternatives. In the same task, we compared processing of concrete and abstract L1 words before and after a new group of participants learned a different set of novel L2 (pseudo)words. The increase in N400 amplitude from pretest to posttest that we observed in Experiment 1 was largely specific to concrete L1 words. This pattern is more consistent with deeper semantic processing of the L1 words after learning than it is with an overall increase in task difficulty; changes in task difficulty should have affected concrete and abstract words similarly. Together then, these results demonstrate that having acquired the L2 words influenced the way in which L1 words were processed.

A65 Variability in BOLD correlates of semantic judgment reduces with proficiency among L2 learners

Angela Grant[1,2], Ping Li[1]; [1]The Pennsylvania State University, [2]Concordia University

Research on second language (L2) acquisition has identified a common network of regions recruited during L2 processing: the language control network (Abutalebi & Green, 2007). Activity in this network, which includes prefrontal cortex, anterior cingulate cortex (ACC), basal ganglia and the inferior parietal lobule, is thought to be inversely correlated with proficiency, such that less proficient learners show more activity (Abutalebi, 2008). Yet, these regions are also frequently implicated in studies of proficient and even simultaneous bilinguals (e.g., Román et al., 2015). Our study uses a multivariate decoding technique in addition to traditional univariate analyses to better differentiate the effects of proficiency on the recruitment of regions in the language control network. Specifically, we used a support vector machine classifier as part of the Decoding Toolbox (Hebart, Görgen & Haynes, 2014) to categorize data from high and low proficiency L2 learners who completed a semantic judgment task. Our analyses find that the classifier was able to identify similar multi-voxel patterns in the caudate nucleus (part of the basal ganglia), ACC, and inferior frontal gyrus (IFG) among high proficiency, but not low proficiency learners. The reduced variability present in the BOLD signal was also accompanied by reductions in variability on a variety of behavioral tasks, including the semantic judgment task itself, participants' self-ratings of L2 proficiency, and their L2 verbal fluency. Our multivariate decoding analyses complement our univariate analysis, which found significantly higher activation in the caudate for the low proficiency learners, while the ACC and IFG did not differ significantly in their gross activation level between the two groups. The combination of univariate and multivariate analyses of L2 BOLD data show that the effects of proficiency are not limited to overall activation level in the language control network. As learners increase in proficiency, the multi-voxel activation patterns within those regions also change to become more consistent, even across learners. Furthermore, the fact that the classifier identified regions in the language control network from a searchlight analysis of the whole brain provides novel support for the importance of the language control network as identified by Abutalebi and Green (2008; Green & Abutalebi, 2013).

A66 Context-dependent filtering in the caudate nucleus of the basal ganglia as a predictor of second-language learning aptitude

Jose M. Ceballos[1,2], Brianna L. Yamasaki[1,2], Chantel S. Prat[1,2]; [1]University of Washington, [2]Institute for Learning & Brain Sciences

Existing research has demonstrated that adults who are better able to extract relevant linguistic cues during L2 learning show better long-term L2 learning outcomes (Miyake & Friedman, 1998). The basal ganglia, a set of interconnected subcortical nuclei, have been identified as key structures for the filtering of contextually relevant information in and out of prefrontal cortex (PFC: Stocco, Lebiere & Anderson, 2010; Cohen & Frank, 2009). Furthermore, successful behavioral performance has been demonstrated to be mediated by the selective coding of task-relevant information by PFC (Duncan, 2010). Based on this research, we hypothesized that individual differences in basal ganglia functioning during a filtering paradigm would successfully predict L2 learning aptitude. To test this prediction, we modified an information-filtering task (Thompson & Duncan, 2009) in which individuals were asked to track one of two semantic features of words presented serially, based on a context-establishing instruction phase. Twenty subjects performed this task while fMRI data were acquired. Subsequently, subjects underwent an eight-week L2 learning period using an immersive French instruction software (Prat, Yamasaki, Kluender & Stocco, 2016). A region of interest (ROI) analysis for the basal ganglia left hemisphere regions of the caudate, putamen, and subthalamic nucleus was conducted in order to relate activity in these brain regions to L2 learning outcomes. Results from the ROI analysis revealed that caudate activation significantly predicted L2 learning outcomes. Specifically, the results revealed a negative correlation between caudate activation during instructions and average quiz accuracy [$r(20) = -0.55$, $p = 0.015$]. These results suggest that individuals with lower L2 learning aptitude rely more heavily on the caudate nucleus in the instruction phase of the filtering task, during which the trial-relevant filtering context is established. In other words, higher L2 learning individuals relied less heavily on signaling from the caudate in order to establish coding selectivity of task-relevant information in PFC structures, possibly due to higher neural efficiency in fronto-striatal dynamics. Overall, this study furthers the field's understanding of the often-understudied fronto-striatal network in L2 acquisition, and provides support for an account of skilled L2 learning that is dependent

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A67 Spontaeous fluctuations of dorsal and ventral reading networks in bilinguals

Jaione Arnaez-Telleria[1], Myriam Oliver[1], Manuel Carreiras[1,2], Pedro M. Paz-Alonso[1]; [1]BCBL. Basque Center on Cognition, Brain and Language, Donostia-San Sebastian, Spain., [2]IKERBASQUE, Basque Foundation for Science, Bilbao, Spain.

Over half of the world's population is bilingual. Despite this fact, most neuroimaging research on reading has studied monolingual readers. Although we know that learning to read in the native language (L1) entails a substantial reorganization of the brain, there are many questions still unanswered about bilingualism and the neural dynamics supporting reading in L1 and in a second language (L2). The dual-stream hypothesis proposes a differential involvement of left-lateralized ventral and dorsal networks in reading processes: Whereas the ventral pathway, including the ventral occipito-temporal cortex (vOT) and anterior inferior frontal gyrus (IFG) regions, supports mapping of orthographic-lexical stimuli onto semantic representations; the dorsal pathway, encompassing parietal lobe, superior temporal gyrus (STG) and IFG pars opercularis, is thought to subserve phonological processing. Although this model has received extensive support from neuroimaging research, it has not been systematically examined in bilinguals and in relation to the main critical factors associated with changes in in the neural correlates of bilingual reading, such as the L2 age-of-acquisition (AoA). Here, we sought to investigate differences in resting-state functional connectivity MRI (rs-fcMRI) within ventral and dorsal reading networks used for L1 and L2 reading as a function of the L2 AoA, while matching participants' age, language proficiency and daily exposure to their L1 and L2. Sixty-five right-handed Spanish monolinguals (n = 22) and Spanish-Basque bilinguals, who acquired their L2 before age 3 (early bilinguals; n = 21) or after age 6 (late bilinguals; n = 22), participated. All of them had minimal exposure to other languages. Based on a L1 and L2 fMRI reading task we identified the highest local maximas for each of the main left and right-lateralized nodes within the ventral (vOT, pars triangularis, pars orbitalis) and dorsal (inferior parietal cortex, STG, pars opercularis) reading networks separately per group (monolinguals, early bilinguals, late bilinguals) and language (L1, L2). Coordinates from these local maximas were used as the centers of mass to build 5-mm radius spheres that were submitted to rs-fcMRI analyses. For all analysis involving L2, monolinguals were excluded and were used as a control group to compare their results with those of the bilinguals in their L1. Results showed that all three groups (i.e., monolinguals, early bilinguals, late bilinguals) exhibited a similar rs-fcMRI pattern for L1 reading nodes across both ventral and dorsal networks. However, changes in the coactivation profiles at rest were observed among early and late bilinguals. Whereas early bilinguals showed a stronger coupling for L2 than for L1 nodes across both reading networks, late bilinguals exhibited a Language by Network interaction due to a significant decrease in the coactivation of the ventral network for L2 relative to L1 reading nodes and a subsequent stronger coupling of the dorsal compared to the ventral network for L2 reading nodes. Our findings suggest a shift in the reliance of the spontaneous fluctuations carried out by the ventral route from L1 to L2 reading, constituting the strongest evidence of changes in large-scale reading networks in bilinguals as a function of the L2 AoA.

A68 The Role of Basal Ganglia Filtering Mechanisms in Second Language Aptitude

Brianna L. Yamasaki[1], Jose M. Ceballos[1], Chantel S. Prat[1]; [1]University of Washington

The goal of the current experiment was to investigate the hypothesis that individual differences in basal ganglia (BG) signal routing mechanisms are central to second language (L2) aptitude. This research was motivated by findings demonstrating that the BG dynamically weight signals based on contextual cues, and project these filtered signals to the prefrontal cortex (PFC: e.g., Stocco, Lebiere & Anderson, 2010). Additionally, recent studies have suggested that BG functioning is impaired in language impoverished populations (e.g., Prat, Stocco, Neuhaus, & Kleinhans, 2016) and enhanced in individuals with high verbal-working-memory capacity (e.g., Prat & Just, 2011). Furthermore, the functioning of this circuit has been hypothesized to be central to bilingual language control, as bilingual individuals must select between co-activated language representations dynamically as their speaking context changes (Stocco, Yamasaki, Natalenko, & Prat, 2014). Thus, we proposed that the ability to prioritize contextually relevant information (as measured by BG signal routing) would predict individual differences in L2 aptitude. To test this prediction, we modified a working memory task used by McNab and Klingberg (2008), in which individuals were either asked to remember the

location of all presented stimuli, or of only a subset. McNab and Klingberg (2008) showed that activity in the BG during the cue to "filter" was predictive of subsequent memory performance. Our modified version used word stimuli, and semantic categories as the "filter" cue. Sixteen participants completed this neuroimaging task before participating in an eight-week language training program (Prat, Yamasaki, Kluender & Stocco, 2016). Dynamic Causal Modeling was used to measure BG signal routing, and the parameters from the best fitting model were then correlated with performance accuracy during learning. Results showed that the strength of signal modulation between BG and PFC during "filter" instructions predicted better performance during L2 learning ($r(14) = .613$, $p = .020$). These findings support the hypothesis that individual differences in BG signal filtering relate to the ability to acquire an L2 in adulthood, and contribute to a broader literature on the role of fronto-striatal communication in linguistic function and dysfunction. References McNab, F., & Klingberg, T. (2008). Prefrontal cortex and basal ganglia control access to working memory. Nature Neuroscience, 11(1), 103-107. Prat, C. S., & Just, M. A. (2011). Exploring the neural dynamics underpinning individual differences in sentence comprehension. Cerebral Cortex, 21(8), 1747-1760. Prat, C. S., Stocco, A., Neuhaus, E., & Kleinhans, N. M. (2016). Basal ganglia impairments in autism spectrum disorder are related to abnormal signal gating to prefrontal cortex. Neuropsychologia, 91, 268-281. Prat, C. S., Yamasaki, B. L., Kluender, R. A., & Stocco, A. (2016). Resting-state qEEG predicts rate of second language learning in adults. Brain and Language, 157, 44-50. Stocco, A., Lebiere, C., & Anderson, J. R. (2010). Conditional routing of information to the cortex: A model of the basal ganglia's role in cognitive coordination. Psychological Review, 117(2), 541. Stocco, A., Yamasaki, B., Natalenko, R., & Prat, C. S. (2014). Bilingual brain training: A neurobiological framework of how bilingual experience improves executive function. International Journal of Bilingualism, 18(1), 67-92.

Meaning: Prosody, Social and Emotional Processes

A69 Processing of contrastive pitch accent in native and L2 English speakers

Aleuna Lee[1], Lauren Stookey[1], Edith Kaan[1]; [1]University of Florida

Previous research on sentence processing has suggested a role of prosodic information like contrastive pitch accent as a cue to define a focus set and restrict upcoming referents (Eberhart et al., 1995; Dahan et al., 2002; Ito & Speer, 2008). The aim of the present ERP study was to investigate the use of contrastive pitch accent during comprehension of English discourse in native (N = 27) and Mandarin-Chinese second-language (L2) speakers of English (N = 17). EEG was recorded while participants listened to short passages in English starting with context sentences (e.g., "Josephine and Gregory are always helpful. They offered us transportation.") followed by four types of critical sentence that differed in the presence of pitch accent on the second proper noun and types of object mentioned. (Sample stimuli: (a) No accent, Different: "We took Josephine's car but left Gregory's bike in the garage"; (b) Accent, Different: "We took Josephine's car but left GREGORY's bike in the garage"; (c) No accent, Same: "We took Josephine's bike but left Gregory's bike in the garage"; (d) Accent, Same: "We took Josephine's bike but left GREGORY's bike in the garage"). The second proper noun ("Gregory's") either carried a contrastive pitch accent (b, d), or did not (a, c); the following noun ("bike") was either different (a, b) or the same (c, d) as the object mentioned previously. If listeners use contrastive pitch accent to anticipate a reference to a previously mentioned type of object, the reference to a different object in (b) should lead to integration difficulty, whereas in (c) the repetition of the noun should be perceived as infelicitous without prosodic marking. Overall, our results showed that both groups of participants were sensitive to prosodic prominence; however, the groups differed in how they used such information. Native English speakers showed a positivity between 200-500 ms for accented versus non-accented proper nouns ("Gregory's"), while such effect was only numerically present in the L2 speakers. When the proper name was accented and the following noun referred to a different object (b), ERPs to the second object ("bike") showed a fronto-centrally distributed negativity between 200-500 ms, resembling the NREF for referential difficulty (Van Berkum et al., 2003). When the proper name was accented and the noun was repeated (d), the N400 at the noun ("bike") was most reduced compared to the other three conditions in native speakers of English. Consistent with previous research, such N400 effects demonstrated semantic facilitation when felicitous intonation was presented, and difficulty with an inappropriate pitch accent (Sedivy et al., 1995; Ito & Speer, 2008). On the other hand, the fronto-central effect and the N400 were most pronounced in the L2 speakers when the proper noun was not accented and followed by a different object (a), whereas the fronto-ce! ntral effect was most reduced in the No-accent, Same condition (c). This suggests that Mandarin-Chinese L2 English speakers have a strong preference for a continuation with the same type of object; and interpret contrastive accent as licensing reference to different objects.

Perception: Auditory

A70 The Motor System's [Modest] Contribution to Speech Perception

Ryan Stokes[1], Jonathan H. Venezia[1], Gregory Hickok[1]; [1]University of California - Irvine

Recent evidence suggests that the motor system may have a facilitatory role in speech perception during noisy listening conditions. Studies have shown both a connected system and a causal role for motor involvement. However, in these studies evidence was collected at only one signal to noise ratio (SNR). If conditions must be noisy before

motor involvement is necessary, then effects will be contingent on the SNR at which they are tested. We used articulatory suppression to occupy motor areas, and a phonemic discrimination task along a range of SNR's. These data, along with passive listening controls, informed psychometric functions, which can be used to better understand the relationship the motor system has with perception. Such a relationship was found, but confined to a limited range of listening conditions. Our findings show that the steep slope of the functions generated exaggerate the minimal effect motor suppression has on perception.

A71 The role of prosody on processing wh-questions and wh-declaratives: An auditory ERP study

Yang Yang[1,2], Leticia Pablos[1,2], Stella Gryllia[1], Niels Schiller[1,2], Lisa Cheng[1,2]; [1]Leiden University Center for Linguistics, [2]Leiden Institute for Brain and Cognition

[INTRODUCTION] Previous behavioral studies showed that clause-type (question or declarative) is prosodically marked and listeners can identify clause-type based on prosody. Nonetheless, little is known about how exactly prosody influences the clause-type identification and how early prosody plays a role in processing. We fill this gap by conducting an auditory ERP study on Mandarin wh-questions, their string-identical wh-declaratives (declaratives containing wh-words) and the cross-spliced cases from the wh-word onwards. The reasons we chose this paradigm are: 1) Mandarin wh-questions and wh-declaratives offer a good test case for prosodic marking of clause-types, as Mandarin is not only a wh-in-situ language where wh-words remain at their base positions but also a wh-indeterminate language where the same wh-word such as shénme can have both interrogative ('what') and non-interrogative interpretations ('something'). 2) Our previous production and perception studies show that wh-questions and wh-declaratives are marked by different prosody, in particular the wh-word shénme (a high pitch and expanded pitch range in questions while a low and flat pitch in declaratives) and that listeners can identify clause-type by hearing shénme accurately. [PRESENT STUDY] An ERP study was conducted with 24 Mandarin native speakers listening to sentences preceded by contexts (2-3 sentences) that bias towards either wh-questions or wh-declaratives. The contexts in each set are only different at the final sentence (i.e., 'XX asked:' biases towards a question versus 'This is something XX is sure of:' biases towards a declarative). After cross-splicing the auditory recording of wh-questions and wh-declaratives from shénme onwards, we obtained four conditions in each set: (a) Declarative-biased context, wh-declarative prosody (subject-adverb-verb-di□nr-shénme-prepositional phrase). (b) Wh-question-biased context, wh-question prosody (sub.-adv.-verb-di□nr-shénme-pp). (c) Declarative-biased context, wh-declarative prosody (sub.-adv.-verb-di□nr) cross-spliced with wh-question prosody (shénme-pp). (d) Wh-question-biased context, wh-question prosody (sub.-adv.-verb-di□nr) cross-spliced with wh-declarative prosody (shénme-pp). By comparing anomalous condition (c) with (a) and anomalous condition (d) with (b), we expect to find prosodic mismatch effects such as early anterior negativities or RAN effects. In addition to prosody-related effects, we may also find N400 effects in (c) and (d), if the semantic violation based on prosody is immediately detected (i.e., in condition (c) shénme with high pitch and expanded pitch range associated with the interrogative interpretation ('what') is in violation with the expected non-question interpretation). [RESULTS & DISCUSSION] Repeated Measure ANOVA analyses showed that when comparing cross-spliced condition (c) with (a), the critical word shénme in (c) elicited negativities in the 200-400ms time-window in the anterior region. The 200-400ms anterior negativities can be interpreted as an early detection of prosodic mismatch in the cross-spliced conditions, which offers evidence for the early and essential role of prosody in processing wh-questions and wh-declaratives. It is of interest that we did not find any significant differences by comparing cross-spliced condition (d) with (b). We interpreted this as a possibility that participants accommodate anomalous condition (d) easily into wh-questions and thus no mismatch effects were observed. As questions and declaratives do not seem to be accommodated the same way, further work needs to be done to investigate this asymmetry in accommodating clause-types.

A72 Convergence of spoken and written language processing in the superior temporal sulcus

Stephen M. Wilson[1], Alexa Bautista[2], Angelica McCarron[2]; [1]Vanderbilt University Medical Center, [2]University of Arizona

The cortical pathways for the processing of spoken and written language have been shown to converge in the superior temporal sulcus (STS). However, the STS contains numerous subdivisions with distinct cytoarchitectonic properties and connectivity profiles, and has been implicated in a wide range of linguistic processes. The overall goal of this study was to better understand the functional and anatomical details of exactly how spoken and written language processing streams converge in the STS. This depends on clarifying the functional parcellation of the STS, which is challenging because of the seamlessly integrated linguistic processes that take place in this region, and because of the inherent physical proximity of the anatomically distinct dorsal and ventral banks. To address these challenges, we quantified neural responses to spoken and written language along with unintelligible stimuli in each modality, employed univariate as well as multivariate analyses, and maximized spatial resolution by using several strategies, including hypercapnic normalization, and masking of veins identified on susceptibility-weighted imaging. We found that the posterior dorsal bank of the STS responded to intelligible and unintelligible inputs in both modalities, yet was able to discriminate between modalities based on distributed multi-voxel patterns of activity. This suggests that the posterior dorsal bank is the

first site at which spoken and written inputs converge. Its response profile is consistent with a role in encoding of phonological and orthographic word forms. The anterior dorsal bank of the STS also responded to intelligible and unintelligible inputs in both modalities, yet unlike the posterior dorsal bank, it was agnostic to input modality, suggesting that this region represents abstract lexical nodes. In the ventral bank of the STS and adjacent gyri, responses to unintelligible inputs in both modalities were attenuated, while intelligible inputs continued to drive activation, indicative of higher level semantic and syntactic processing. Taken together, our results suggest that the processing of spoken and written language converges on the posterior dorsal bank of the STS, which is the first of a heterogeneous set of language regions within the STS, with distinct functions spanning several levels of linguistic processes and representations.

A73 Stress-timing via Oscillatory Phase-locking in Naturalistic Language

Phillip M. Alday[1,2], Andrea E. Martin[1,3]; [1]Max-Planck-Institute for Psycholinguistics, [2]University of South Australia, [3]University of Edinburgh

Linking hypotheses between cortical oscillations and the hierarchical structure of speech and language posit a correspondence across multiple timescales and levels of representation: fine speech structure is represented in the gamma band, while the speech envelope, i.e. syllables and words, in the alpha and theta bands (Ding et al., 2016; Giraud & Poeppel, 2012; Peelle & Davis, 2012). However, these studies have largely focused on oscillatory power as well as auditory power (i.e. the speech envelope) and have ignored oscillatory phase. Oscillatory phase has also been proposed to entrain to speech rhythms, leading to optimised sampling of the speech signal (Gross et al. 2013). However, these proposals fail to account for acoutic-phonological realizations of basic linguistic structure, such as phonological stress. Here we used pitch and intensity information as automatically measurable acoustic proxies for phonological stress (using Praat) and compared them to oscillatory phase across the frequency spectrum from 1 to 30 Hz. The EEG data were reanalyzed from Alday et al. (biorXiv) with 50 participants listening to a 23 minute long story in German read by a trained native speaker. Correlating the sine of the oscillatory phase with pitch and intensity revealed a strong peaks around 3--4 Hz and secondary peak around 7--8 Hz. The 4 Hz peak provides converging evidence that linguistic stress serves as a time-locking event for speech-tracking in the theta band, i.e. that linguistic stress serves as a phase-resetting event to (re-) align the stimulus rhythm with cortical rhythms, which are unable to change their period. The peak in the low alpha band maches previous studies which have shown that data stress is reliably detected in the time domain, i.e. ERPs, which are thought to reflect alpha phase resetting at least in part (cf. Knaus 2013, Min et al. 2007, Hanslmayr et al. 2007). Linguistic stress thus reflects the fundamental organizational unit in spoken language, working as a pacemaker and providing necessary structure for the frequency domain. In natural speech, asynchronous speech, syllables are irregular in length and timing and provide a poor fundamental unit. Instead stress provides the timing foundation upon which further phonological structure, e.g. syllables, and then morphosyntactic structure can built. Here, we demonstrated that the acoustic realizations of stress match the patterns predicted for syllables in oscillatory dynamics.

Phonology and Phonological Working Memory

A75 Phonological Feature Repetition Suppression in the Left Inferior Frontal Gyrus

Kayoko Okada[1], William Matchin[2], Gregory Hickok[3]; [1]Loyola Marymount University, [2]University of California, San Diego, [3]University of California, Irvine

Models of speech production posit a role for the posterior inferior frontal gyrus (pIFG) in encoding complex phonological representations for speech production, at the syllable or word-level. Here we add further support for such a role with an fMRI experiment of word sequence production using a phonemic similarity manipulation. We adapted and modified previously published experimental paradigm using tongue twisters. Subjects silently articulated words cued by sequential visual presentation that varied in degree of phonological feature overlap in consonant onset position: high overlap (two shared phonological features; e.g. /r/ and /l/) or low overlap (one shared phonological feature, e.g. /r/ and /b/). We found a significant repetition suppression effect in the left pIFG, with increased activation for phonologically dissimilar words compared to similar words.

A76 Brain responses to intensive intervention for reading disability

Einar Mencl[1,2], Stephen Frost[1], Dan Brennan[1], Jeff Malins[1], Kenneth Pugh[1,2,3], Robin Morris[4]; [1]Haskins Laboratories, [2]Yale University, [3]University of Connecticut, [4]Georgia State University

This ongoing project tracks children with standardized behavioral measures and pre-post neurobiological (fMRI) measures as they engage in a 70-week structured in-school reading intervention. All children are either low reading ability or meet criteria for reading disability, and have additionally demonstrated resistance to standard classroom literacy education. To date, 52 children have successfully completed the intervention sequence including behavioral testing and MRI scanning. Based on composite behavioral criteria (significant growth on Woodcock-Johnson 3 Passage Comprehension; Basic Skills; Reading Fluency; and Test of Transfer), 18 responded to the intervention and 34 did not. On average across all children, neuroimaging data revealed broad pre-to-post increases in brain responses to real printed words across several parts of the language/reading network, including the inferior

frontal gyrus; posterior superior temporal gyrus; and parts of the inferior parietal cortex. To more precisely control for maturation, time effects, and other nuisance variables in this sample, we further examined which brain areas changed more in Responders versus Non-Responders. This analysis revealed specific increases in the middle temporal gyrus, inferior frontal gyrus, and the inferior occipito-temporal cortex. Taken together, these results suggest that successful response to intervention is related to the coordinated, increased engagement of a set of specific brain areas previously known to support both phonological processing (middle temporal and inferior frontal) as well as putatively visual processing (ventral stream).

A77 A tDCS study of the implicit learning of foreign cognate and non-cognate words

Joshua Payne[1], Paul Mullins[1], Marie-Josephe Tainturier[1]; [1]Bangor University

Some studies suggest that transcranial direct current stimulation (tDCS) over left temporoparietal cortex can enhance the acquisition of new words in healthy adults, as this region is thought to be involved in the acquisition of form-meaning connections. The goal of our study was to extend these findings to a real foreign language and to examine the relative effects of stimulation on cognate and non-cognate words as a function of phonological memory ability. We expected cognate words to be learned and retained more easily and that tDCS would enhance learning, particularly for non-cognates. In addition, we expected tDCS facilitation to be more pronounced for participants with poorer phonological memory. Methods: Thirty-two monolingual English speakers completed three experimental sessions on consecutive days, and a follow-up session one week later. We recorded accuracy and RTs during implicit vocabulary learning tasks, adapted from Flöel et al. (2008), conducted in two consecutive sessions (1mA active vs. sham tDCS). Half of the target Dutch nouns were non-identical cognates (BOOK -> boek) and half matched non-cognates (WINDOW -> raam). Backward translation tasks were used to assess learning and retention, immediately, the following day, and a week following acquisition. tDCS was applied single-blind to the left temporoparietal region, with anode centred over CP5, and a contralateral supraorbital reference. Phonological memory ability was measured using the CTOPP-2. Results: Mixed effects analyses showed significant gains in overall vocabulary acquisition, with a Dutch-English cognate advantage. Performance for cognates in backward translation tasks was stable at all three post-stimulation time points. Non-cognates showed initial increases in performance the day after learning, which decayed a week later. At the group level, performance during and after active tDCS did not differ significantly from sham. We observed a significant interaction between Phonological Memory, Stimulation and Cognate Status. Participants with poorer phonological memory learned more non-cognates during active tDCS versus sham. Unexpectedly, those with higher phonological memory showed an overall decrement in performance during active stimulation. Phonological Memory did not significantly modulate the effect of tDCS on backward translation. Discussion: Even following brief exposure to a FL, phonological form similarity affects how easily meaning can be acquired for translation equivalents in an implicit learning task. We observed specific effects of tDCS for people with lower phonological memory abilities in line with some recent findings in older adults. The novel finding that tDCS negatively impacts performance for participants with higher phonological memory may be due to an overstimulation of temporal cortex in this group, in line with a population coding account of tDCS effects. Response times analysis is in progress, which may be more sensitive to the effects of stimulation for better learners and/or cognate stimuli. Multiple stimulation sessions may also be more effective, particularly in young people. Direct comparison of multiple montages and systematic exploration of multiple tES techniques/parameters (e.g., tRNS, multi-session) would provide insight into potentially subtle neural changes. Manipulation of key psycholinguistic variables, such the phonological similarity manipulation we employed, may highlight the specific role of regions inovlved in lexical processing and language learning.

A78 Sensory memory for phoneme sequences within spoken words in native-English and native-Polish listeners

Monica Wagner[1], Jungmee Lee[2], Valerie Shafer[3]; [1]St. John's University, [2]University of South Florida, [3]The Graduate Center, CUNY

The refractory response within the auditory evoked potential (AEP) to repetition of a same word compared to the response to repetition of a different word is of interest as a measure of sensory memory in individuals with auditory processing deficits. Thus, to understand normal processes of sensory memory, the current study examined the effects of attention and language experience on sensory memory for phoneme sequences in native-English and native-Polish adults. Participants listened to same and different nonsense word pairs within two experimental task conditions designed to modulate attention. During one of two testing sessions, participants listened to word pairs and performed a syllable identification task to the second word in the pairs ("With Task") and in the alternate testing session, participants listened to word pairs without performing a behavioral task ("Without Task"). These experimental task conditions were presented to two groups of 24 participants (48 participants) in a counterbalanced sequence (96 testing sessions). Each group of 24 participants consisted of 12 native-English and 12 native-Polish adults. Nonsense word pairs contained a phoneme sequence contrast (/st-sət/) that occurs in both the English and Polish languages in word onset and a phoneme sequence contrast (/pt-pət/) that occurs in only the Polish language in word onset. The AEP response to the target word (i.e., second word) in the same pairs (e.g., /pətima-pətima/) and different pairs (/ptima-pətima/)

was analyzed. The target word in the same and different pairs was unchanged. Thus, a larger response to the target in the different pairs relative to the target in the same pairs suggests that the brain registered the additional sound in the different pair. Preliminary examination of results at averaged fronto-central electrode sites revealed an effect of native-language experience, attention and salience at approximately 400 ms. Specifically, the larger positive response to the different target relative to the same target was either present or clearly more prominent for the "With Task" relative to the "Without Task" experimental conditions, which suggests an effect of attention. Also, language experience with a phoneme sequence contrast as well as frequency of the phoneme sequence contrast within the language influenced the detection response. For example, in the "With Task" conditions, the response to the different target relative to the same target was larger for the /pt-pət/ contrast in the Polish listeners than the English listeners and the response to the /st-sət/ contrast was larger in the English listeners than the Polish listeners. Also, the English group showed a larger response to the /st-sət/ contrast than the Polish group showed to the /pt-pət/ contrast, suggesting an effect of salience of the phonemes. These results suggest that attention, native-language experience and frequency of input of a phoneme sequence within a language should be considered when examining sensory memory for phoneme sequences.

Speech Motor Control and Sensorimotor Integration

A79 Oral cavity numbing reduces sensorimotor adaptation to altered auditory feedback

Hardik Kothare[1,2], Inez Raharjo[1,2], David Klein[3], Danielle Mizuiri[1], Kamalini Ranasinghe[1], Shethal Bearelly[1], Steven W. Cheung[1], Srikantan Nagarajan[1], John F. Houde[1]; [1]University of California, San Francisco, [2]University of California, Berkeley, [3]New York University

Sensorimotor adaptation experiments in speech have shown that the speech motor control system learns to partly compensate for consistent alterations of auditory feedback. These compensatory changes persist for some time even after the feedback alteration is removed. It has long been postulated that somatosensory feedback plays a modulatory role in constraining such adaptation to altered auditory feedback. Here, we examined this role by assessing the effect of orosensory numbing on adaptation to altered formant feedback. We conducted formant adaptation experiments with real-time alteration of formant frequencies. Participants (20 subjects in the lidocaine group, and 15 subject in the placebo group) were prompted to produce the word 'head' (vowel /□/) 90 times. The repetitions were split into a baseline non-altered-feedback block of 20 trials, followed by a hold block of 50 trials where the auditory feedback was altered by raising the first formant (F1) by 200 Hertz, followed by a non-altered-feedback washout block of 20 trials. Participants then swished for a minute with a numbing solution of 5ml of 4% lidocaine and 5ml of strawberry lemonade or (in the placebo group) 5ml of water flavoured with lemon rind and 5ml of strawberry lemonade. Effectiveness of numbing by lidocaine was verified using nylon monofilament sutures that mapped the tactile threshold of the tip of the tongue at various time points in the experiment. After swishing with either numbing or placebo solution (depending on group), the same formant adaptation experiment was then repeated. Pre-swish and post-swish adaptive responses were calculated in both the lidocaine group and the placebo group. Adaptation values along the F1 axis were normalised to individual baseline F1 frequency values. A generalised linear model (GLM) revealed that adaptation values were significantly reduced in the post-swish adaptation experiment for the group that swished with lidocaine ($p<0.0001$). This reduced adaptation for the lidocaine group remained significant in the washout block ($p=0.0019$). Reduced adaptive response in the hold block and washout block was not seen in the placebo group. To verify that somatosensory feedback was indeed altered by the lidocaine solution and not by the placebo solution, buckling force data for the filaments was run through a similar GLM model. Tactile sensitivity of the tip of the tongue was reduced significantly for the lidocaine group ($p<0.05$) and sensitivity remained unaltered for the placebo group. The observed reduction in adaptation to altered auditory feedback resulting from oral numbing runs counter to the enhancing effects numbing has been shown to have on immediate compensation for transient auditory perturbations in speaking. Nevertheless, these results are consistent with our State Feedback Control model of speech motor control.

Writing and Spelling

A80 Electrophysiological correlates of internal performance monitoring in typed language production

Svetlana Pinet[1], Nazbanou Nozari[1]; [1]Johns Hopkins University

Monitoring in spoken production can be accomplished via two channels: (a) an internal channel independent of overt auditory feedback, and (b) an external channel which processes the auditory feedback. The relative contribution of these two channels to monitoring is still debated. Complete blockage of the external channel in spoken production is challenging due to bone conduction. In typing, however, visual feedback can be easily suppressed. This study assesses the sufficiency of the internal channel by comparing behavioral and electrophysiological data during typing with and without immediate visual feedback. Behavioral and EEG data were collected from 17 neurotypical young adults while they typed 352 7-9 letter words from dictation under time pressure. Visual feedback was either delayed (experimental condition) or presented immediately during typing (control condition).

In the experimental condition, participants were asked to judge the accuracy of their response after each trial (metacognitive judgement), before delayed visual feedback was presented. We collected 809 errors in the experimental and 872 errors in the control conditions. The availability of visual feedback did not impact accuracy (experimental: 72.9 ± 19%, control: 70.9 ± 15%, $t(16) = 0.79$, $p = 0.44$), response latencies (experimental: 337 ± 40, control: 324 ± 45, $t(16) = 1.15$, $p = 0.27$), or typing speed (experimental: 144 ± 18 ms /keystroke, control: 140 ± 23 ms /keystroke, $t(16) = 1.42$, $p = 0.17$). However, a significantly lower percentage of errors was self-corrected in the experimental (7%) compared to control (42%) condition ($t(16) = -7.1$, $p < 0.001$). This discrepancy might imply that error detection in typing is heavily dependent on visual feedback. But metacognitive reports in the experimental condition showed that participants were aware of 51.9% of their errors (hit rate), and rarely detected a correct response as an error (4.6% false alarm; $d' = 1.7$). The latter finding points to an efficient internal channel for error detection. To examine how information from the internal (metacognitive judgments) and external (visual feedback) channels is combined, we analyzed the EEG signal at the time of feedback presentation, after metacognitive judgments. Feedback (correct/incorrect response) modulated a positive fronto-central component from 200 ms post feedback presentation. The effect of metacognitive judgments showed an interaction with feedback from 500 ms, creating four distinct waveforms, corresponding to correct rejections, hits, misses and false alarms with increasing positivity over centro-parietal electrodes. These results suggest that monitoring sequentially combines information from both external and internal channels. In summary, our behavioral results showed that even though correction rate was much lower with delayed visual feedback, error awareness rate in the absence of visual feedback matched the correction rate when visual feedback was immediate. These findings suggest that the internal channel is sufficient for error "detection", but error "correction" in typing depends heavily on the external channel. Post-feedback EEG results showed a clear pattern of combined sensitivity to information from both external and internal channels. These results constitute the first demonstration of EEG correlates of metacognitive awareness in language production.

Poster Session B

Wednesday, November 8, 3:00 – 4:15 pm, Harborview and Loch Raven Ballrooms

Control, Selection, and Executive Processes

B1 The role of individual differences in inhibition on sentence choice during speech

Malathi Thothathiri[1], Daniel Evans[1]; [1]The George Washington University

Language contains multiple structural options for expressing meaning (e.g., double-object dative (DO): Mark gave Laura the pen, prepositional-object dative (PO): Mark gave the pen to Laura). How do speakers choose between such competing options during sentence production? We hypothesized a role for exposure to different structures and individual differences in inhibition. We report behavioral and neuroimaging studies that tested these hypotheses and elucidated the neurocognitive mechanisms supporting choice during speech. The studies used a training and subsequent production paradigm that allowed us to manipulate language exposure within the lab. During training, participants watched puppet-enacted transfer actions, heard DO and PO datives, and repeated the sentences (e.g., Kate gave the tiger the cup). Ten dative verbs appeared twelve times each. Four verbs appeared only in DO (DO-only), four only in PO (PO-only), and two equally in the two structures (Equal-DO-PO). Assignment of verbs to exposure conditions was counterbalanced across lists. Subsequent to training, participants described new videos using dative sentences of their choice. The test videos contained different animals and objects than training. Eighty-eight participants completed the behavioral study. During test, they produced fewer DO than PO sentences overall, consistent with a dispreferrence for the DO dative found in previous studies. We sought to identify factors that enabled the production of the dispreferred structure. The results revealed: (a) A significant linear effect of exposure condition on proportion DO produced (DO-only>Equal-DO-PO>PO-only). Thus, exposure to verbs in the DO structure increased DO production with those verbs. (b) A significant correlation between inhibition (as measured by Stroop) and DO production in the Equal-DO-PO but not the other conditions. Thus, individuals with better inhibition were more likely to produce the dispreferred structure, but especially so for verbs that appeared equally often in two competing structures during training, replicating a previous study [1]. Twenty-five participants completed the neuroimaging study. The scan occurred within 1-3 days after training. DO productions following a DO versus a PO were analyzed separately due to known syntactic priming effects from a previous trial. Producing DO after a PO (i.e., changing from a primed structure) showed widespread activation that was positively correlated with Stroop performance. Individuals with better inhibition showed greater activation than those with poorer inhibition in medial and lateral frontal regions associated with executive function. Activation during DO production overlapped with activation during Stroop in the anterior cingulate cortex (ACC) only. Splitting by exposure condition, ACC activation showed a significant linear trend (DO-only<Equal-DO-PO<PO-only). Thus, the strongest activation was associated with producing DO structures with verbs that had only appeared in PO (and thereby involved overriding previous exposure). This overriding appeared to be costly, however. Individuals

showing strong ACC activation for DO production with PO-only verbs produced significantly fewer DO structures with those verbs. To summarize, individual differences in inhibition interacted with statistical properties of language exposure to determine how often speakers produced dispreferred versus preferred structures. Our novel behavioral and neuroimaging paradigm yielded mechanistic insights into how structural choices are made during speech. [1] Thothathiri & Rattinger (2015), PNAS.

B2 Sentence comprehension under conflict in aphasia

Malathi Thothathiri[1], Edward Wlotko[2]; [1]The George Washington University, [2]Moss Rehabilitation Research Institute

Sentence comprehension involves the integration of multiple (e.g., semantic and syntactic) cues. When these cues conflict, sentence interpretation may place increased demands on comprehension-relevant processes. We hypothesized that comprehension under conflict could rely on one or more of: (1) robust syntactic comprehension that can override other misleading cues; (2) short-term memory (STM) to store a sentence for re-parsing; and (3) executive function (EF) to resolve competition between interpretations. We conducted contrastive case studies of aphasic patients with different deficit combinations to elucidate the contribution of these processes to comprehension under conflict. Five patients with aphasia completed a battery of comprehension, STM, and EF tasks more than a year after their stroke (ages 53-72; 2 Male, 3 Female). Syntactic comprehension was assessed using a reversible-sentence-to-picture-matching task. For STM, we used rhyme probe, category probe, digit and word spans. For EF, we used the Stroop and Flanker tasks. We investigated how patients' performance in these tasks related to performance on the critical conflict sentence comprehension task. In this task, sentences contained either congruent or incongruent syntactic and semantic cues (Congruent: The rabbit was chased by the fox; Incongruent: The fox was chased by the rabbit). In the incongruent case, syntactic structure led to an interpretation that conflicted with semantic expectations (foxes usually chase rabbits rather than vice versa). Participants were asked to match the sentence (e.g., The fox was chased by the rabbit) to one of 4 pictures, which included the target picture (rabbit chasing fox), the reversed picture (fox chasing rabbit), and 2 unrelated distractors (chance assuming intact lexical comprehension=50%). One patient (S3) performed at chance in reversible sentence comprehension (53.3%, chance=50%), suggesting an inability to use syntactic cues for assigning thematic roles. A second patient (S2) was 60% accurate in reversible sentence comprehension and had clear STM deficits (Rhyme: 1.29, Category: 3, Digit: 2, Word: 1.33). In the syntax-semantics conflict task, both patients overrelied on semantic cues, leading to worse performance on conflict (S3=42.5%; S2=47.5%) than non-conflict sentences (S3=77.5%; S2=85%). Thus, impairment in syntactic comprehension and/or STM was associated with inaccurate sentence comprehension under conflict. The remaining three patients showed relatively more intact reversible sentence comprehension (S1=100%; S4=80%; S5=67%) and STM (e.g., Word span: S1=3.41; S4=3.01; S5=3.71). These patients were also relatively more accurate in the syntax-semantics conflict task (conflict vs non-conflict sentences: S1=97.5% vs 95%; S4=67.5% vs 87.5%; S5=75% vs 80%). All three patients showed exaggerated reaction time (RT) costs in EF tasks (e.g., Stroop: S1=46%; S4=62.8%; S5=88.5%), suggesting decreased efficiency in resolving conflict. These patients also showed high RT costs for conflict relative to no-conflict sentences (S1=12.2%; S4=34.4%; S5=15%. Compared to S2=2.6%; S3=-29.8%). Taken together, our results suggest that (1) sentence comprehension under conflict requires intact syntactic comprehension, as expected; (2) STM could be important for scaffolding sentence comprehension, especially under conflict; and (3) inefficient conflict resolution during EF tasks may correspond to inefficient but not necessarily inaccurate comprehension under conflict. These findings highlight the differential roles of processes needed for accurate and efficient sentence comprehension.

B3 Lexical Planning in Sentence Production Is Highly Incremental: Evidence from ERPs

Liming Zhao[1,2], Yufang Yang[2]; [1]Academy of Psychology and Behavior, Tianjin Normal University, [2]Institute of Psychology, Chinese Academy of Sciences

The scope of lexical planning, which means how far ahead speakers plan lexically before they start producing an utterance, is an important issue for research into speech production, but remains highly controversial. The present research investigated this issue using the semantic blocking effect, which refers to the widely observed effects that participants take longer to say aloud the names of items in pictures when the pictures in a block of trials in an experiment depict items that belong to the same semantic category than different categories. As this effect is often interpreted as a reflection of difficulty in lexical selection, the current study took the semantic blocking effect and its associated pattern of event-related brain potentials (ERPs) as a proxy to test whether lexical planning during sentence production extends beyond the first noun when a subject noun-phrase includes two nouns, such as "The chair and the boat are both red" and "The chair above the boat is red". The results showed a semantic blocking effect both in onset latencies and in ERPs during the utterance of the first noun of these complex noun-phrases but not for the second noun. The indication, therefore, is that the lexical planning scope does not encompass this second noun-phrase. Indeed, the present findings are in line with accounts that propose radically incremental lexical planning, in which speakers plan ahead only one word at a time. This study also provides a highly novel example of using ERPs to examine the production of long utterances, and it is hoped

the present demonstration of the effectiveness of this approach inspires further application of ERP techniques in this area of research.

B4 Prediction under Load: The Effects of Cognitive Load Presence and Type on Anticipation and Competition in Spoken Language Processing

Kate Pirog Revill[1]; [1]Emory University

There is an ongoing debate about whether prediction is fundamental to language processing or whether it is a cognitively costly strategy that is deployed only under likely circumstances. Further, there are questions about the level and specificity of the predictions that are made, and what mechanisms or brain systems are used to generate these predictions. Previous research has shown that participants make anticipatory fixations to likely target objects following a biasing verb. Fixations to phonological 'cohort' competitors are reduced when an incompatible biasing context is present. Here, we examine the effect of a resource-taxing memory load task on participants' abilities to use biasing verb information to make anticipatory fixations to likely targets or to reduce competition from inconsistent cohort competitors. Participants heard sentences like 'The person will sell/ drive the truck' while viewing displays containing a truck and several distracter objects, one of which could be a cohort competitor (trunk) that was a plausible completion following one verb but not the other. Before half of the trials, participants were given a list of spatial locations or a list of consonants to remember; they reported the list back following the selection of the sentence's referent. Participants remembered a three-item list of locations (squares in a 4x4 grid) equally as well as participants remembered a five-item list of consonants (from among 16 possible choices), correctly reporting back 91.7% and 92.0% of the memory items respectively. Main task accuracy also remained high (> 99%) despite the presence or type of cognitive load. Analysis of anticipatory eye movements showed a small but significant effect of cognitive load, as target curves were shifted 45ms later when a cognitive load was present. Despite the delay, participants made anticipatory fixations to potential target objects following a constraining verb in both load conditions, with target fixation curves shifted 205ms earlier relative to a nonconstraining verb. This effect did not interact with load presence and was not affected by whether the load was spatial or verbal. However, load presence and type did affect the amount of lexical competition from a displayed cohort competitor. As expected, there was a significant effect of verb constraint on the size of the competitor effect; participants fixated cohort competitors less when the verb was constraining than when it was not. Unlike anticipatory fixations, this effect interacted with load: the difference in cohort fixations between a biasing and neutral context was smaller when the participant had to maintain a memory load. Furthermore, load type may matter; participants were still able to use context from a biasing verb to reduce competitor fixations while maintaining a spatial memory load, but context did not significantly reduce competitor fixations for participants asked to maintain a verbal memory load. Taken together, this data suggests that while at least some forms of prediction in language processing are resistant to the presence of a secondary, resource-demanding task, other consequences of prediction, like the modulation of lexical competition, may be more demanding and may rely on domain-specific language production mechanisms.

B5 Neural tracking of attended continuous speech in monolinguals and early bilinguals

Andrea Olguin[1], Tristan Bekinschtein[1], Mirjana Bozic[1]; [1]University of Cambridge

A noisy acoustic background often surrounds speech and listeners have to isolate the target talker from the background in order to process a single speech stream. This selective attention results in stronger neural encoding of the attended speech envelope compared to the unattended one (Ding & Simon, 2014). A prominent but controversial hypothesis in the bilingualism literature states that knowing two languages leads to an enhancement in selective attention (e.g., Bak et al., 2014; Krizman et al., 2012, but see Paap et al., 2015), predicting that bilinguals will show different patterns of synchronisation between the neural activity and the attended speech envelope compared to monolinguals. We tested this hypothesis by tracking the neural encoding of attended continuous speech in monolinguals and early bilinguals in the context of different types of acoustic and linguistic interference. In the first study, 22 English monolinguals attended to a narrative in English presented to one ear, while ignoring interference presented to the other ear. Four different types of interference were presented to the unattended ear: a different English narrative, a narrative in a language unknown to the listener (Spanish), a well-matched non-linguistic acoustic interference (Musical Rain), and no interference. The neural activity was recorded by a dense array 128-channel EEG system and cross-correlated with the speech envelopes for both attended and unattended streams. Results showed that there was significantly more robust neural encoding for the attended envelopes than the ignored ones across all conditions. We also saw that the type of interference significantly modulated the encoding of attended speech, with the strongest encoding seen when the interference was in the same known language (English) and weakest when the interference was non-linguistic noise (Musical Rain). Unattended linguistic interference (in both English and Spanish) was encoded more strongly than the unattended non-linguistic noise, suggesting that different types of interference trigger different depths of processing analysis. The second study carried out the same dichotic-listening paradigm on 22 early Spanish-English bilinguals. Participants were instructed to attend to a narrative in Spanish presented to one ear, while ignoring one of four different types of interference presented to the unattended

ear: a different Spanish narrative, a narrative in a language unknown to the listener (Serbian), non-linguistic acoustic interference (Musical Rain), and no interference. Equivalent analyses showed a different pattern of results to that observed in monolinguals: early bilinguals appear to encode the attended and unattended streams equally when they are both in their native tongue (Spanish), but behave comparably to monolinguals with other types of interference. Taken together, these results demonstrate that top-down selective attention differentially modulates envelope encoding in early bilinguals and monolinguals. They will be discussed in the context of the relevant theories of selective attention and bilingualism.

B7 Prediction-related activity in the medial prefrontal cortex reflects processing of cataphor cues *Andrew Jahn[1], Dave Kush[2], Ashley Lewis[1], Julie Van Dyke[1]; [1]Haskins Laboratories, [2]Norwegian University of Science and Technology*

Introduction: The role of executive function in language - in particular, prediction and prediction error (PE) – is an area that has received increasing attention in linguistic research. To date, most linguistic studies using fMRI have focused on the left inferior frontal gyrus (LIFG) as a key hub in both syntax-processing and cognitive control of interference (Novick et al., 2005; Rogalsky et al., 2008). However, recent computational models of executive function have shown the medial prefrontal cortex (mPFC) to be involved in prediction and PE across a wide range of experimental contexts. We sought to test the predictions of one of these computational models (Alexander & Brown, 2011) in a linguistic context. According to this model, prediction-related activity should linearly increase over time until the predicted event occurs. Methods: We scanned 23 young adults (ages 18-27) reading sentences containing a cataphor construction, wherein a referring pronoun ("he") is placed before its antecedent ("John"), as below: When he returned the car that had been rented two days ago, John went home. The cataphor creates an expectation for an antecedent to appear later in the sentence. According to model predictions, there should be a ramping up of activity in the mPFC starting at the cataphor and ending at the antecedent. To assess this, we ran a finite impulse reponse (FIR) model to estimate activity at each second up to 5 seconds before the onset of the antecedent. We extracted this data from a 5mm sphere placed on the peak activity for PE found in a study by Jahn et al. (2016). To validate our paradigm, we also examined gender mismatch effects; conditions similar to the example sentence above, but with "John" replaced by "Sarah." Results were voxel-wise corrected at $p<0.001$ and cluster corrected with an updated version of AFNI's 3dClustSim (cf. Eklund et al., 2016). Results: We found significant mismatch effects in the dorsal anterior cingulate cortex (dACC) and left inferior frontal gyrus (LIFG), corroborating previous studies of gender mismatch. Our ROI analysis based on the Jahn et al. 2016 study showed a significant linear trend of increasing activity in the 5 seconds before the onset of the antecedent. Conclusion: This study is one of the first to apply computational modeling from the decision-making literature to fMRI studies of language. These results suggest that the mPFC is associated with increased prediction over time, and that this is a domain-generalizable function. This represents a step towards combining modeling across different fields, and may yield novel hypotheses about which brain regions may contribute to reading disability.

B8 Spatiotemporal neuronal activation patterns during verbal fluency tasks *Shawniqua T. Williams[1], Preya A. Shah[1], Vitória Piai[2], Heather Gatens[1], Abba Krieger[1], Timothy H. Lucas, II[1], Brian Litt[1]; [1]University of Pennsylvania, [2]Radboud University*

-----BACKGROUND----- Tests of verbal fluency are frequently used to evaluate linguistic and cognitive function in a variety of neurocognitive disorders including epilepsy, Alzheimer's disease and ADHD (Troyer et al. 1997). Impaired performance reflects deficits in lexical access ability and/or executive control (Shao et al. 2014). Functional studies show that verbal fluency tasks activate a broad network of bifrontal and bitemporal regions, most notably the left inferior frontal, precentral and fusiform gyri (Parks et al. 1988; Birn et al. 2010). However, the timing of activation of these regions has yet to be elucidated. Intracranial electroencephalography (iEEG) provides a unique opportunity to investigate the neuronal activation patterns associated with verbal fluency task performance with high spatial and temporal precision. -----METHODS----- We used subdural recordings to study the neuronal activation patterns in patients undergoing presurgical evaluation for intractable epilepsy. Silastic-embedded platinum-iridium electrodes (AdTech Medical) were placed in the subdural spaces or inserted into mesial temporal regions based on clinical necessity. Recordings were obtained at rest and during semantic and phonemic verbal fluency tasks using a Natus or Neuralynx data acquisition system (sampling frequency >500Hz). Epochs were extracted from 1250ms prior to 750ms after onset of each utterance. After removal of spikes and other artifact, high gamma (70-110Hz) spectral power was determined in 200ms moving windows with 10ms step sizes using the Thomson multitaper method (Thomson 1982), and log-normalized by the resting high gamma power at each contact. For one subject, high gamma estimates were limited to 85-110Hz due to artifact in the 70-80Hz range. -----RESULTS----- Eight implants were recorded, 5 of which were predominantly left hemispheric. All subjects were left-dominant for language and had epilepsy onset after language development. Left temporal lobe epilepsy (TLE) patients tended to have worse performance than right TLE patients. In all but one subject we observed robust increases in high gamma activity in sensorimotor cortex starting 300ms prior to utterance onset. There were also high gamma increases in posterior temporal

regions starting 250ms after utterance onset. Differences between semantic and phonemic conditions varied in timing and location across subjects. Among subjects in whom mesial temporal depth electrodes were present, a significant correlation was observed between maximum (across electrode contacts) task-related hippocampal high gamma activity and production rate in semantic ($p<0.01$) but not phonemic ($p=0.72$) verbal fluency tasks. This relationship was not seen when the sampled contacts were restricted to hippocampi involved in the epileptic onset zone. -----DISCUSSION----- To our knowledge, this is the first study using iEEG to characterize spatiotemporal activation patterns in a letter- and category-motivated free recall format. Our results are consistent with studies of stimulus-locked word generation (Edwards et al. 2010; Korzeniewska et al. 2008; Indefrey 2011). Variability in the differences between semantic and phonemic verbal fluency conditions may reflect inter-individual variability in search strategies and conceptual representations (Hirshorn & Thompson-Schill 2006; Wang et al. 2011). The correlation between hippocampal activity and performance appeared to be driven by the healthy (nonepileptic) hippocampus. Further analyses will investigate the roles of lower frequency oscillations and category imageability.

B9 Electrophysiological evidence for the time course of syllabic and sub-syllabic processing in Cantonese Chinese spoken word production

Andus Wing-Kuen Wong[1], Ho-Ching Chiu[1], Jie Wang[2], Siu-San Wong[1], Hsuan-Chih Chen[2]; [1]City University of Hong Kong, [2]Chinese University of Hong Kong

To produce a spoken word, one needs to access the lexical representation of the target and to retrieve the phonological form of the utterance before articulation. The latter process has been termed phonological planning. It has long been assumed that phonemic segments are the first selectable phonological units following lexical access. Recent studies on Mandarin Chinese and Japanese, however, have shown that the first selectable phonological planning units are atonal syllables (syllables without the lexical tone specified) and moras, respectively. Some researchers therefore proposed the proximate unit hypothesis suggesting that the first selectable phonological planning unit (i.e., the proximate unit) is language dependent. In the case of Chinese spoken word production, according to the proximate unit hypothesis, phonological planning starts with the retrieval of the atonal syllable followed by the specification of the sub-syllabic units. Although there is accumulating evidence suggesting the important role of atonal syllable in both Mandarin and Cantonese Chinese, no clear evidence has yet available regarding the relative time course of syllabic and sub-syllabic processing in Chinese spoken word production. The present study was therefore conducted to address this issue using the picture-word interference task with concurrent recording of event-related brain potential (ERP) signals. Thirty-five native Cantonese-speakers were asked to name aloud individually presented pictures and ignore an accompanying auditory word distractor. Half of the picture stimuli had a monosyllabic Cantonese name and the other half had a disyllabic Cantonese name.The target and distractor either shared the same atonal syllable (i.e., Syllable Related), the same syllable-body (i.e., Body Related), or were unrelated. Participants' naming latencies were significantly different between Syllable Related condition (776 ms) and its unrelated control (816 ms), $t(34)=8.14$, $p<.001$, and between Body Related condition (790 ms) and its unrelated control (809 ms), $t(34)=3.94$, $p<.001$. Mean amplitude values in each successive bin of 50-ms window post-target were obtained and submitted for ANOVAs. For mono-syllabic targets, the ERPs of Syllable Related and unrelated conditions started to diverge within 300 ms post-target, whereas the waves of Body Related and unrelated conditions began to diverge from the time window of 300-350 ms. For di-syllabic targets, significant ERP effects were found in the Syllable Related condition in the time windows between 400 and 500 ms, whereas significant Body Related ERP effects were found only in the time window between 450 and 500 ms. In this study, the Syllable Related priming observed was larger in size than the Body Related priming, regardless of the length of the target (i.e., monosyllable or disyllable targets). More importantly, the ERP effects associated with Syllable Related priming appeared earlier than those associated with Body Related priming, and the same pattern was observed in both monosyllabic and disyllabic targets. These results are consistent with the proximate unit hypothesis that the nature of the proximate unit is language dependent, and that syllable retrieval precedes sub-syllabic specification in phonological encoding of Cantonese Chinese.

B10 Role of Left Hemisphere Language Areas in Visuospatial Working Memory

Juliana Baldo[1], Selvi Paulraj[1,2], Krista Parker[1], Brian Curran[1], Nina Dronkers[1,3]; [1]VA Northern California Health Care System, [2]Palo Alto University, [3]University of California, Davis

Visuospatial functioning involves the ability to conceptualize and use visual and spatial representations to execute a task. A disruption in this system can affect processes as diverse as attention, memory, drawing, locomotion, and navigation. Traditionally, visuospatial functioning has been associated with posterior regions of the brain, usually parietal cortex, particularly in the right hemisphere (RH). While there is ample evidence that the RH plays a special role in visuospatial functioning, deficits have also been observed in patients with left hemisphere (LH) lesions on tests ranging from visual memory to drawing to spatial attention. The source of such deficits has been unclear, with some studies suggesting a direct impact of language functioning on visuospatial performance. Other studies have suggested that visuospatial impairment in LH patients arises from damage to homologous regions in the LH that also support visuospatial processing. Thus far, small sample sizes have made it difficult to draw

strong conclusions. In the current study, 71 individuals with a history of a single, chronic left hemisphere stroke and a range of aphasia severity were administered the Spatial Span subtest of the WMS-III, which includes forward and backward spatial span. The behavioral and lesion data were analyzed using voxel-based lesion symptom mapping (VLSM) software that allowed us to identify brain regions in the left hemisphere most critical for forward and backward spatial span. Results: Backward spatial span showed significant differences between aphasia types, with lower scores in participants with more severe aphasia, particularly Broca's aphasia. However, there were no significant differences on forward spatial span. Voxel-based lesion symptom mapping (VLSM) was then applied to identify critical left hemisphere correlates of spatial span performance. The voxels associated with spatial span (both forward and backward) were located in left posterior superior temporal and inferior parietal cortex, regions associated with phonological storage components of verbal working memory. The current findings suggest that language and associated areas in the posterior left hemisphere play a role in visuospatial working memory. These results are consistent with prior findings showing that subtle changes in visuospatial processing (e.g., spatial attention) occur following left hemisphere stroke, and suggest that visuospatial functioning is supported in part by the left hemisphere.

Writing and Spelling

B11 Tracking keystroke sequences at the cortical level

Svetlana Pinet[1,2], Gary S. Dell[3], F.-Xavier Alario[2]; [1]Johns Hopkins University, [2]Aix-Marseille Universite & CNRS, [3]University of Illinois at Urbana-Champaign

Language production must solve the problem of serial order when all items of a sequence (e.g., letters of a word) get activated but each should be launched at the appropriate time. Several proposals postulate the existence of inhibitory processes to achieve correct ordering (Houghton, 1990; Rumelhart & Norman, 1982). However, the cognitive and physiological implementations of this inhibition remain to be determined. In this study, we recorded EEG during typing. Our previous work consistently reported a meaningful pattern of electrophysiological activities over motor cortices prior to the first keystroke of a sequence, showing that the activation of the contralateral motor cortex co-occurs with the inhibition of its ipsilateral counterpart (Pinet et al., 2015, 2016; Scaltritti et al., 2017). Because sequences provide contrasting environments in terms of recruited effectors (e.g., bimanual vs. unimanual), we expected activation and inhibition processes to develop differently according to sequence properties. Eighteen right-handed participants were selected for their ability to type without need for looking at their hands. EEG was acquired via 128-channels while participants typed short words on a computer keyboard. Stimuli (both auditory and visual) were divided into three conditions: single (one letter), unimanual (two-letter words, typed with one hand), bimanual (two-letter words, typed with two hands). Over the contralateral hemisphere, all conditions presented a negative (activation) component before the first keystroke and unimanual sequences were associated with higher negative amplitude. Over the ipsilateral hemisphere, both single and unimanual conditions presented a positive (inhibition) component, while bimanual sequences exhibited a negative component. Statistical analyses (cluster-based non parametric analyses) confirmed these differences. In the case of bimanual sequences, both hemispheres exhibited negative components with similar time-course, albeit shifted in time. A detailed analysis of the specific time courses allowed the conclusion that the activations observed over each hemisphere reflected the temporal sequence of the two hands required for the response. These results show that the activity recorded over motor cortices prior to sequence execution is finely tight to the content of the prepared sequence. Both contralateral and ipsilateral components are modulated by different factors, which points to their relative independence. Because differences were already observed before the first keystroke, sequences appear to be substantially prepared before execution begins, compatible with keystroke pre-activation. We also observed similar activation of a single keystroke, whether isolated (single letter) or part of a (bimanual) sequence, which argues for unitary activation processes. Moreover, a positive inhibitory component was only observed in unimanual contexts, regardless of the length of the sequence. Thus, inhibition appears tied to some characteristics of the sequence produced, such as the effectors involved, but independent of the number of elements. This strongly suggests the existence of a processing step dealing with selecting involved effectors that will then deploy a flexible system for inhibiting alternate effectors if necessary. Although vastly ignored in previous cognitive models of sequence production, we showed that the effectors recruited in a sequence constitute an important processing level. Our results could help bridge the gap between cognitive hypotheses and neurophysiological implementation of inhibition.

B12 Mental Self-Government of Brain's Multi-Leveled Reading and Writing Systems: Before and After Multi-Leveled Language Instruction

Todd Richards[1], Kevin Yagle[1], Daniel Peterson[1], Robert Abbott[1], Kathleen Nielsen[1], Virginia Berninger[1]; [1]University of Washington, Seattle, Washington

Introduction: The research aim was to understand mental self-government of the complex reading and writing brain. Methods: Before and after participating in computerized instruction aimed at multiple levels of language, 39 students in grades 4 to 9, who were of average or higher verbal cognitive ability and varied along a continuum of reading and writing skills, were given clinical measures of working memory supporting language learning, which

had been validated in programmatic genetics and imaging research, and brain imaged. FMRI connectivity was measured using a Philips 3T scanner during six leveled reading tasks (subword—letters and sounds, word--correct spellings and homonyms, word— words with and without true affixes, syntax—with and without homonym foils, syntax—with and without affix foils, and multi-sentence text and three writing tasks—handwriting, spelling plus handwriting, and cognitive idea generating and planning for composing. The Brain Connectivity Toolbox was used to generate clustering coefficients using a correlation matrix generated from 68 different cortical brain regions selected on basis of prior research showing cingulo-operculum network involvement in adaptive control during language learning. After controlling for multiple comparisons, significant fMRI connectivity clustering coefficients were identified in 8 brain regions bilaterally (authors, in press) and correlated, controlling for multiple comparisons, with clinical measures of working memory components and BASC Adaptivity. The eight bilateral regions with significant clustering coefficients were cingulate gyrus, superior frontal gyrus, middle frontal gyrus, inferior frontal gyrus, superior temporal gyrus, insula, cingulum (cingulate gyrus), and cingulum (hippocampus). Working memory measures were phonological coding, orthographic coding, and morphological coding (storage and processing of word forms); syntactic coding; the phonological loop and orthographic loops for integrating internal language codes with motor systems for interacting with external world through mouth or hand/fingers, respectively; and supervisory attention for focused and switching attention. Results and Discussion: 1) Each working memory measure correlated with at least one brain region with a high clustering coefficient, but the working memory measure-brain region correlations varied with specific reading or writing tasks and level of written language. 2) The BASC Adaptivity parent ratings, used to assess behaviorally the adaptive control function of the cingulo-operculum network, significantly correlated with graph clustering coefficients in right middle frontal gyrus on the grapheme-phoneme task, right cingulate gyrus on the sentence + or – homonym foil task, and left cingulate gyrus on the alphabet writing task at time 1 (not given at time 2). 3) After intervention, fewer brain-working memory correlations were significant, suggesting that mental government became more efficient. 4) Prior to instruction, only one correlation involved a loop, but after instruction, eight involved loops. After instruction, on reading tasks, only orthographic loop or phonological loop correlated with brain regions with significant clustering coefficients, and on writing tasks, only focused attention, morphological coding, or orthographic loop did. Nature of mental self-government may change in response to instruction. 5) At both Times 1 and 2, more correlations with brain regions involved orthographic and morphological coding than phonological coding. All three codes are needed to read and spell English morphophonemic orthography.

Grammar: Morphology

B13 Incremental working memory effects across consecutive nominal constituents: An ERP study

Alicia Parrish[1], Kaylin Smith[1], Alan Beretta[1]; [1]Michigan State University

Models of incremental sentence processing describe the integration of new words into a sentence, but many experimental tests of these models have needed to constrain themselves to testing differences in words between two different sentences. Exploiting the ability to control for phrase boundary and word category effects by using nominal compounds, this study uses Gibson's (1998) well-established SPLT model to investigate the working memory effects as the parser moves from the first (N1) to the second (N2) to the third (N3) nominal constituent in triple-noun compounds. We created 35 sets of triple-noun compounds in Icelandic, a language with rich inflectional morphology and highly productive compounding, in a 2x2 design of number/case/gender agreement between the determiner and N1 and N2 such that there were the following four conditions: (i) Agree-Agree: determiner agrees with N1 and N2; (ii) Nonagree-Agree: determiner does not agree with N1 but agrees with N2; (iii) Agree-Nonagree: determiner agrees with N1 but not with N2; (iv) Nonagree-Nonagree: determiner does not agree with N1 or N2. In all conditions, the compound was placed in a sentence frame, and N3 agreed with the determiner to ensure that sentences were grammatical. There are three main components of the relevant predictions from Gibson's model: (i) when there is a lack of agreement, it is not possible to integrate the noun/compound with the determiner; (ii) new discourse referents are only introduced through integrations; and (iii) there are multiple integrations on nominal constituents after N1 in order to create the [N1 N2] compound and then integrate with the determiner. Forty-seven native Icelandic speakers completed this ERP study. They read sentences presented via RSVP and we measured responses at the presentation of N1, N2, and N3. Higher working memory load is indexed by a sustained anterior negativity (Fiebach et al., 2005; Phillips et al., 2005). All results reported are for the anterior region across the 300-700ms window. We find that the predictions made by the SPLT model are borne out in the ERP responses. The Agree-Agree condition shows significant sustained increases in negativity for N2 compared to N1 and for N3 compared to N2. The Nonagree-Agree condition shows similar increases in negativity as later nominal constituents are encountered, but to a lesser extent than in the Agree-Agree condition because there is no integration at N1 and no new discourse referents are introduced between the determiner and N2. In the Agree-Nonagree condition, N1 and N2 show no difference because there is no new integration possible on N2. N3 shows an increase in negativity, reflecting two integrations and an intervening discourse referent. In

the Nonagree-Nonagree condition, N2 and N3 show no difference because they both integrate constituents with no intervening discourse referents. Both N2 and N3 are more negative than N1, at which no integration could occur. This study provides strong support for a model of sentence processing that relies on working memory costs at integration points and, crucially, takes into account the cost of intervening discourse referents.

B14 Neural correlates of processing case and inflection: fMRI evidence from Russian

Anna Chrabaszcz[1], Maxim Kireev[2], Svyatoslav Medvedev[2], Kira Gor[3]; [1]University of Pittsburgh, [2]N. P. Bechtereva Institute of the Human Brain, [3]University of Maryland

The mechanisms underlying processing of morphologically complex words are still a matter of debate. According to the whole-word storage view, inflected words are stored and retrieved from memory as whole units (Butterworth, 1983). Conversely, the decompositional account claims that inflected words are decomposed into constituent morphemes and are computed using combinatorial mechanisms (Fruchter & Marantz, 2015; Taft, 2004). However, when it comes to processing inflected nouns, very often it is not easy to isolate decompositional processes because case and inflection are often confounded. E.g., in a study by Szlachta et al. (2012) nouns with zero inflection had the form of the Nominative case, while nouns with overt inflection were used in the oblique case. The goal of the present study is to differentiate neural correlates associated with processing of case (Nominative vs. Genitive) and inflection (zero vs. overt -a) using inflected nouns in Russian—a language with rich morphology (e.g., -a.NOM/-a.GEN/-ø.NOM/-ø.GEN). The effect of case is taken as evidence of the role of case hierarchy in the nominal inflectional paradigm (Nominative > Genitive). The effect of inflection is taken as evidence of morphological decomposition, or affix stripping. Eighteen monolingual adult Russian speakers (mean age = 25, male = 12) performed a visual lexical decision task adapted from Gor et al. (2017) while their BOLD signal was recorded (Philips 3T Achieva, event-related design). Stimuli consisted of 280 Russian nouns broken down into four critical conditions and counterbalanced between two presentation lists. Additional 70 words were added as fillers. Nonce words were added to each list to counterbalance the number of real words. Analysis of error rate and reaction time indicated that nouns in the Nominative case were processed faster and more accurately compared to nouns in the Genitive case regardless of the type of inflection, although within the Nominative case, nouns with zero inflection were processed faster than nouns with overt inflection. Whole-brain analyses of the changes in the BOLD signal established an increased activation for overtly compared to zero-inflected nouns in several brain areas including left inferior frontal gyrus, and—bilaterally—supplementary motor area, pre- and postcentral gyri, fusiform gyrus, and cerebellum. These results provide evidence in favor of the decompositional account in morphological processing – more resources are needed to decompose the noun into a stem and an affix. In terms of case effects, an increased BOLD signal was revealed for nouns in the Genitive case compared to Nominative case in the clusters located in the left postcentral gyrus and left insula, right MTG and STG, right fusiform gyrus, and supramarginal gyrus bilaterally. These data suggest that accessing the Genitive form within the nominal paradigm in the mental lexicon is more effortful compared to the retrieval of the Nominative form. Combined with behavioral results, the study supports morphological decomposition of inflected nouns and the special status of the citation—Nominative—form in visual word recognition by differentiating the neural correlates involved in the processing of case and inflection.

Grammar: Syntax

B15 Event-Related Potentials Indicate a Role for Word Frequency in L1 and L2 Grammatical Processing

David Abugaber[1], Irene Finestrat[1], Alicia Luque[1], Kara Morgan-Short[1]; [1]University of Illinois - Chicago

Various approaches to psycholinguistics posit a critical role for the frequency with which particular linguistic forms are encountered in a language user's input. Indeed, converging evidence from several methodologies, including from event-related potentials (ERPs), has found performance and processing effects for the frequency of individual lexical forms (Van Petten & Kutas, 1990; Van Zeeland & Schmitt, 2013; Webb & Chang, 2015). However, a common prediction of frequency-based accounts is that frequency would also have effects on grammar, such that grammatical processing would be less difficult for high-frequency forms than for lower-frequency forms (Ellis, 2002). Evidence for this has previously been found through corpus-based analyses (e.g., Ellis & Ferreira-Junior, 2009), longitudinal studies of L2 learners (e.g., Madlener, 2015), and behavioral experiments using both offline (e.g., Lee, 2002; Slabakova, 2015) and online (e.g., Ellis, Simpson-Vlach, & Maynard, 2009; Lehtonen et al., 2012) methodologies. However, to the authors' knowledge, no study to date has examined these frequency effects at a direct, neurolinguistic processing level, as assessed by ERPs. Such an experiment would provide deeper insight into the nature of grammatical processing while overcoming certain issues with the aforementioned approaches (such as underreporting and reactivity) and being able to detect effects that might not be captured through behavioral measures alone (McLaughlin, Osterhout, & Kim, 2004; Tokowicz & MacWhinney, 2005). To address this gap in the research, an ERP study was conducted in which eight English-L1 Spanish-L2 learners (enrolled in intermediate-level Spanish foreign classes in a university setting) were asked to perform grammaticality judgment tasks on stimulus sentences that were either correct or contained a syntactic (phrase structure) violation. These were presented via a rapid serial visual presentation

paradigm. The study was conducted in two separate sessions, with one session performed in L1 English and another in L2 Spanish. Critically, the stimulus sentences varied not only by their grammaticality status (phrase structure violation vs. correct) but also in terms of the critical words' frequency in the language as a whole (low frequency vs. high frequency), as gauged using the BNC (BNC Consortium, 2007) and LexESP (Sebastián-Gallés, 2000) corpora. For both L1 and L2 processing, global ANOVAs revealed Violation by Frequency interactions in the 300-500 millisecond post-stimulus time window indicating marked negativities for grammatical violations involving high-frequency (vs. low-frequency) critical words. By contrast, in the 500-900ms time window, for both L1 and L2 there were trends towards Violation by Frequency interactions that were suggestive of positivity effects (P600s) towards grammatical violations with high-frequency (but not low frequency)critical words. Although data collection for this project is ongoing, these preliminary results seem to suggest a role for word frequency as a critical factor in grammatical (syntactic) processing, as indicated by differences in the ERP effects for low vs. high-frequency words. Beyond merely informing theories on the nature of both L1 and L2 neurolinguistic processing, such findings have practical implications for language teachers vis à vis manipulating input frequency so as to best foster students' second language development.

B16 Phrase Structure Building Evidenced by Differential Network Modulations

Chiao-Yi Wu[1,2], Emiliano Zaccarella[2], Angela D. Friederici[2]; [1]Nanyang Technological University, [2]Max Planck Institute for Human Cognitive and Brain Sciences

The basic steps in building up language involve arranging two words of different lexical categories into a hierarchical structure. While the cognitive state of this process is widely discussed, a clear picture of its neurobiological basis has yet to be discovered. In the current study, we examined the neural mechanisms underlying basic phrase structure building in Chinese. Eighteen native speakers (8 male, mean age 23.9 years) were asked to judge whether a sequence of two visual stimuli could form a phrase to describe a noun in a 3T MRI scanner. We used syntax-driving determiners (Det), semantics-embedded classifiers (CL), and a symbol (#) to generate two-component sequences and manipulated two factors: sequence structure (phrase or list) and number of words (2-word or 1-word), resulting in four conditions: 2-word phrase (2-PH: Det + CL), 2-word list (2-LS: CL + CL), 1-word phrase (1-PH: Det + #), and 1-word list (1-LS: CL + #). Imaging data preprocessing and analyses were performed in SPM12. Differential responses to the conditions were identified in the left pars opercularis (BA44) and pars triangularis (BA45) of Broca's area, and the left posterior middle temporal gyrus (pMTG) (cluster-level FWE-corrected $p < 0.05$). These regions served as regions-of-interest for effective connectivity analysis using dynamic causal modelling. Intrinsic connections were defined as bidirectional connections between every two regions for all models. Modulation effects by each task condition on any of the intrinsic connections were considered. Driving inputs from all conditions were specified on only BA44, only BA45, or both BA44 and BA45, producing a total of 192 models for comparison. All models were grouped into three families based on the driving inputs, and Bayesian model selection revealed that the models with driving inputs to both BA44 and BA45 outweighed the others (exceedance probability = 0.80). Bayesian model averaging and posterior probability (Pp) tests were conducted to evaluate the parameter estimates in the winning family, showing that the parameter estimates of all intrinsic connections and driving inputs were significantly deviant from zero ($Pp > 0.95$ corrected for multiple comparisons). The phrase conditions, where the first word (Det) opened a phrase, had stronger modulations on the connection from BA44 to pMTG compared to the list conditions, which highlights the pivotal role of this connection in phrase building and its association with syntactic integration. Within Broca's area, the connection from BA44 to BA45 was negatively modulated by 2-PH whereas that from BA45 to BA44 by 2-LS. As BA44 is proposed to process syntax and BA45 semantics, the modulations by 2-PH and 2-LS may be respectively related to syntactic and semantic control mechanisms. Differential modulation effects were also found on the connections from pMTG to BA44 and to BA45, reflecting the particular demands on syntactic and semantic evaluation for the four conditions. Overall, our findings demonstrate differentiated network modulations emerging from sub-parts of Broca's area and their interactions with pMTG in the process of phrase structure building, and provide important implications for understanding the foundation of language learning in humans.

B17 Asymmetric Binarity as a Cognitive Universal: The Rhythm of Syntactic Structure

Danielle Fahey[1], Dirk-Bart den Ouden[1]; [1]University of South Carolina

Introduction: In all languages and all musical traditions, universal rules group elements hierarchically, with elements organized asymmetrically. In language, Merge theoretically combines elements in phrasal structures, with one element governing the other, recursively, to form sentences [1]. In rhythm, a similar asymmetric hierarchy of beats is proposed in the Generative Theory of Tonal Music [2]. Just like syntactic processing, assigning beats into rhythmic strings, 'beat induction,' is automatic and unconscious [3]. Merge and beat induction assign structure not only to grammatical phrases, but also to inherently unstructured sequences. Overlapping perisylvian brain regions supporting both language [4] and rhythmic [5] processing have been implicated in these mechanisms. Because overlapping cortical regions have shown support for similar roles in both domains, this project tested whether structurally comparable linguistic and rhythmic

input would be processed similarly in core regions of the language network, inferior frontal and posterior superior temporal cortex. Methods: 19 right-handed adult English-native speakers underwent Magnetic Resonance Imaging (MRI) while auditory stimuli were presented. Neuroimaging data were analyzed using SPM12, with region-of-interest (ROI) analyses of the inferior frontal gyrus (IFG) opercularis, triangularis and orbitalis, and the posterior superior temporal gyrus (pSTG). Linguistic stimuli provided participants with three types of input: (1) grammatical phrases, (2) semi-randomly sequenced words, containing words in an ungrammatical order (no hierarchical phrases), (3) 'jabberwocky' stimuli, containing phonotactically-valid English non-words, conjugated by inflectional morphemes. Rhythmic stimuli provided participants with (4) rhythmically-patterned, (5) arrhythmic, and (6) regular beats. Rhythmically-patterned beats provided rhythmic 'tunes.' Arrhythmic beats varied in tempo and were characterized by random beat sequences. Regular beats sounded like ticking clocks, without differences between beats in the acoustic signal. These sets of linguistic and rhythmic stimuli should be processed similarly due to their structural congruence: (1) and (4) are structured sequences; (2) and (5) are unstructured sequences that will violate grammaticality rules; and (3) and (6) are not inherently structured, but should be assigned hierarchical structuring. Results: A RM ANOVA showed a 4-way interaction ($p<.05$) between hemisphere, ROI, domain, and 'grammaticality'. Follow-up tests in the left IFG operculum revealed higher activation for (2) than for (3) ($p=.025$), for (3) than for (1) ($p=.072$), for (4) than (6) ($p=.035$) and for (4) than (5) ($p=.021$). Tests in the pSTG also revealed higher activation for (4) than (6), and for (4) than (5) (both, $p<.001$). Conclusion: These results support prior research suggesting overlap in brain regions responsible for both rhythmic and syntactic processing, specifically in the IFG operculum. However, the function of these regions for linguistic and rhythmic input is likely different, as linguistic and rhythmic 'grammaticality' were not processed symmetrically within each region. This analysis suggests that the left IFG operculum and pSTG are domain general in their overall cortical roles, yet domain-specific in the type of processes they support within the domains of language and rhythm processing. References: [1] Chomsky, N. (1995). [2] Lerdahl, F. & Jackendoff, R. (1983). [3] Honing, H. (2012). [4] Friederici, A. D., & Gierhan, S. M. (2013). [5] Danielsen et al., (2014).

B18 VOS Preference in Truku Sentence Processing: Evidence from Event-Related Potentials

Masataka Yano[1,2], Keiyu Niikuni[1], Hajime Ono[3], Sachiko Kiyama[1], Manami Sato[4], Apay, Ai-yu Tang[5], Daichi Yasunaga[6], Masatoshi Koizumi[1]; [1]Tohoku University, [2]Japan Society for the Promotion of Science, [3]Tsuda University, [4]Okinawa International University, [5]National Dong Hwa University, [6]Kanazawa University

Introduction: In many languages with flexible word order, transitive sentences in which the subject precedes the object have been reported to incur a less processing cost during sentence comprehension compared with those in which the object precedes the subject. This observation brings up the question of why this subject-before-object (SO) order should be preferred in sentence comprehension, together with the related empirical question of whether this preference is universal across all human languages. Methods: We conducted an event-related potential (ERP) experiment to address these two issues by examining the word order preference in Truku, a Formosan Austronesian language spoken in Taiwan. The syntactically basic word order of Truku is verb-object-subject (VOS) as shown in (1a) and (2a), and SVO is derived by preposing S to the sentence-initial position as shown in (1b) and (2b). Truku has a symmetrical voice system (also referred to as Focus System). In Actor Voice (AV), S refers to an ACTOR, as in (1), while in Goal Voice (GV), S is a GOAL or a PATIENT, as in (2). (1) a. AV-VOS: qmqah emqliyang niyi ka embanah niyi. kick.AV blue DET NOM red DET 'The red kicks the blue.' b. AV-SVO: embanah niyi o qmqah emqliyang niyi. red DET FOC kick.AV blue DET (2) a. GV-VOS: qqahan embanah niyi ka emqliyang niyi. kick. GV red DET NOM blue DET b. GV-SVO: emqliyang niyi o qqahan embanah niyi. blue DET FOC kick.GV red DET In the ERP experiment, 25 native speakers of Truku were auditorily presented these four types of sentences (18 females, M = 61.6, SD = 12.6). The participants were asked to judge whether the event described in a sentence matched a picture presented after the sentence. Results: The result showed that SVO elicited a larger positivity compared to VOS at the third region (i.e., SVO versus VOS), irrespective of VOICE. This result indicates that the syntactically basic word order, VOS has a processing advantage over SVO in Truku. Discussion: This result aligns well with the theory that accounts word order preference in terms of grammatical factors, such as syntactic complexities (e.g., Dependency Locality Theory, Gibson, 1998). Since SVO has a more complex syntactic structure in Truku, this theory expects SVO to be more difficult to process than VOS. The larger positivity for SVO reflects an increased processing cost to integrate a fronted S with its original position. On the other hand, our result is not consistent with the theory that accounts word order preference by appealing to the relative order of ACTOR and PATIENT. If SO preference that has been reported in previous studies reflects a preference for the ACTOR-before-PATIENT order, we expect that SVO should be easier to process than VOS in Actor Voice. This prediction was not borne out by our result. Conclusion: The SO preference in sentence comprehension reported in previous studies may not reflect a universal aspect of human sentence comprehension. Rather, processing preference may be language-specific to some extent, driven by syntactic differences in individual languages.

B19 A meta-analysis of seven FMRI-studies on artificial grammar learning

Julia Udden[1]; [1]Department of Psychology and Linguistics, Stockholm University, Stockholm, Sweden

The artificial grammar learning (AGL) paradigm enables systematic investigation of acquisition of linguistically relevant structures. It is paradigm of interest for natural language processing research interfacing with theoretical linguistics, as well as for comparative research on language acquisition and evolution. The FMRI literature on AGL spans at least fifteen original studies on distinct samples. We have used the GingerALE method in a meta-analysis of this literature. By forming the union across statistical landscapes from each study, centered at the reported peak coordinates (spread determined by the number of subjects), the activation likelihood estimation method determines the overall likelihood of activation of clusters in the union map by a permutation test. We only included peak activations from the contrast comparing activity for non-grammatical > grammatical sequences (NG > G) during the classification phase of grammaticality judgments, which resulted in seven included studies. When thresholding the meta-analysis of the NG > G contrast at an FDR-corrected level of 0.05 or alternatively correcting at the cluster level (using a cluster-forming threshold of $p > 0.001$) with permutation testing, six clusters were significant: the left and right frontal operculum, the left and right IFG, and the left and right middle frontal gyrus (MFG). When correcting for multiple comparisons with FDR, without any assumptions on the correlations in the data, only the bilateral frontal operculum (FOP - extending into the inferior frontal gyrus on the left), were significant. These results emphasize the relatively larger contributions from the right hemisphere seen in AGL, compared for example to complex syntax in natural language experiments. A majority of adult AGL studies use visual presentation, and the literature thus has to be carefully taken into consideration as being biased towards finding the activations related to visual processing. The most robustly activated region was the FOP, which has been implicated a causal node affecting cognitive control processes and which has also been described as a part of the salience network. It is possible that the non-grammatical sequences are more salient, perhaps even mildly threatening to participants (they are also dispreferred in preference tests). The results reveal a network markedly different from the regions most robustly involved in processing related aspects of natural language processing, for example natural language syntax (e.g. LIFG and left posterior superior/middle temporal gyrus). LIFG remains a region of overlap of artificial and natural syntactic processing. The robust activation of the nearby FOP region (bilaterally) is notable as a homologue pair of structures that are less often implicated in natural syntactic processing. However, the adjacent anterior insula, clearly left-lateralized, has repeatedly been implicated as one of the most reoccurring sites to display lesions in aphasia patients with both production and comprehension deficits. In summary, the results point to the crucial involvement of the bilateral frontal operculum and several (mostly perisylvian) regions in the right lateral hemisphere. I interpret the degree of activity as dependent on grammar and as interacting with input modality.

B20 Isolating syntactic structure-building in the brain: An MEG study on Bosnian-Croatian-Serbian

Diogo Almeida[1], Aida Talić[2], Željko Bošković[2], Jon Sprouse[2]; [1]New York University Abu Dhabi, [2]University of Connecticut

One of the biggest challenges in the study of the neurobiology of language is how to dissociate the operations that deal with the formal aspects of sentence construction (i.e., syntax) from their meaning. On the one hand, traditional grammatical violation paradigms have the problem that they produce syntactic and semantic/pragmatic effects that are inherently correlated. On the other hand, within the domain of grammatical sentences, it is hard to find variations in syntactic structure that induce no changes in their semantic or pragmatic interpretation. Therefore, while there are many paradigms that purport to isolate the semantic/pragmatic components of language, it is much harder to isolate its formal structure-building component. Here we capitalize on syntactic constructions of Bosnian-Croatian-Serbian (BCS) that may provide a unique window into syntactic structure building. Namely, constructions using adjective/quantifiers like "mnogo", "ovoliko" or "toliko" (translation: "many") allows virtually identical paired structures, one involving morphological gender agreement between the adjective/quantifier and the head noun, such as "Tvrde da *mnogi ljudi* vole ljeto" ("[They] claim that *many people* like summer"), and the other without any such agreement, such as "Tvrde da *mnogo ljùdi* voli ljeto" ("[They] claim that *many people* like summer"), that are, for all intents and purposes, virtually identical in meaning. However, several syntactic tests indicate that the non-agreeing version involves a full quantifier phrase (i.e., a DP), whereas the agreeing version involves simply an adjectival phrase (i.e., a NP), a difference that can be captured by the distinction between External and Internal Merge. Therefore, these BCS structures provides us with a candidate case of minimally distinct but theoretically relevant constructions that target the basic structure building operation of Merge in the syntax without any apparent change in the interpretation of the resulting sentences. We designed an MEG study to test these constructions with the intention of finding the neural correlates of differences in syntactic structure building dissociated from differences in meaning that normally go hand-in-hand. Thirty speakers of BCS participated in the study, which employed a probe detection task. In addition to the critical items, we also tested control constructions involving semantic anomalies that elicit N400 effects and control constructions involving basic phrase structure building violations that elicit ELAN/P600 effects, which are generally respectively taken to provide a window into

(lexico-)semantic processing and syntactic processing. Clear N400m and P600m effects were observed in the control tasks, but they were different from the effects observed in the critical items, which were observed at several time points, starting at around 170 ms (M170), and again between 300-400 ms (N400m/LAN). Further source localization analyses will clarify the loci of these differences, and help identifying the unique properties of the syntactic variants of interest.

B21 The Left Inferior Frontal Gyrus is Necessary for Syntactic Phrase Formation: Evidence from Transcranial Magnetic Stimulation

Lars Meyer[1], Anne Elsner[1], Philipp Kuhnke[1], Angela D. Friederici[1], Gesa Hartwigsen[1]; [1]Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany

Language comprehension requires the grouping of words into syntactic phrases, because the sheer number of sentences' words prohibits their individual encoding into verbal working memory. Virtually all neuroimaging studies on syntactic phrase formation report activity of the left inferior frontal gyrus (lIFG). Yet, this evidence is only correlative, and it is further questioned by unequivocal evidence from patients with tissue damage to the lIFG due to stroke or tumor lesions. Here, we employed repetitive transcranial magnetic stimulation (rTMS) to establish the functional necessity of the lIFG in the formation of syntactic phrases. To this end, we presented 48 healthy young adults with sentences that allow for two alternative ways of grouping their words into syntactic phrases (e.g., The client sued the murderer with the corrupt lawyer.). Participants indicated their grouping choice via button press. At the critical point in the sentences (i.e., at the offset of the murderer, where participants either continued or terminated a syntactic phrase), we transiently perturbed task processing in the lIFG with high-frequency rTMS. Without rTMS, participants are known to be biased to terminate a syntactic phrase at this point in the sentence. Strikingly, rTMS to the lIFG, compared to the disruption of a conservative control area (i.e., right IFG), significantly reduced this bias—indicating participants' disability to form a syntactic phrase from the presented word sequence. Our result provides the first causal evidence for a functional necessity of the lIFG in in the grouping of words into syntactic phrases.

B22 Selective interference with sentence production by direct electrocortical stimulation of the inferior frontal gyrus

Edward F. Chang[1], Garret Kurteff[1], Stephen M. Wilson[2]; [1]University of California, San Francisco, [2]Vanderbilt University Medical Center

Electrocortical stimulation mapping (ESM) has provided important insights into the neuroanatomy of language, due to its high spatial and temporal resolution, and the causal relationships that can be inferred from transient disruption of specific functions. Almost all ESM studies to date have focused on word level processes such as naming, comprehension and repetition. In this study, we used ESM to identify sites where stimulation interfered selectively with sentence production. Fourteen patients undergoing left hemisphere neurosurgery participated in the study. Significant expanses of perisylvian frontal, temporal and parietal regions were exposed in all participants. Patients were presented with pictures depicted a boy and a girl engaged in one of seven simple transitive actions (push, pull, hug, kiss, kick, chase, wash), and were asked to describe each picture using a simple sentence (e.g. "The boy is pushing the girl") while stimulation was applied to a range of fronal, temporal and parietal sites. No patients had significant aphasia at baseline, and all were readily able to describe the pictures in the absence of cortical stimulation. Patients performed between 14 and 72 trials (mean 36.6 ± 13.7). When sites were found where stimulation interfered with sentence production, the same locations were stimulated again on later trials to establish reproducibility. We found sites were stimulation interfered with sentence production in a reproducible manner in eight out of fourteen patients. Nine sites were localized to the dorsal posterior inferior frontal gyrus (pars triangularis and opercularis), and none of these sites were implicated in any other language functions that were tested (counting, picture naming, repetition of single words). Interference with sentence production took several different forms, including mis-assignment of arguments to grammatical roles ("The boy is washing the boy"), omission of function words and inflectional morphology ("Girl is hug the boy"), misassignment of nouns to verb slots ("The girl is boying (.) is uh (.) pushing the boy"), and various paragrammatic constructions ("Uh (.) the girl (.) is (.) is (..) um (.) it was bathed she bathed him"). The remaining site was localized to the superior temporal gyrus, but it was not specific to sentence production; stimulation of this site also interfered with picture naming and repetition. Our findings suggest that the dorsal posterior inferior frontal gyrus is critically important for the generation of syntactic structure, since it was the only site where stimulation selectively interfered with sentence production.

B23 Cortical tracking of linguistic structures: the role of covert prosody

Anastasia Glushko[1,2], David Poeppel[3,4], Max Wolpert[1,2], Toivo Glatz[5], Karsten Steinhauer[1,2]; [1]McGill University, [2]The Centre for Research on Brain, Language and Music, [3]New York University, [4]Max Planck Institute for Empirical Aesthetics, [5]University of Groningen

Using magnetoencephalography (MEG), Ding, Melloni, Zhang, Tian, and Poeppel (2016) have shown that neural oscillations track structural characteristics of spoken language. Because MEG power peaks appeared at the same frequencies as the syntactic phrase boundaries and in the absence of overt prosodic phrase boundary cues, the authors concluded that their results reflected processing of hierarchical syntactic structures. We tested the validity of this claim by investigating the relative role of syntactic and covert prosodic phrasing in the increase of oscillatory

power at phrasal rate. We hypothesized that effects reported by Ding and colleagues (2016) were mediated by covert prosodic/rhythmic chunking (see e.g., Steinhauer & Friederici, 2001; Nozaradan, Peretz, Missal, and Mouraux, 2011). Our participants' electroencephalography (EEG) was recorded while they were listening to German four-word sentences or sequences of four nonwords of the same duration (1 second in total; 250 ms/(non-)word), which differed in their prosodic/rhythmic structure. Sentences of two types of syntactic phrasing were used: e.g., "Tom | goes to Bonn" ("1+3" syntactic grouping: word 1 forms a noun phrase; words 2-4 form a verb phrase; note that the sentences were presented in German) and "Your song | sounds good" ("2+2" syntactic grouping). Each sentence was presented in two versions of prosodic grouping ("1+3" and "2+2"), both of which sounded natural, but only one of which corresponded to the syntactic grouping of the respective sentence. After listening to the sentences containing overt prosodic cues, German native speakers (N=17) were presented with the same sentences with all prosodic cues eliminated (i.e., sentences with flattened pitch and controlled sound intensity contours). Participants were asked to mentally map the intonation of the overt-prosody sentences onto the de-prosodized stimuli. We found that at least in a subset of experimental conditions with no overt prosodic cues, frequency tagging analysis reflected processing of covert (mentalized) prosodic grouping rather than formal syntactic structure of the speech stream (e.g., a 1Hz but not a 2Hz EEG power peak for sentences with 2+2 syntactic and 1+3 prosodic grouping). Additionally, we tested the domain-general nature of this cognitive chunking mechanism in the same frequency tagging experimental setting by presenting participants with nonwords grouped either based on vowel quality (1+3: "kö-bü-gü-tü" vs. 2+2: "kö-bö-gü-tü") or on music-like pitch differences. Neural tracking of rhythmic structure in these conditions was similar to that for sentences with overt and covert prosodic grouping. In the case of nonword sequences, the effects were independent of the specific cues used to mark chunk boundaries and detectable in the absence of sound intensity modulations in the auditory stimulus. Our preliminary results, therefore, suggest that the emergence of EEG power peaks corresponding to the rate of syntactic phrasal boundaries is mediated by the processing of covert prosodic/rhythmic grouping of the sentences. Given the absence of a one-to-one correspondence between prosodic and syntactic grouping in natural language, caution should be taken when using the frequency tagging technique as a marker of syntactic processing/grammar learning in neurolinguistic research.

B24 Investigating the neural mechanisms of syntactic expectations *Leon O. H. Kroczek[1], Angela D. Friederici[1], Thomas C. Gunter[1]; [1]Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany*

Communicative situations typically provide listeners with contextual information. One such information is speaker identity. Listeners are able to adapt to the individual language use of a particular speaker and can use this information in order to generate expectations. This can be observed even for syntactic structure. In this fMRI study, we asked how top-down effects of expectations are implemented on a neural level and how they affect syntactic processing. Twenty-eight participants were presented with German sentences spoken by two different speakers. Speakers differed in the probabilities by which they produced sentences with a particular syntactic structure [Subject-Object-Verb (SOV) vs. Object-Subject-Verb (OSV)]. One speaker had a high probability to produce SOV sentences and a low probability to produce OSV sentences (SOV-Speaker), and vice versa for the other speaker (OSV-Speaker). After exposure to the speakers in a training session, listeners were able to generate expectations about a sentence structure solely on the basis of speaker identity. These expectations were then investigated in a test session that was conducted in the MRI scanner. In order to disentangle syntactic processing and syntactic expectations we used two types of trials: (1) Unambiguous sentences where the syntactic structure information was provided by the case-marking of the determiners and expectations were based on speaker identity, and (2) ambiguous sentences where the determiners were replaced with noise and therefore only speaker information but no syntactic structure information was provided. Performance in the comprehension task showed an interaction between Speaker and Structure. The typical performance advantage of the easy SOV sentences over the complex OSV sentences was reduced for the OSV-Speaker compared to the SOV-Speaker . Analysis of the unambiguous trials showed a main effect of syntactic structure with increased activation for the OSV structure in a left-lateralized network including the IFG (BA44), pMTG, precentral gyrus and preSMA. In a next step, we analyzed sentences on basis of whether they were expected or unexpected and not based on their syntactic complexity. Unexpected structures showed increased activation in the right IFG (BA44) and bilateral network comprising the MFG, Angular Gyrus, preSMA and IFG (BA47). Crucially, analysis of the ambiguous trials allowed to investigate speaker-specific expectations in the absence of syntactic structure information. We observed increased activation for the OSV-Speaker compared to the SOV-Speaker in the bilateral Insula and Putamen and the left ACC/preSMA. While the processing of complex syntactic structures activated a left-lateralized fronto-temporal network, the processing of unexpected structures (independent of complexity) activated a bilateral frontal-parietal network with a focus to the right hemisphere. This may index the recruitment of attentional mechanisms when an expectation is violated. Interestingly, in absence of any explicit syntactic structure information speaker-expectations were shown to activate cortical and sub-cortical brain regions. In case of

the OSV-Speaker this may reflect a controlled modulation of linguistic processing when the default syntactic structure needs to be inhibited in favor of the structure that is expected on basis of the speaker. These results give insight into the neural implementation of expectations in a communicative context.

Language Therapy

B25 Effects of morphosyntactic therapy and tDCS on the spontaneous speech of individuals with aphasia

Vânia de Aguiar[1,3], Adrià Rofes[2,3], Roelien Bastiaanse[4], Rita Capasso[5], Marialuisa Gandolfi[6,7], Nicola Smania[6,7], Giorgio Rossi[8], Gabriele Miceli[9]; [1]Department of clinical Speech and Language Studies, Trinity College Dublin, Dublin, Ireland, [2]Global Brain Health Institute, Trinity College Dublin, Ireland, [3]International Doctorate in Experimental Approaches to Language And the Brain (IDEALAB) Universities of Groningen (The Netherlands), Newcastle (UK), Potsdam (Germany), Trento (Italy) and Macquarie University (Australia), [4]Center for Language and Cognition, University of Groningen, The Netherlands, [5]S.C.A. Associates, Rome, Italy, [6]Neuromotor and Cognitive Rehabilitation Research Centre, USO Neurological Rehabilitation, Azienda Ospedaliera Universitaria Integrata (AOUI) of Verona, Verona, Italy, [7]Department of Neurological and Movement Sciences, University of Verona, Verona, Italy, [8]Department of Neurology, Santa Maria del Carmine Hospital, Rovereto, Italy, [9]Center for Mind/Brain Sciences (CIMeC), University of Trento, Italy

BACKGROUND. Language rehabilitation for individuals with post-stroke aphasia has positive effects, which can be enhanced by the use of transcranial direct current stimulation. Such effects are frequently demonstrated in carefully designed experimental outcome measures, which are closely related to the treatment task. These measures have high sensitivity to detect change, but lack the ecological validity necessary to determine whether such treatments may yield improvements in spontaneous language production. METHOD. Nine patients received a sentence-level treatment requiring the production of verbs in sentence completion and sentence construction tasks, and verb forms in the three most frequent tenses in Italian. Patients presented with varying clinical profiles, but in all cases had difficulties in verb and sentence production. At the beginning of each 1-hour treatment session, 20 minutes of tDCS were administered at 1mA, through 35cm2 electrodes. A bicephalic montage was used, with the anode placed over individually-tailored left hemisphere areas. The study used a within-subjects, randomized, sham-controlled, double-blind, cross-over design, with two 10-session treatment phases separated by a 2-week washout period. Connected speech samples were collected before and after each treatment, and at a 6-month follow-up assessment, in a standardized fashion. Changes over time were analyzed at group and individual levels, through comparison with a normative sample of 19 individuals. RESULTS. In group analyses, the Mean Length of Utterance (MLU) showed no significant change between before (t1) and after the first treatment (t2), but a significant decrease was detected after the second treatment (t3) in relation to t2 ($z=-2.073$, $p=0.038$) and t1 ($z=-2.49$, $p=0.015$). Two patients performed within norm at t1 and t2, and moved to below norm at t3 and t4. Another patient performed below norm only at t3. The remaining patients performed below norm in all assessments. No group-level change was observed in the proportion of subordinate sentences over time. One patient moved from below to within norm between t1 and t2, and then performed below norm again at t3 and t4 (6-month follow-up). Another patient moved from within to below norm between t1 and t2 and then performed within norm at t3 and t4. A third patient performed below norm at t3, while showing within norm performance at t1 and t2. No significant changes were detected in words per minute. To examine whether the decrease in MLU was related to a tradeoff between length and accuracy in sentence production, an analysis of errors was conducted. No significant changes were detected in the proportion of lexical, phonological, or morphosyntactic errors. Change in performance over time was also not significantly different in the tDCS treatment condition, when compared to Sham. DISCUSSION AND CONCLUSION. While treatment yielded improvements in lexical retrieval for treated and untreated verbs (de Aguiar et al., 2015), these effects did not transfer to connected speech. Further analyses with a focus on individual clinical profiles and lexical diversity measures are needed to establish if reduced MLU may be explained by strategic changes at the sentence planning level, or by changes at processing levels different to those considered so far.

Language Disorders

B26 Prominence in sentence comprehension in schizophrenic subjets: An ERP study

María Francisca Alonso-Sánchez[1], Lucía Zepeda-Rivera[1], Aland Astudillo; [1]Universidad Santo Tomás, [2]Universidad de Valparaíso

Background Schizophrenia is a chronic neurobiological disorder with recurrent tendency and wide heterogeneity of positive, negative and mood symptoms, among them delusions, hallucinations, catatonic or disorganized behavior, apathy, reduced thought fluidity, disperse and unproductive language, and difficulty with goal oriented behaviors (APA, 2014). Besides, schizophrenia involves alteratiosn in executive function, psychomotor speed and social skills (Tandon, Nasrallah, & Keshavan, 2009). Another relevant feature is the impediment that the symptoms generate in social, occupational and daily life activities (Tandon, Nasrallah, & Keshavan, 2009). The communication in schizophrenia is heterogeneous and the descriptions are usually subjective and unspecific, commonly using scales such as Andreasen (1986) that

decompose the schizophrenic language in 18 criteria (speech poverty, content poverty, pressure speech, tangential discourse, derailment, incoherence, illogicity, clanging, neologisms, approximate words, goal loss, perseverations, echolalia, blockade, pedantic and self-referential discourse). With the use of error detection tests along with EEG measurements, some authors have observed that subjects with schizophrenia are insensitive to syntactic and semantic violations (Kuperberg, 2000), other authors have observed normal triggering of N400 of the semantic component and in the ELAN component, whereas the P600 wave has not been triggered against elicitation with syntactic incongruities (Ruchsow, 2003). Likewise, it has been observed that subjects with schizophrenia have lower P600 wave amplitude in response to syntactic and semantic violations. Although there are several studies that present evidence of syntactic alteration, there are still discrepancies about the syntactic alteration in subjects with schizophrenia and their interrelation with the semantic level. In this context, the language alteration in schizophrenia is still not distinguishable from in the syntactic level and the limits with the semantic deficit. The mayor concern of sentence interpretation is the semantic and syntactic interface. Particulary, in spanish the information that determine the prominence of a sentence element is the hierarchy stablished by the thematic role (Gattei, 2015). The dative object-experiencer verbs makes the reanalysis of initial target object structure more easily, modulated by the tematic hierarchy and is associated with a N400 ERP. Furthemore, the prominence reversal of SVO senteces with a psych verb cued morphosyntactically elicits a P600 due to thematic mismatch (Bornkessel-Schlesewsky, 2014). According to this, the aim of this study was to assess the prominence information span in schizophrenia subjects. Methods An ERP study was made with sentences constructed with variation in the thematic structure of the verb (activity or psych verbs) and with manipulation of the word order (SVO or OVS). The schizophrenic subject were matched in age and education with healthy controls. The ERP were recorded with an 64 channel Biosemi EEG. The signal processing was made with EEGLAB. The artifacts were removed with ICA correction. Results The analysis of the response time and the accuracy of response shown the performance deficit of the schizophrenic subjects. Additionally it was observed the differences in the SVO with psych verbs associated with de P600 component and the OVS activity verb associated with the N400 component among the schizophrenic and healthy subjects.

B27 Structural connectivity subserving verbal fluency revealed by lesion-behavior mapping in stroke patients

Mingyang Li[1], Yumei Zhang[2], Luping Song[3], Ruiwang Huang[4], Junhua Ding[1], Yuxing Fang[1], Yangwen Xu[1], Zaizhu Han[1]; [1]National Key Laboratory of Cognitive Neuroscience and Learning & IDG/McGovern Institute for Brain Research, Beijing Normal University, Beijing, China, 100875, [2]Department of Neurology, Beijing Tiantan Hospital, Capital Medical University, Beijing, China., [3]Rehabilitation College and China Rehabilitation Research Center, Capital Medical University, Beijing, China, 100038., [4]Center for the Study of Applied Psychology, Key Laboratory of Mental Health and Cognitive Science of Guangdong Province, School of Psychology, South China Normal University, Guangzhou, China, 510631.

Tests of verbal fluency have been widely used to assess the cognitive functioning of persons, and are typically classified into two categories (semantic and phonological fluency). While widely-distributed divergent and convergent brain regions have been found to be involved in semantic and phonological fluency, the anatomical connectivity underlying the fluency is not well understood. The present study aims to construct a comprehensive white-matter network associated with semantic and phonological fluency by investigating the relationship between the integrity of 22 major tracts in the whole brain and semantic fluency (measured by 3 cues) and phonological fluency (measured by 2 cues) in a group of 51 stroke patients. We found five left-lateralized tracts including the anterior thalamic radiation (ATR), inferior fronto-occipital fasciculus (IFOF), uncinate fasciculus (UF), superior longitudinal fasciculus (SLF) and frontal aslant tract (FAT) were significantly correlated with the scores of both semantic and phonological fluencies. These effects persisted even when we ruled out the influence of potential confounding factors (e.g., total lesion volume). Moreover, the damage to the first three tracts caused additional impairments in the semantic compared to the phonological fluency. These findings reveal the white-matter neuroanatomical connectivity underlying semantic and phonological fluency, and deepen the understanding of the neural network of verbal fluency.

B28 Impoverished Remote Semantic Memory in Mild Cognitive Impairment

Nathaniel B. Klooster[1,2], Arun Pilania[1], David A. Wolk[1], Anjan Chatterjee[1,2]; [1]University of Pennsylvania, [2]Moss Rehabilitation Research Institute

Alzheimer's Disease (AD) is an enormous public health issue and promising interventions are under development attempting to treat it. Many of these interventions focus on both pre-symptomatic and prodromal stages of disease. Thus, cognitive assessments that are sensitive to the earliest manifestations of Alzheimer's pathology are critical for screening and as outcome measures for therapeutic studies. Mild Cognitive Impairment (MCI) is a heterogenous clinical category frequently associated with prodromal AD and a common target group for such studies. More granular assessment of cognitive changes specific to underlying AD-related pathophysiology may be of particular value in this group. In most cases of MCI, previously acquired knowledge of word meanings and facts about the world is considered to be intact and largely indistinguishable from that of healthy participants. While MCI patients may have subtle impairments in language

abilities, impairments in semantic memory are not regarded as prominent and have not been the main focus of previous research. Here, we test the hypothesis that people with MCI have semantic memory impairments. To test this hypothesis, we apply sensitive measures of depth and richness of semantic knowledge from the language learning and psycholinguistic literatures, measures that previously revealed impairments in patients with focal (and stable) hippocampal damage, impairments not captured by standard neuropsychological assessments. The Word Associates Test (WAT) is a receptive measure of depth of vocabulary used in first and second-language learning research. Consisting of 40 questions, each item has a target word with eight possible associates. Participants choose four correctly matching synonyms or collocates from among the eight possibilities for each target. The number of senses a word can take (e.g. bar: to prevent from entering, a place to drink alcohol, the legal profession, a piece of candy, a metal rod) is a widely studied measure of semantic richness. The Senses-listing task presents participants with 20 target words from normed databases and gives them one minute to list as many different senses of each target word as possible. Compared to demographically matched healthy comparison participants, MCI patients performed significantly worse on the WAT and showed a trend toward producing fewer senses to polysemous target words. These deficits, on both productive and receptive measures of semantic richness and depth of vocabulary knowledge suggest that semantic memory is impoverished in patients with MCI. Future work will examine the degree to which these experimental measures are more sensitive to MCI status than standardized measures, the degree to which they are linked to MTL integrity by determining their relationship with structural MRI, and their specificity for prodromal AD in MCI as measured by the presence of cerebral amyloid as revealed by PET imaging, a marker of AD pathology.

B29 Similarity-based interference effects in reflexive binding: Empirical evidence from aphasia

Maria Varkanitsa[1,2], David Caplan[1]; [1]Massachusetts General Hospital - Harvard Medical School, [2]University College London

Existing models of sentence processing have argued that establishing dependencies relies on cue-based retrieval mechanisms that often lead to interference effects. Here we report data from a visual-world eye-tracking experiment investigating processing of antecedent-reflexive dependencies in stroke patients with aphasia (PWA). Four PWA (mean age = 56, mean education = 15 yrs) have participated to date. Stimuli included auditorily presented short stories introducing characters ("mother", "bride", "teacher"), critical sentences presented along with four pictures, and comprehension probes. Condition 1 included critical sentences and probes of the type "The bride with the spectacular heels covered herself with the veil./ Did the bride cover herself/the teacher?", and condition 2 "The mother of the bride with the spectacular heels covered herself with the veil./ Did the mother of the bride cover herself?". Critical regions for fixation analyses were the reflexive region and the final sentence region. A target-advantage score compared to the discourse distractor was calculated, by subtracting the proportion of fixations to the distractor element ("teacher") from the proportion of fixations to the target ("bride" in condition 1, "mother" in condition 2). For condition 2 we also calculated a target-advantage score compared to the intervener, by subtracting the proportion of fixations to the intervener ("bride") from the proportion of fixations to the target ("mother"). Correctly and incorrectly comprehended trials were examined separately. In condition 1, the PWA had an accuracy of 77.5% (range: 65%-100%). In correct trials, they exhibited a target preference in the reflexive and final region, whereas in incorrect trials they exhibited a distractor preference in the final region. In condition 2, their accuracy dropped to 47.5% (range: 10%-90%). In correct trials they exhibited a distractor and intervener preference in the reflexive and final region, whereas in incorrect trials they exhibited a target preference again in both regions. Fixation patterns in condition 1 indicate that failure in processing antecedent-reflexive dependencies in PWA may be due to interference from a distractor item established in the discourse ("teacher") that is similar to the target ("bride"). Fixation patterns in condition 2 seem to suggest that the PWA exhibit an incoherent fixation pattern. However, given that critical sentences in the two conditions are only minimally different, we argue for an alternative interpretation; the PWA often misinterpreted the comprehension probes the same way they misinterpreted the sentences, that is, they erroneously retrieved the intervener or the distractor as the antecedent of the reflexive in the probes. Therefore, in trials with an intervener/distractor preference they gave a YES response, whereas in trials with a target preference they replied NO. In other words, their correct trials could actually be considered as incorrect and vice versa. In this case, their fixation pattern confirms the effect of similarity-based interference in processing antecedent-reflexive dependencies. This needs further exploration with simpler probes ("Did the mother cover herself?"). We conclude that our results are consistent with interference effects from elements in the sentence and context on on-line processing of reflexives in aphasia, and provide evidence for cue-based retrieval mechanisms.

B30 Brain Network Reorganization for Language after Complete Prenatal Hemispheric Infarction

Salomi S. Asaridou[1], Özlem Ece Demir-Lira[2], Danny Siu[1], Susan Levine[2], Steven L. Small[1]; [1]Department of Neurology, University of California, Irvine, [2]Department of Psychology, The University of Chicago

Recent studies have identified a set of regions that comprise a "core" language network with many critical nodes in the left hemisphere. Disruptions of this

network have been described in adults with stroke, with language outcomes that correlate with the degree of left intrahemispheric connectivity. Here, we present a rare case of an individual born without a left hemisphere who nevertheless developed age-appropriate language skills. Using a graph theoretic approach, we investigated the topological properties of brain networks that were congenitally restricted to the right hemisphere. Our patient suffered a prenatal infarction involving the entire left cerebral hemisphere. We collected MRI data on our case at age 14y;2mo as part of a larger study comparing individuals with perinatal stroke with typically developing control cases. Thirty-one typically developing children (age 13y;6mo± 9.9m; 5 left-handed, 18 males) with no reported history of neurological or developmental disorders served as controls. Language performance was tested with standardized language tests and our case fell within the control performance range. Diffusion weighted imaging (60 directions, b-values: 0, 1,000, 2,000s/mm2 ,voxel size=1.5mm3) data were preprocessed with FSL, the tensors were fitted, and deterministic fiber tracking was performed with Diffusion Toolkit. The T1-weighted image was segmented and parcellated into 83 areas with Freesurfer using the Lausanne 2008 atlas. Structural connectomes were computed with the Connectome Mapper using fiber length to construct 83-by-83 connectivity matrices, and the Brain Connectivity Toolbox enabled estimation of graph theoretical network measures of the thresholded, weighted, undirected connectivity matrices. Bayesian hypothesis testing was used to estimate the probability that a member of the control population would obtain a different score than the case in the network measures. In our case, the right hemisphere was significantly more densely connected compared to either hemisphere or whole brain in the control sample; it was also significantly less efficiently connected (more connections, less efficient network). This pattern could reflect the result of compensatory network changes, as having a more densely connected unique hemisphere could help accommodate for the absence of the left hemisphere. With respect to individual nodes, the left dorsal IFG (a core language network node) had significantly higher degree centrality than its right homologue in the control participants, contrasting with our patient, who had degree centrality in the right dorsal IFG that did not differ from that of the homologous left dorsal IFG of controls. Whereas in controls, degree centrality in the left STG was significantly higher than the right, our patient's right STG degree centrality was not significantly different than either the left or right STG from the control sample. These nodal findings are in agreement with evidence from left hemispherectomy patients showing left-like patterns of activation in their contralesional hemisphere, with particularly increased activity in the right IFG. To conclude, being born without a left hemisphere leads to dramatic reconfiguration of brain network connectivity, as demonstrated by global density and efficiency, as well as mirror-like network properties in core language nodes, as demonstrated by degree centrality.

B31 Lesion predictors of response to semantically-based naming treatment in chronic aphasia

Michelle Gravier[1], Michael Dickey[1,2], William Hula[1,2], Patrick Doyle[1,2]; [1]VA Pittsburgh Healthcare System, [2]University of Pittsburgh

INTRODUCTION Several recent studies have implicated lesion site in naming treatment response in chronic aphasia, with better outcomes being variously related to more intact frontal (Abel et al., 2015; Marcotte et al., 2015), temporo-parietal (Bonilha et al., 2016; Fridriksson, 2010), or subcortical (Parkinson et al., 2009; Meinzer et al., 2010) brain regions. Independently, Dell and colleagues (2013) found that lesion in distinct regions predicted parameters related to semantic and phonological processing (s- and p-weight) in the interactive two-step model of naming (Schwartz et al., 2006). These brain areas partially but not completely aligned with the frontal/temporo-parietal/subcortical distinction. If lesions to s-/p-weight volumes of interest (VOIs) underlie naming impairments and help determine naming-treatment response, this might help explain the inconsistent findings above. Therefore, the current study investigated whether Dell et al's parameter VOIs or frontal/temporal-parietal/subcortical VOIs predicted response to semantically-focused naming treatment. METHOD Participants: Fourteen adults with chronic aphasia following single left-hemisphere stroke received intensive semantic feature analysis (SFA; Boyle & Coelho, 1995) treatment as part of an ongoing clinical trial. Lesion Characterization: Prior to treatment, all participants completed a T1-weighted structural MRI scan. Lesions were manually segmented using ITK-SNAP (Yushkevich et al., 2006) and normalized to the MNI template using the SPM12 clinical toolbox (Rorden et al., 2012).VOIs corresponding to s-weight and p-weight voxel-lesion parameter maps from Dell et al (2013) and frontal/temporo-parietal/subcortical VOIs based on Crosson et al. (2009) were defined via the Automated Anatomical Label Atlas (AAL, Desikan et al., 2006). Overlap between lesions and VOIs (lesion proportion) was calculated using MarsBaR (Brett et al., 2002). Analysis: The outcome measure was naming-probe accuracy for treated and semantically-related untreated items at treatment entry, exit, and one-month follow-up. Item-level data were analyzed using multilevel generalized linear regression with a logistic link function in R. Each lesion VOI was tested in a separate model including main effects and interactions of lesion proportion, probe time (entry/exit or exit/follow-up), and item type (treated/untreated). Models also included total lesion size as a covariate and random intercepts for items and participants. RESULTS Entry/exit: The main effect of lesion proportion in s-weight VOI approached significance when controlling for total lesion size ($p = 0.075$), but no two- or three-way interactions were significant. No other VOIs had significant effects. Exit/

follow-up: The main effect of s-weight lesion proportion remained nearly significant (p=0.08). Two-way interactions between subcortical VOI lesion and probe time (p=0.04) and probe type (p=0.02) were significant. DISCUSSION Larger lesions in areas linked to s-weight (the parameter representing efficiency of connections between semantic and lexical representations) predicted worse naming overall, but did not predict treatment-related changes. This contrasts with recent findings that s-weight positively predicted SFA-related improvement for treated and untreated items (Dickey et al., in prep). Interestingly, greater lesion in subcortical VOI predicted better maintenance for treated items but worse maintenance of generalization effects. This suggests that subcortical structures may play an important and sometimes surprising role in longer-term maintenance of treatment effects (Meinzer, et al., 2010; Parkinson et al., 2009).

B32 Predicting Western Aphasia Battery Subscores from the Spatial Distributions of Localized Brain Lesions

Grant Walker[1], Gregory Hickok[1], Julius Fridriksson[2]; [1]University of California, Irvine, [2]University of South Carolina

Neuropsychology provides insight into the neurobiology of language by identifying critical brain networks that result in predictable deficits when damaged. We examined the relationship between the spatial distributions of stroke-induced brain lesions and performance on a comprehensive test battery of language function. We used archived, de-identified, neuroimaging and behavioral assessments from 162 participants enrolled in an ongoing study of left-hemisphere ischemic stroke at the University of South Carolina. Binary lesion maps were manually segmented by a neurologist from structural MR images and warped to the MNI space. The Western Aphasia Battery (WAB; Kertesz, 1982) includes behavioral tests to assess spontaneous speech fluency and information content (Speech), auditory verbal comprehension of single words and commands (Comp), repetition of phrases from single words to sentences (Rep), and naming objects or producing single-word responses to verbal prompts (Naming). These subscores combine into a composite measure of aphasia severity (AQ), and also indicate a diagnostic category. The average AQ in our sample was 62.7 (range: [5, 98.6]); the sample diagnoses included Broca's (31%), Anomia (18%), Resolved (14%), Conduction (11%), Global (10%), Wernicke's (7%), and a single Transcortical Mixed case. 3-D lesion maps were transformed in two ways: 1) total lesion volume (TLV) was calculated, and 2) each map was vectorized and normalized to have unit length, effectively controlling for TLV. All behavioral measures were normalized with z-scores. We constructed partial least-squares (PLS) regression models to predict each WAB subscore and the AQ from the lesion vectors, and we used simple linear regression to predict the same measures from TLV. We used permutation tests (n=1,000; one-tail, =.05) to identify voxels that were associated with a significant decrease in test scores. We constructed bootstrap estimates (1,000 samples) for the in-sample variance accounted for (VAF) and cross-validation estimates (1,000 pseudorandom 80/20 splits) for the out-of-sample VAF. We regressed TLV against the behavioral score residuals after removing voxel-based in-sample VAF, to determine if the transformations provided unique contributions to linear predictions. All behavioral measures yielded significant voxel associations. 18,472 Speech voxels (61% in-sample VAF) clustered in precentral and postcentral gyri, and inferior and middle frontal gyri. 22,969 Comp voxels (51% in-sample VAF) clustered in the temporal lobe. 8,837 Rep voxels (56% in-sample VAF) clustered in posterior temporal lobe, supramarginal gyrus, and postcentral gyrus. 6,688 Naming voxels (51% in-sample VAF) clustered in the temporal lobe, including the pole, and the supramarginal gyrus. 611,236 AQ voxels (59% in-sample VAF) covered nearly 2/3 of the left lateral cerebrum. For all measures, voxel-based regression had ~10% more in-sample VAF than TLV; TLV accounted for an additional 2-3% variance in the residuals, either significant (p<.05) or trending (p<.10). The out-of-sample VAF was ~8.5% less than the in-sample VAF; TLV and PLS regression had similar out-of-sample VAF. The spatial distributions of lesions provided information about behavioral deficits beyond TLV. The PLS regression models help identify critical neural substrates of speech-language functions.

B33 The neural representation of concrete and abstract verb processing in aphasia

Reem S. W. Alyahya[1,2], Ajay Halai[1], Paul Conroy[1], Matthew A. Lambon Ralph[1]; [1]Neuroscience and Aphasia Research Unit, University of Manchester, United Kingdom, [2]King Fahad Medical City, Saudi Arabia

Processing concrete concepts is easier and more efficient than processing abstract ones in healthy adults and people with language impairments following brain damage (aphasia). This concreteness effect led some researchers to propose segregated neural correlates to process concrete and abstract concepts. While, concreteness effects have only been documented in nouns, some studies have shown differences between processing nouns and verbs in aphasia. The aim of this study was to explore the behavioural status of concrete and abstract verb processing in aphasia, and identify their neural representation using lesion-symptom mapping. A review of the available neuropsychological and aphasiological tests suggested that there is a dearth of comprehension tests for abstract verbs. Therefore, we developed a neuropsychological test to assess the comprehension of concrete and abstract verbs. Specifically, we generated a new verb synonym judgement test that consists of 80 verb stimuli, in which we manipulated imageability and frequency values across and within conditions, yielding four categories: concrete high-frequency, concrete low-frequency, abstract high-frequency and abstract low-frequency. Normative data was collected from 25 elderly healthy participants and the results

revealed ceiling effects across all four categories (> 97.2%). Subsequently, the test was administered to a cohort of 48 participants with chronic post-stroke aphasia, including a diverse range of aphasia classifications and severities. The results using a 2 x 2 ANOVA revealed a significant effect of imageability, with better comprehension of concrete verbs (Mean = 33.13, SD = 7.5) compared to abstract verbs (Mean = 23.64, SD =9.2). There was no effect of frequency or interaction effect between imageability and frequency on verb processing. This provides evidence that processing concrete verbs is more robust than abstract verbs in chronic post-stroke aphasia, which aligns with existing literature on concrete and abstract noun processing. Lesion-symptom mapping was conducted using voxel-based correlational methodology. The results revealed a range of common cortical regions that support processing concrete and abstract items in the left anterior temporal lobe and posterior supramarginal gyrus. Further direct contrast between concrete and abstract items revealed significant graded differences between them. Specifically, left frontal regions (inferior frontal gyrus, middle frontal gyrus and pre-central gyrus) were associated with processing abstract over concrete verbs; whereas, left posterior temporal and occipital regions (inferior temporal gyrus, posterior middle temporal gyrus and inferior lateral occipital cortex) were associated with processing concrete over abstract verbs. The current findings are consistent with results using other methods, such as functional neuroimaging and neuro-stimulation, proposing graded differences between the neural representation of concrete and abstract concepts. The contribution of left posterior ventral regions with concrete words probably reflects the activation of visual imagery associated with concrete concepts. On the other hand, the involvement of frontal regions with abstract words can be interpreted in terms of its role in semantic control, as a result of the variable meanings associated with abstract concepts, especially when the items is presented as a single word rather than a full context.

B34 Left hemisphere frontotemporal effective connectivity during semantic feature judgments: Differences between patients with aphasia and healthy controls

Erin Meier[1], Swathi Kiran[1]; [1]Boston University, Sargent College of Health and Rehabilitation Sciences

Making semantic judgments requires integrated functioning of anatomically-distributed regions implicated in low-level conceptual processing (e.g., left anterior/mid middle temporal gyrus [LMTG]), semantic control (e.g., left inferior frontal gyrus [LIFG]), and domain-general executive processes (e.g., left middle frontal gyrus [LMFG]) (e.g., Binder et al., 2009; Noonan et al., 2013). Left hemisphere (LH) stroke forces reorganization of this system. Compared to controls, persons with aphasia (PWA) may rely more heavily on domain-general regions due to difficulty with language and/or damage to canonical language cortex (Brownsett et al., 2014). However, little is known about the dynamic coupling between semantic network nodes in PWA. Therefore, we employed fMRI and dynamic causal modeling (DCM; Friston et al., 2003) to investigate differences between PWA and controls in effective connectivity of a three-node LH semantic network. Sixteen PWA (10M, mean age=64.9 years) and 17 age-matched controls (10M, mean age=60.4 years) completed an event-related fMRI task during which participants decided whether written features applied to real (experimental) or scrambled (control) pictures. MR and connectivity methods similar to Meier, Kapse, & Kiran (2016) were applied. In short, a DCM model space was created according to exogenous task-based perturbation to LIFG, LMFG or LMTG with all combinations of uni- or bidirectional inter-regional connections specified across 72 models. Models were partitioned into separate families (i.e., #1: LIFG input, #2: LMFG input, #3: LMTG input). Random effects family-wise Bayesian Model Selection (fw-BMS) determined which model family best fit individual and group data (Penny et al., 2010). Bayesian Model Averaging across each family generated parameter values indicating the strength/direction of task-based effects on regions and connections. Two-way (group x family) ANOVA and MANOVA were performed to determine group differences in regions and connections, respectively. Patients exhibited significantly poorer task accuracy than controls ($t(17)=-3.32$, $p=.004$). Group-level fw-BMS indicated models with task-induced perturbation to LIFG (family #1) best fit control data ($xp=.881$). Family #3: LMTG input best fit PWA group data ($xp=.499$), but only six PWA showed a preference for family #3 per single-subject fw-BMS. Patient model fit was not related to the amount of spared tissue in any region ($r=-.025$-$.351$, $p=.199$-$.930$). Regarding parameters, patients exhibited significantly weaker task-induced perturbation to all regions than controls ($F(1,93)=16.02$, $p<.001$). However, connection values were significantly more positive (i.e., excitatory) for PWA ($F(6,88)=6.13$, $p<.001$) for all connections except LIFG->LMFG and LMTG->LMFG. Overall, these findings illustrate that LH stroke alters the functional topography of the semantic network in PWA. Despite heterogeneity in model fit, patients relied more on lower-level processing by LMTG to drive semantic decisions whereas controls relied on LIFG, consistent with semantic control requirements for successful task completion (Thompson-Schill et al., 1997). PWA also exhibited weaker local task-based activity in all three regions but greater coupling between regions compared to controls. These collective results may reflect patients' ability to process basic semantic information but difficulty in selecting correct features, which requires efficient communication between network nodes. This work provides an essential foundation for future investigations aiming to leverage connectomics in improving our understanding of recovery in PWA.

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B35 Transcranial Direct Current Stimulation Changes Functional Connectivity in Primary Progressive Aphasia

Bronte N. Ficek[1], Zeyi Wang[2], Kimberly Webster[1,3], Brian Caffo[2], Kyrana Tsapkini[1]; [1]Department of Neurology, Johns Hopkins Medicine, Baltimore, MD, [2]Department of Biostatistics, Johns Hopkins School of Public Health, Baltimore, MD, [3]Department of Otolaryngology, Johns Hopkins Medicine, Baltimore, MD

Introduction: The effects of transcranial direct current stimulation (tDCS) on brain functional connectivity have been explored in healthy aging (Stagg 2014) as well as stroke (Marangolo 2016). However, findings are still unclear. Furthermore, there is relatively little known about the effects of tDCS on functional connectivity in neurodegenerative disease. In the present study, we aimed to assess the effects of anodal tDCS over the left inferior frontal gyrus (IFG) on resting-state functional connectivity in a group of patients with primary progressive aphasia. Methods: We used a within-subjects crossover design, with two phases of 15 consecutive days of either tDCS or sham therapy with a 2-month wash-out period. Anodal, left-IFG tDCS (2x2 inches, 2 mA/minute) was administered for 20 minutes each day, simultaneous with the start of daily, hour-long oral and written naming therapy. For 25 participants, rsfMRI data were acquired for 7 minutes (210 time-point acquisitions) before, after, and 2 months after phase one of intervention. For this analysis we used MRICloud (Oishi 2009), an automated image parcellation approach (atlas-based analysis (ABA)), in which the brain was divided into 283 structures. In an ROI-ROI analysis, Pearson's correlation coefficients were obtained from averaged time courses of each region and z-transformed with Fisher's method. Regions selected for analysis were the left IFG opercularis, orbitalis, and triangularis (stimulated area) and other common written and oral language production areas in the left hemisphere (MFG, SPG, SMG, AG, STG, MTG, ITG and FuG), as well as their right homologues. For each pair of ROIs, we measured change in correlation immediately after and 2 months post intervention as compared to before intervention. Results: Behaviorally, gains in written naming scores (both trained and untrained items) in the tDCS condition were significantly greater than those in sham ($p<0.05$). Imaging analysis revealed three main results. 1) Anodal stimulation over the left IFG significantly increased functional connectivity within the IFG between its subregions. 2) Within the language network, connectivity between the left IFG and other areas of the language network (MTG and fusiform gyrus) decreased in tDCS relative to sham (after correcting for multiple comparisons). 3) Composite scores for neither the language network nor the default mode network showed any significant difference between tDCS and sham. Discussion: Our results align with previous results in healthy aging but not in stroke populations and show that tDCS downregulates the hyperactivity usually observed in frontal areas (Amadi 2013) and upregulates hypoactivity in posterior areas in an adaptive way, as it corresponds to behavioral improvements. These preliminary results show that downregulation of hyperactivity in frontal areas may be one mechanism for effective tDCS. Acknowledgements: Thank you to the Science of Learning Institute at Johns Hopkins University and the National Institute of Health (NIDCD) for award R01 DC014475. References: Stagg CJ, Bachtiar V, Amadi U, et al. Elife. 2014;3:e01465. Marangolo P, Fiori V, Sabatini U, et al. J Cogn Neurosci. 2016;28:724–738. Oishi K, Faria A, Jiang H, et al. NeuroImage. 2009;46(2):486-499. Amadi U, Ilie A, Johansen-Berg H, Stagg CJ. NeuroImage. 2013;88C:155-161.

B36 Changes in neural activity during a semantic verification task as a result of treatment in persons with aphasia

Shreya Chaturvedi[1], Jeffrey Johnson[1], Yansong Geng[1], Erin Meier[1], Swathi Kiran[1]; [1]Boston University

Introduction Numerous studies have investigated the effects of rehabilitation on neural activation in persons with aphasia (PWA); however, results vary. Some report the recruitment of right language regions (Peck et al., 2004; Thiel et al., 2013) and others report the importance of the left hemisphere and perilesional activation in semantic processing specifically (Fridriksson, 2010; Fridriksson et al., 2012). To build upon these investigations, we examined changes in activation during a semantic feature verification task after a 12-week treatment for anomia. Methods Twenty PWA (age range = 42 – 79 years, M = 61, SD = 10.9; months post onset [MPO] range = 10 – 152; M = 56, SD = 49.3) received language treatment to improve naming for 36 items over two categories. Treatment was provided twice a week for 2 hours per session and involved sorting pictured items by category; multiple attempts at naming pictured items; reading/reviewing semantic features of an item; and verifying whether or not various features applied to pictured items. Treatment was terminated after 12 weeks or when PWA achieved 90% accuracy on two consecutive weekly naming probes. Before and after treatment, PWA were scanned on a semantic feature verification task to decide whether or not written features applied to pictured items. Stimuli were pictures of trained items (experimental condition) and scrambled pictures (control condition). To obtain normative data on task-specific activation, 19 healthy control participants were scanned on the task as well. Individual and group analyses based on the General Linear Model (GLM) were performed for each time point (pre- and post-treatment) for the contrast of: trained pictures – scrambled pictures. Additionally, treatment-induced changes in activation were identified in SPM post-treatment relative to pre-treatment. We also accounted for percent improvement (average percent change across two trained categories) and lesion volume in whole brain analyses. Results 18 out of 20 patients improved after treatment, as indicated by a paired t-test comparing their

average pre-treatment and post-treatment naming accuracy (t17 = 4.9, p< 0.001) (M = 25%, range = -6 to 65%, SD = 0.2). Healthy participants showed significant activation for semantic feature verification in Left Inferior Frontal Gyrus (LIFG), and) LPosterior Medial Temporal Gyrus (LPMTG). In patients, increased activation that emerged as a function of treatment was found in LSuperior MG, LHippocampus, LS Occipital Gyrus, LCuneus, RAnterior Cingulate Cortex, RParacentral Lobule, and RAngular Gyrus. Bilateral activation was demonstrated in IFG, MCC, MFG, MOG, Pre and Postcentral Gyrus, and Precuneus. Accounting for percent improvement in rehabilitation, LSFG, LMFG, RSFG, RMFG, RIFG, LPostcentral Gyrus, LSOG, LPrecuneus, RAngular Gyrus, and RSOG showed increased activation. Conclusion Our results indicate patterns of activation consistent with previous studies that PWA employ traditional language specific regions like IFG (Turkeltaub, Messing, Norise, & Hamilton, 2011), However, we also found that patients showed increased activation in domain general regions like MFG, ACC, and Precuneus (Fedorenko, Duncan, & Kanwisher, 2013). Cumulatively, this suggests that the semantic verification tasks engage both task specific and domain general systems as a result of semantic feature based treatment.

Meaning: Lexical Semantics

B37 Hemispheric Processing of Iconic and Arbitrary Words: A Line Bisection Study

Vijayachandra Ramachandra[1], Rachel Panick[1], Cara Maher[1], Gabriella Trezza[1], Brittney Coan[1]; [1]Marywood University

Words in a language are generally considered arbitrary. A number of languages (such as Japanese, Korean, sub-Saharan African languages, etc.) and number of words in English, however, are non-arbitrary (or iconic) (Perniss et al., 2010). For example, English words such as gleam, glitter, and glow (all with a prefix 'gl') refer to 'light'. It is well established that the left hemisphere is dominant for processing words but a recent neuroimaging investigation in Japanese showed that unlike arbitrary words which are processed in the left hemisphere, iconic words show high levels of activation in the right hemisphere, which is generally involved in processing non-verbal sounds (Kanero et al., 2014). In the current study, we wanted to investigate hemispheric processing of arbitrary and iconic words in English using a simple line bisection test. 20 healthy young right-handed adults (10 men and 10 women) between 18 and 25 years who did not have any sensory or neurological issues were asked to bisect 46 horizontal straight lines (21 cm long X 2 mm wide placed at the center of an A4 size white paper), at what they gauged as their mid points. We placed either arbitrary (e.g. girl, room, etc.) or iconic (e.g. bam, ouch, etc.) words at both ends of some of the lines. They were compared with bisections for horizontal lines with neutral stimuli at the ends (i.e., XXX marked at the ends). When young typical adults bisect a line, they usually show a more left-side deviation from the midline (pseudoneglect). A right hemisphere lateralization for iconic words would lead to a more left bias and a left hemisphere lateralization for arbitrary words would lead to a less left-side bias (this is because of greater processing in the hemisphere contralateral to the side of spatial bias). Along these lines, we expected to see a more left-side bias for iconic words and a less left bias for arbitrary words when compared to the bisections for neutral stimuli. We also expected to see more left deviations for lines with iconic words when compared to lines with arbitrary words. As expected, we observed the pseudoneglect phenomenon in our participants while bisecting lines with neutral stimuli at the ends (M= -0.276, SD=0.446). Contrary to what we expected, a less leftward deviation when compared to lines with neutral stimuli was seen for both iconic and arbitrary words (M for iconic = -0.133, SD= 0.421, t=2.88 (318), p=0.004; M for arbitrary= -0.128, SD=0.463, t=2.80 (318), p=0.005). This less left bias can be attributed to increased left hemisphere activation for words. Moreover, the presence of iconic words did not lead to a more left side deviation when compared to arbitrary words (t=0.102, p=0.919) showing the importance of the left-hemisphere in semantic processing of words irrespective of the type. Comparison of these results with the recent neuroimaging study in Japanese and future directions will also be discussed.

B38 Neural Correlates of Semantic Coherence in English and Chinese Speakers during Natural Language Comprehension

Jixing Li[1], Christophe Pallier[2], Yiming Yang[3], John Hale[1]; [1]Cornell University, [2]INSERM-CEA Cognitive Neuroimaging Unit, [3]Jiangsu Normal University

Introduction: Semantically incoherent words influences sentence comprehension. For example, in the sentence "He spread the warm bread with socks", although "socks" is grammatically correct (i.e., noun), it hinders comprehension and elicits a large N400 effect (Federmeier & Kutas, 1999). Despite a large body of work on semantic expectation in sentence comprehension (e.g., Brothers et al. 2015; Federmeier & Kutas 1999; Lau et al. 2013), the neural correlates of semantic coherence remain unclear. It is also unknown whether there would be a cross-linguistic difference in the location of semantic coherence in the brain. The current study correlated time-series predictions from semantic coherence and fMRI data recorded while both English and Chinese participants listened to a same story in the scanner. The results showed that both English and Chinese speakers activated the precuneous cortex in response to semantic coherence, consistent with previous studies reporting the precuneous cortex for semantic processing (e.g., Binder et al. 2009; Leshinskaya et al. 2017; Lundstrom et al. 2005). Methods: 31 English speakers (20 female, mean age = 21.5) and 33 Chinese speakers (16 female, mean age = 20.7) listened to the whole audiobook of "The Little Prince" (in English or Chinese translation, respectively) for about 100 minutes across nine sections, and completed four quiz questions after

each section. BOLD functional scans were acquired using a multi-echo planar imaging (ME-EPI) sequence with online reconstruction (TR=2000 ms; TE's=12.8, 27.5, 43 ms; FA=77 ; matrix size=72 x 72; FOV=240.0 mm x 240.0 mm; 2 x image acceleration; 33 axial slices, voxel size=3.75 x 3.75 x 3.8 mm). Preprocessing was carried out with AFNI version 16 and ME-ICA (Kundu et al., 2011). Semantic vector representations of contents words in the story were generated by Mikolov et al.'s (2013) skipgram model. The training corpora for the English and Chinese models are all the English articles (n=4275675) and Chinese articles (n=744150) on Wikipedia. We then quantified semantic coherence between a word and its previous context as the negative cosine between the word and the mean of the previous 10 words' vectors. Higher negative cosine value indicates lower semantic coherence. We also included four nuisance variables into the GLM analysis, performed using SPM12: word rate marks the offset of each spoken word in time; word frequency gives the log-frequency of each word in movie subtitles (Brysbaert & New, 2009; Cai & Brysbaert, 2010); intensity and f0 are marked at every 10 ms of the audio. These regressors were not orthogonalized. Results: Semantic coherence is associated with the precuneous cortex for both English and Chinese speakers ($p < 0.05$ FWE, $k > 20$). Chinese speakers showed additional bilateral anterior superior temporal gyrus (aSTG) activation. Direct comparison of the two groups confirmed stronger activity in the left aSTG for Chinese speakers than for English speakers (see Table 1 and Figure 1). Conclusion: We provided cross-linguistic evidence for semantic coherence in the precuneous cortex, suggesting that semantic coherence is a cognitively different process from other semantic processes, such as semantic combination (Bemis & Pylkkänen, 2011).

B39 State-dependant organization of the functional connectome with age

Perrine Ferré[1], Yassine Benhajali[1], Jason Steffener[2], Yaakov Stern[3], Yves Joanette[1], Pierre Bellec[1]; [1]Centre de Recherche de l'Institut Universitaire de Montréal, [2]University of Ottawa, [3]Columbia University

According to the World Health Organization, the proportion of individuals over age 60 is expected to double by 2050. Considering this demographic shift, a better understanding of the mechanisms required to maintain cognitive health during normal and pathological aging is a crucial goal for contemporary health researchers. Most of our knowledge on brain functioning in aging focused on declining function (e.g.: working memory). Language processing related to vocabulary and semantic knowledge, which stand at the heart of inter-individual relationships, appear relatively well preserved and as such might shed light on reorganization processes at stake in healthy aging. In the past decade, connectivity measures in functional magnetic resonance imaging gained popularity to study age related brain mechanisms, established mainly on "task free" experimental design. But recent evidence points towards highly dynamic neurofunctional processing in aging, and it remains to be determined if age-related differences in functional connectivity are dependent on the cognitive context. From a sample of 300 adults ranging from 18 to 80 years old, we explored semantic and general cognitive performance in correlation with age, education and other socio-demographic characteristics. Then, 286 individuals reaching fMRI standards for quality assessment were tested systematically for whole brain connectivity to search for consistent differences as a function of age, performance or education during an fMRI session of resting-state and while performing three language tasks (antonyms, synonyms, picture naming). Our results confirm a behavioral dissociation between semantic and neuropsychological performance: increasing age favors better performances for language tasks. Major discrepancies were further observed between task-evoked and resting state connectivity patterns. Mean functional connectivity shows a general tendency to decrease with age, but increases in synchronicity between core semantic-reading regions were revealed only during task performance. No interactions were to be found between connectivity patterns and performance or education as a function of age. We propose that investigation of functional connectivity in aging cannot solely rely on resting-state imaging data, especially when interpretation of behavioral data (performance) is at stake. Our results challenge the current models of aging. We find no evidence of traditional compensation-related mechanisms in regards with preserved performance, which suggests a unique signature of semantic networks connectivity in aging.

B40 Commonalities in the neural encoding of sentence meaning across widely distributed brain regions

Andrew Anderson[1], Edmund Lalor[1], Leonardo Fernandino[2], Rajeev Raizada[1], Scott Grimm[1], Vankee Lin[1], Xixi Wang[1]; [1]University of Rochester, [2]Medical College of Wisconsin

Deciphering how sentence meaning is represented in the brain remains a major challenge to science. Semantically related neural activity has recently been shown to rise concurrently in spatially distributed brain regions as successive words in a sentence are read. However, what semantic content is represented by different regions, what is common across them, and how this relates to different elements of sentences' grammatical structure is weakly understood. To address these questions, we apply a semantic model of words' meaning, based on human ratings of a diverse set of 65 sensory/motor/emotional and cognitive features of experience with words' referents, to interpret brain activation patterns elicited in sentence comprehension. 14 participants were scanned using functional Magnetic Resonance Imaging (fMRI) as they read 240 sentences describing everyday situations. Through a process of mapping fMRI scans of brain activation back into the semantic model space: we test which brain regions reconstruct semantic features associated with different elements of sentences' grammatical structure; and which semantic features are reconstructed by different regions.

From left temporal, inferior parietal, inferior frontal and superior frontal brain regions we extract semantic features associated with all elements of grammatical structure investigated and many common components of experience. This newly reveals that during sentence comprehension: there are strong commonalities in the encoding of sentence meaning across multiple distributed brain regions; and the neural codes from many regions enable reconstruction of diverse aspects of humans' experience.

B41 Multivariate pattern analysis reveals semantic information in brain areas activated for nonwords

Hillary Levinson[1], Samantha Mattheiss[1], William W. Graves[1]; [1]Rutgers University

The neural basis of semantic cognition has been investigated using univariate analysis of functional magnetic resonance imaging (fMRI) data for at least the past 20 years. These analyses have proven to be very effective in revealing neural regions involved in the putative neural semantic network, which significantly overlaps with the default mode network (DMN). However, there have been some inconsistencies across fMRI studies in terms of the primary regions involved in semantic processing. These discrepancies have most often been found in studies that manipulate the level of task difficulty, where increasing levels of difficulty activate regions outside of the putative semantic network/DMN, such as the task positive network (TPN). We recently observed this pattern in a lexical decision task with high and low imageability words, where the word-nonword contrast revealed nonword activation primarily in the DMN (including angular gyrus and posterior cingulate), and word activation in the TPN (including inferior frontal junction, intraparietal sulcus, and ventral occipitotemporal sulcus). Here we investigated whether the putative semantic areas activated for nonwords also encoded semantic information. This was determined by classifying high and low imageability words using multivariate pattern analysis (MVPA), implemented in the PyMVPA suite. We trained a Sparse Multinomial Logistic Regression classifier on fMRI data restricted to the nonword contrast to determine whether participants were reading high or low imageability words. It reliably classified imageability category at 83.3% accuracy ($p < .05$ by Monte Carlo simulation). This suggests that semantic information is present even in areas activated by meaningless nonwords. Although previous activation of putative semantic areas by nonwords was presumably due to difficulty effects, this analysis shows difficulty effects and semantic information can co-localize in the same neural network.

B42 ERP and fMRI exploration of the organizational structure of abstract versus concrete words in neurotypical adults

Chaleece Sandberg[1]; [1]Penn State University

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 through associative connections, while concrete words are organized into natural categories (Crutch, Connell, & Warrington, 2009). This project aims to determine if this hypothesis is supported with neuroimaging data. It is predicted that words in their 'dispreferred' context (concrete = associative; abstract = categorical/similarity) will have higher activation and more of an N400 effect than words in their 'preferred' organizational context (concrete = categorical/similarity; abstract = associative). Nineteen right-handed English-speaking neurotypical adults (NTA; 8 male), ranging in age from 18-64 (μ=36) have participated in the EEG portion of the experiment to date. A subset of sixteen NTA (7 male), ranging in age from 18-62 (μ=36), have participated to date in the fMRI portion of the experiment. Each participant performed the same semantic-relatedness task during both the EEG and fMRI scan. The semantic-relatedness task was adapted from Crutch et al. (2009). Forty semantically-related word pairs were in each of four conditions: abstract similar, abstract associated, concrete similar, and concrete associated. Unrelated word pairs balanced yes/no responses and served as a baseline for the N400. The abstract and concrete word pair lists were matched on frequency and familiarity, but differed on imageability and concreteness. ERP data were analyzed using BrainVision Analyzer software. Preprocessing included ICA to mitigate the effects of eye blinks. Repeated measures ANOVA were used to compare conditions at three electrodes – Fz, Cz, and Pz – within the N400 time window. fMRI data were analyzed using SPM12. Routine preprocessing was conducted and a general linear model was used for statistical analysis. The contrasts of interest included main effects and interactions of concreteness (abstract vs. concrete) and relation type (association vs. similarity). For the ERP data, there was a statistically significant ($p<.05$) N400 effect for the unrelated items compared with the related items. The concrete similarity condition had a significantly lower ($p<.05$) N400 than every other condition at Pz. While the other conditions were not significantly different from each other, the fact that the concrete similarity condition had the lowest N400 peak is in line with the predictions. For the fMRI data, there was a main effect of concreteness in line with previous work (Binder, Desai, Graves, & Conant, 2009). There was also a main effect of relation type, and an interaction effect. In right inferior frontal gyrus, more activation was noted for concrete words in a similarity context and abstract words in an associative context (preferred). Right hippocampus, right middle occipital gyrus, left superior frontal gyrus, and left superior occipital gyrus showed more activation for concrete words in an associative context and abstract words in a similarity context (dispreferred). While not specifically predicted, these results suggest that different

regions may support processing related to preferred versus dispreferred semantic contexts. Combined, these data suggest there may be differential semantic organization for abstract and concrete words.

B43 How using concepts changes them: A graph theory approach *Yoed N. Kenett[1], Zareh Kaloustian[1], Sharon L. Thompson-Schill[1]; [1]University of Pennsylvania*

The generative capacity of language entails an ability to flexibly combine concepts with each other. Investigating how individuals combine concepts can shed unique light on different aspects of conceptual knowledge, including the cognitive mechanisms that enable the generative and flexible use of language. Conceptual combination can occur either by using an attribute of one concept to describe another (attributive combination) or by forming some relation between two concepts to create a new one (relational combination). For example, while some interpret the noun-noun combination whale boat as "a large boat", applying the attribute "large" of the whale to the boat; others interpret this combination as "a boat that hunts whales", applying a thematic, relational role between whales and boats. Prior research has addressed whether common or distinct processes support these two putatively different types of combinations. We turn the question around and ask whether the consequences of these combination types on our conceptual system might differ, by comparing semantic memory networks before and after participants perform either attributive or relational conceptual combinations. We characterized the semantic network of participants using their free association responses to 50 cue words taken from five semantic categories (such as animals or fruits and vegetables). These association responses were obtained twice, before and after completing a conceptual combination task that was biased to elicit either attributive or relational interpretations to half of these cue words. Semantic networks of these 50 cue words were computed based on association correlations – the overlap of association responses between any pair of cue words. With this procedure, we were able to assess the main effect, within subjects, of conceptual combination (by comparing the structure of the semantic networks at both time points) as well as the interaction, between subjects, of the type of conceptual combination on network change. We find a general effect on the semantic networks: The structure of network decreases after participants conceptually combine some of the concepts in the network. However, the relational combination manipulation has a greater effect. Furthermore, only the relational combination manipulation leads to an increase in the network's connectivity. Overall, our results demonstrate that semantic networks can be applied to study group-level effects of different conceptual combination mechanisms and indicate that the relational combination manipulation has a greater effect on semantic memory structure than an attributive combination manipulation. Our findings are in line with current theories of semantic memory, which view it as a dynamic system. Such theories argue that both context (task demands) and individual differences (processing style) lead to short- and long-term changes in semantic memory structure. We show how manipulating concepts in the semantic network (through a conceptual combination manipulation) changes the structure of the network. Thus, the work reported here is a first step at harnessing computational network science to investigate the effects of different conceptual combination mechanisms on semantic memory structure. It demonstrates the efficacy of applying semantic network analysis in understanding high-level cognition.

B44 Distinguishing Metaphors that Differ in their Encoded Force Patterns *Vesna Gamez-Djokic[1], Elisabeth Wehling[2], Lisa Aziz-Zadeh[1]; [1]University of Southern California, [2]University of California, Berkeley*

Previous studies indicate that action verbs activate sensorimotor brain regions that process specific motor features relevant to the meaning of action verbs. For example, areas of the premotor cortex have been shown to be sensitive to the degree of implied force in action-related phrases (e.g., "pushing the piano" vs. "pushing the chair"). However, it is currently unknown whether action-related metaphors that imply an action towards or away from an agent should, similarly, recruit specific sensorimotor programs (e.g., force direction) to encode the meaning of more abstract events. To explore these questions, we used an MVPA whole-brain searchlight analysis to look for patterns of activity across voxels in the brain that could successfully classify two categories of familiar metaphors that differ in their encoded force dynamics: 1) Metaphors drawing on action-verbs that imply an away-from-self force toward an antagonist and relate to the act of communicating (e.g., "She's pushing the agenda"); 2) and metaphors drawing on action-verbs that imply a force that would move the antagonist towards the self and relate to cognizing (e.g., "She's grasping the idea"). The results revealed that activity across voxels within fronto-parietal motor regions (e.g., precentral gyrus/premotor cortex, SPL, and IPL), could successfully distinguish between these two types of metaphors. In addition, some of these voxels overlapped with voxels in brain regions that were significantly activated in a motor localizer task involving object-directed hand actions. Taken together, these findings support a degree of motor specificity even for more abstract event descriptions during metaphor comprehension.

Grammar: Morphology

B45 Morphological processing in Chinese: An ERP study *Lin Chen[1], You Li[2], Charles Perfetti[3]; [1]Sun Yat-sen University, [2]South China Normal University, [3]University of Pittsburgh*

There is a relatively broad consensus that morphologically complex words, such as playground, are decomposed into their constituent morphemes during word recognition. However, researchers disagree about how the morphological processing happens. Some models advocate that morphological processing is initially based on purely orthographic analysis (Lavric et al., 2007, 2012). The alternative hypothesis suggests that morphemic-meaning can be accessed rapidly and constrains initial morphological decomposition (Diependaele et al., 2011; Feldman et al., 2012). The present study addresses this decomposition issue, using ERPs to provide new evidence for morphological processing in Chinese. Twenty-five (13 male) undergraduate students participated the experiment. The stimuli were 116 sets of prime-target pairs. For each set, there are two versions, one for each of two conditions: transparent and opaque. In the transparent condition, the two-character word prime and the one-character target shared the first morpheme and had a semantically transparent relationship (公开-公 [make public-public]). The prime-target pairs in the opaque condition shared the first morpheme but had an semantically opaque relationship (公主-公[princess-public]). There were the two sets of control prime-target pairs in which the two-character word primes were transparent words and opaque words, respectively. The two-word prime was orthographically, morphologically and semantically unrelated to the one-character target. There were 116 filler pairs of which the targets were non-characters to counterbalance the responses. Each trial began with a central 500ms fixation (+). Primes were presented for 40ms followed by a backward mask (#####) for 500ms. The target appeared with offset of the mask, remaining until a response was made. Participants were instructed to make a character or non-character response to the target. There was a main effect of prime type for RTs, $F(1,24)=23.21$, $p<.001$. Responses in the morpheme-shared condition was significantly faster than those in the control condition. Paired t test was used to compare the magnitude of priming for transparent items and opaque items. No differences were found $t(24)=1.19$, $p=.24$. ERP recordings and data analysis The ERP amplitude analyses focused on time windows centered on P200, N400 and P600. Repeated measures ANOVAS with the factors word transparency (transparent, opaque), region (anterior [FZ, FCZ], central [CZ, CPZ], posterior [PZ, POZ]), and prime type (morpheme-shared, control) were carried out. There were no effects of experimental variables in the 200-300ms time window. There was a main effect of prime type in the 300-500ms time window, $F(1,24)=18.75$, $p<.001$. Morpheme-shared condition (4.47) produced a reduced negativity relative to non-repeated condition (2.94). There was an significant interaction between regions and transparency in the 500-800ms time window, $F(2,48)=6.51$, $p<.05$. Further analysis showed that in the posterior, the mean amplitude of opaque words (3.55) was significantly more positive than transparent words (2.95), $F(1,24)=6.48$, $p<.05$. The results support that, morphological processing in Chinese depends more on orthographic analysis.

Perception: Orthographic and Other Visual Processes

B46 Letters to the left of me, letters to the right: Examining parafoveal flanker effects during word recognition

Trevor Brothers[1], Matthew J. Traxler[1], Tamara Y. Swaab[1]; [1]University of California, Davis

During reading, the presence of nearby letter strings can influence word identification, even when these flanking letters are task irrelevant. Our goal in the present experiments was to explore the mechanisms of this parafoveal flanker effect and to investigate the temporal relationship between orthographic processing and semantic activation. In Experiment 1, words surrounded by congruent flankers (RA RAGE GE) were recognized faster than those with incongruent flankers (TH RAGE IN), replicating previous results. Critically, priming was identical for visually dissimilar letters of a different case (ra RAGE ge), suggesting that flanker priming occurs at the level of abstract orthographic units. In Experiment 2, we showed that flankers derived from semantically related words (LE BORROW ND) also produce faster lexical decisions. Finally, in an experiment using event-related potentials, incongruent flankers produced larger N400 amplitudes and caused a delay in the onset of the N400 semantic priming effect. Together, these findings suggest that irrelevant parafoveal letter strings can be processed at both the orthographic and semantic level and that early orthographic interference can delay semantic activation. We discuss implications of these findings for models of word recognition as well as recent computational models of the N400.

Perception: Auditory

B47 Asymmetrical MMNs to socially-marked biological sounds: a potential challenge to the phoneme underspecification hypothesis

Roberto Petrosino[1], Diogo Almeida[2], Andrea Calabrese[1], Jon Sprouse[1]; [1]University of Connecticut, [2]New York University - Abu Dhabi

Mismatch negativities (MMNs) occur when two sounds are presented in an oddball paradigm with one sound played frequently as standard, and the other played infrequently as the deviant. Prima facie, swapping the roles of two sounds shouldn't affect the MMN; however, there is a growing literature demonstrating asymmetrical MMN effects (aMMNs) when the two sounds are phonemes: the MMN is larger with one role ordering than the reverse. MMNs have long been used to probe abstract categories in speech perception (Näätänen et al. 1997, Phillips et al. 2000), as such these aMMNs have been interpreted as evidence that MMNs are sensitive to asymmetries in the

abstract representation of phonemes, specifically whether each phoneme in the pair is fully specified for articulatory features in the lexicon, or underspecified for one or more features (e.g., Eulitz & Lahiri, 2004, Scharinger et al. 2012, Schluter et al. 2017). Our goal in this project is to better understand aMMNs so as to better interpret the strength of this evidence. We have three concrete questions: (i) Do aMMNs arise for other biological sounds?, (ii) Are aMMNs sensitive to other higher-order abstract categories, such as social markedness?, and (iii) Can lower-level acoustic differences explain the directionality of aMMNs? To answer these questions, we looked for aMMNs to three biological sounds – [flatulence], [cough] and [sniff] – that are (i) relatively frequent, (ii) differ in social markedness, and (iii) differ in spectral and temporal acoustic properties. We also included a linguistic pair – [s] and [z] – to confirm that we can observe aMMNs in general. We created ten tokens of each condition, 250ms long, processed using the best practices of the aMMN literature. We tested 24 right-handed participants in an auditory oddball paradigm with six blocks (with the order randomized for each participant): [s]-[z], [flatulence]-[cough], [cough]-[sniff], in each of the two role assignments. We calculated MMNs by comparing the deviant of a sound to the standard of the same sound from a different block (the identity MMN). For the linguistic condition, the MMN response to [z] was larger than the MMN to [s], as expected. For the biological sounds, the MMN to [flatulence] was larger than the MMN to [cough]. There was no significant difference between [cough] and [sniff]. First, our results suggest that aMMNs are not specific to language. This suggests that aMMNs could in principle be used to explore other types of abstract representations. Second, the larger MMN to [flatulence] suggests that aMMNs may be sensitive to the abstract representations of social markedness. Third, spectral MFCC-based analyses suggest that lower-level acoustic properties cannot explain this aMMN, as it places [cough] and [sniff] as most distinct from one another, and [flatulence] in between the two (contrary to our results). This new dimension to aMMNs raises a new question for existing aMMNs to linguistic sounds: Is the aMMN due to underspecification as previously argued, or due to a different abstract property like phonological markedness? Future studies dissociating underspecification and markedness will be necessary to answer that.

B48 Language effects for theta oscillatory activity within cortical sensory processing

Monica Wagner[1], Silvia Ortiz-Mantilla[2], Valerie Shafer[3]; [1]St. John's University, [2]Rutgers University, [3]The Graduate Center, CUNY

In a previous study of the auditory evoked potential (AEP) responses to native and non-native phoneme sequences within nonsense words, we demonstrated that the P1-N1-P2 and T-complex reflected recognition of spectro-temporal features within phoneme sequences similarly in native-English and native-Polish adults and subsequent sound processing reflected language group differences. These language group differences were reflected in a subgroup of participants for which vigilance to the speech stimuli was reduced. In order to further explore early sensory processing, time-frequency analysis in source space was conducted on this same group of participants. Research evidence of dynamic oscillatory changes has furthered our understanding of language processing in the brain. In the current study, we investigated sensory processing within theta oscillatory activations to the /pt/ consonant cluster that occurs in the Polish language in word onset, but not the English language. EEG was recorded as 24 participants (12 English and 12 Polish) listened to same and different nonsense word pairs. Nonsense words within the pairs contained the phoneme sequence onsets /pət/, /st/, /sət/ and /pt/. Using time-frequency analysis, induced (TSE, Temporal spectral evolution) and evoked (ITPL, Inter-trial phase locking) oscillatory activity was examined at source level. Sources of the N1 responses to the /pt/ onset were identified with a three-dipole model, which explained ~97% of the variance in the data. Statistical analyses were conducted using permutation testing and cluster identification. Our examination of theta oscillatory activity (4 – 8 Hz) showed that the English listeners elicited significantly more power (TSE) than the Polish listeners to the /pt/ cluster at the sensory processing level within auditory cortex through 500 ms. Also, the responses by the English listeners showed more phase locked activity (ITPL) to the non-native onset cluster in the same time window. These results may suggest less allocation of neural resources to the familiar phoneme sequence by the Polish listeners, while greater activation is needed for the English listeners to processes the unfamiliar phoneme sequence onset. Thus, analyses of oscillatory activity provided additional information pertaining to native and non-native language processing during sensory processing that was not found using traditional analysis of AEPs.

B49 Neurobiological mechanisms of efficient encoding: A pilot EEG study.

Nicholas Walker[1], Christian Stilp[2], Keith Kleunder[3], Julia Evans[1], Meredith Scheppele[1]; [1]Univeristy of Texas at Dallas, [2]University of Louisville, [3]Purdue University

Kluender, Stilp and Kiefte (2013) propose that efficient encoding of covarying perceptual attributes is an important mechanism of auditory learning that may have implications for language learning. Prior work has shown that participants encode covarying statistical structures in the auditory system (Stilp, Rogers, & Kluender, 2010). Changes in brainstem, thalamocortical, and corticothalamic processing may explain efficient perceptual encoding. EEG provides a tool for examining perceptual encoding of information as sounds are being heard. The purpose of this project is to determine if tracking of covarying stimulus properties is due to efficient encoding (bottom-up changes) or top-down processing. Methods: Seven college-aged participants with normal hearing, and no history of language or neurological disorders completed the

experiment. The protocol consisted of four phases: passive exposure, two testing blocks and passive exposure. Stimuli from Experiment 1 in Stilp et al. (2010) were used. Passive exposures consisted of 250 random presentation of the sounds used in the experiment (1000 ms ISI). Testing blocks were identical to blocks of Experiment 1 from Stilp et al. (2010). EEG analysis is restricted to the passive exposure blocks to examine changes in encoding of information and assess the feasibility of using time-frequency analysis to examine encoding of information. EEG data were recorded using a 64-channel BrainVision actiCHamp system. Bad channels were deleted prior to analysis. Ocular and single channel artifacts were removed using infomax ICA with EEGLAB (Delorme & Makeig, 2004). EEG data were segmented into 5 second epochs around stimuli. Epochs were then average referenced and baseline corrected to the prestimulus interval. Continuous wavelet transforms were computed at 100 log-spaced frequencies from 3Hz to 100Hz. Wavelet power was computed and baseline corrected to a prestimulus interval (-250 to – 50 ms) using a decibel correction. Weighted intertrial phase clustering was computed across conditions (Cohen, 2014). Results: From pre-testing to post-testing, there is a significant difference in theta phase clustering and power at left and frontal electrode sites (T7, F7, FZ) during the N1 component, from 100-200 ms after sound onset, with decreased theta phase clustering and power. Conversely, there is a significant increase in alpha power from pre-testing to post-testing from 100-200 ms. Discussion: Efficient encoding of covarying information in audition has been proposed as a learning mechanism important for speech perception (Kluender et al., 2013). The measured changes in brain activity are occurring during the perception of the sound stimuli, which suggests changes in the way the brain is processing the auditory information. Decreases in theta power and phase clustering may suggest an increase in processing efficiency or habituation to the task. However, increases in alpha power have been associated with increased attention and memory (Bastiaansen, Posthuma, Groot, & de Geus, 2002; Bishop, Hardiman, & Barry, 2010; Klimesch, 1999, 2012) and are in line with improved processing of the stimuli. These differences in theta and alpha frequency bands are occurring during the N1 response which is generated by thalamic and primary auditory cortex, and may suggest efficient encoding is occurring prior to higher level perceptual processes.

B50 Representations of amplitude modulations in auditory onsets, ramp tones, and speech in the human superior temporal gyrus

Yulia Oganian[1,2], Edward Chang[1,2]; [1]Department of neurological surgery, University of California, San Francisco, [2]2Center for Integrative Neuroscience, University of California, San Francisco

Making sense of complex auditory inputs requires temporally precise parsing of single events out of the auditory stream. Auditory event onsets are typically marked by an increase in amplitude, and previous animal and human studies identified the dynamics of amplitude rise at onset as a central feature encoded throughout the subcortical auditory pathway. Amplitude modulations, however, also mark changes within ongoing sounds, e.g. in the speech envelope. Yet, it is unknown how the human auditory cortex differentiates between amplitude rises in silence and within an ongoing sound, and whether onset encoding can account for tracking of the speech amplitude envelope. To address this, we designed tone stimuli containing amplitude ramps, rising from silence (ramp-from-silence, RfS, condition), or from an amplitude baseline (ramp-from-baseline, RfB, condition). The sound intensity of ramps increased linearly to peak amplitude and returned to silence/baseline, with varying rates of amplitude change. We recorded local field potentials using intracranial multi-electrode arrays placed over the temporal lobes of six patients undergoing evaluation for epilepsy neurosurgery, as they passively listened to the tones. In both conditions, ramps elicited transient responses in the high gamma frequency range (HG, 70-150 Hz) in posterior (p) and middle (m) superior temporal gyrus (STG), with larger HG amplitudes for fast-rising ramps. We observed a striking double dissociation of response types: pSTG encoded the rate of amplitude change in the RfS condition only, whereas mSTG encoded the rate of amplitude change in the RfB condition only. Crucially, the rate of amplitude envelope modulation in continuous speech was also represented in mSTG, but not in pSTG. Our results reveal functionally and spatially distinct representations of sound onsets in silence and in background along STG. Moreover, our data suggest that speech amplitude tracking in mSTG may rely on the same neural mechanisms as the encoding of onsets in background.

Language Genetics

B51 Translational research in dyslexia: genetic rodent models inform understanding of mechanisms in humans

Tracy Centanni[1,2,3], Fuyi Chen[4], Anne B Booker[4], Andrew M Sloan[3], Sara D Beach[2,5], Ola Ozernov-Palchik[6], Sidney C May[2], Michael P Kilgard[3], Joseph J LoTurco[4], Dimitrios Pantazis[2], Tiffany P Hogan[7], John DE Gabrieli[2]; [1]Texas Christian University, [2]Massachusetts Institute of Technology, [3]University of Texas at Dallas, [4]University of Connecticut, [5]Harvard University, [6]Tufts University, [7]MGH Institute of Health Professions

Introduction: Dyslexia is the most common developmental language disorder, affecting 5-15% of children and having several long-term consequences including lower self-esteem, academic and vocational difficulties, and higher delinquency rates later in life. Given the complex genetic basis of dyslexia, there is a great deal of heterogeneity within this population with respect to the underlying biological mechanisms and the corresponding behavioral deficits, although auditory perceptual and/or processing difficulties are commonly reported. Since causal genetics

work is difficult in humans, research has turned to the rodent as a model system. In a rat, candidate dyslexia genes can be manipulated and the corresponding effects on sensory perception and behavioral discrimination of phonemes can be easily evaluated. However, it has been unknown whether such findings would provide applicable insights into humans with dyslexia. Methods (rat): In utero suppression of either Kiaa0319 or Dcdc2 was accomplished in Wistar rats using RNA interference. At the age of 3-6 months, neural responses to speech sounds and tones were acquired from a) experimentally naïve animals, and b) animals that underwent behavioral training on several speech sound discrimination tasks prior to neural recordings. Experimenters were blind to the genetic status of each animal during the course of all data acquisition and analysis. Methods (human): Following behavioral assessment, magnetoencephalography (MEG) data were collected from children and adults with and without dyslexia. Both children and adults were exposed to speech sounds in a passive paradigm, while adults also completed a rapid speech discrimination task. Saliva samples were acquired from children for testing of KIAA0319 markers. Results (rat): Suppression of Kiaa0319 led to increased variability in the timing of primary auditory cortex action potentials in response to speech sounds and tonal stimuli, as well as behavioral deficits on speech sound in noise and truncated speech sound discrimination tasks. Suppression of Dcdc2 did not interfere with neural consistency or with phoneme discrimination, but did cause deficits on a rapid speech sound discrimination task and interfered with neural plasticity over the course of training. Results (human): Children with dyslexia exhibited significantly higher primary auditory cortex variability compared to typically-reading peers, though not all children's brain variance significantly differed from that of the control group. Risk markers in KIAA0319 were correlated with this finding, such that children with two risk alleles had higher variability than children with one risk allele or no risk alleles. In adults, we found neural and behavioral evidence of poorer accuracy on the rapid speech sound task in dyslexics. Conclusions: We found that genetic work in rats provided valuable insights into possible gene-brain-behavior relationships in humans with dyslexia and will play a critical role in the future to better understand gene-gene interactions in dyslexia. In humans, we identified a potential gene-brain basis for heterogeneity in dyslexia, suggesting that a better understanding of the core deficits in each individual will enable personalized assessments and interventions for those who struggle to acquire reading.

Phonology and Phonological Working Memory

B52 Converging evidence from univariate and multivariate fMRI analyses suggests a phonological buffer in the left supramarginal gyrus

Qiuhai Yue[1], Randi C. Martin[1], A. Cris Hamilton[1], Nathan S. Rose[2]; [1]Rice University, Houston, TX, USA, [2]University of Notre Dame, Notre Dame, IN, USA

Phonological short-term memory (pSTM) refers to the capacity for retaining speech sounds for a short period of time. The current study evaluated two theories of pSTM: the buffer account, which proposes a dedicated pSTM store (e.g., Baddeley, 2000), and the embedded processes account, which argues that pSTM consists of the activated portion of phonological long-term memory (LTM) (e.g., Cowan, 2001). Previous findings from patients showing poor phonological STM with preserved word recognition support the buffer account (Warrington & Shallice, 1969; Vallar & Baddeley, 1984), and lesion localization suggests that the left inferior parietal lobe supports the phonological buffer (Shallice & Vallar, 1990). Evidence from neuroimaging studies on healthy subjects has been mixed, with some showing sustained delay-period activity in regions outside those for the LTM representation of speech sounds (Paulesu et al., 1993) but others showing sustained activity solely in LTM regions (e.g., superior temporal lobe) (Ravizza et al., 2011). However, most studies have used visually presented verbal stimuli (e.g., Ravizza et al., 2011), making it unclear whether subjects relied on phonological retention. In addition, recent studies on visual STM using a multivariate approach (e.g., multivariate pattern analysis; MVPA) have complicated the interpretation of delay-period activity, with some studies showing that visual mnemonic information could be decoded from LTM regions during the delay period, even though no sustained activity was observed (Riggall & Postle, 2012). The present study addressed the limitations of previous studies by using auditory stimuli, and employing both univariate and multivariate analyses. We scanned 15 healthy young adults while they performed an immediate discrimination task (perception) and a delayed recognition task (STM). In both, we manipulated the stimulus type (nonwords vs. chords), and for the STM task we manipulated memory load (one vs. three-items). Using the perception task, a region in the left superior temporal cortex was found to support speech recognition. However, contrary to the predictions of the embedded processes account, this region failed to show a memory load effect, or any sustained activation, during the delay period. Moreover, MVPA decoding during the delay period was unsuccessful in this region by a perception classifier or an encoding classifier. While successful decoding was observed with a maintenance classifier, decoding accuracy was unrelated to behavioral performance. In contrast, consistent with the buffer approach, univariate analyses revealed a set of fronto-parietal regions, including the left supramarginal gyrus, which showed sustained activity and load effects during the delay period. Using MVPA, stimulus decoding was successful with both encoding and maintenance classifiers and, in the left supramarginal gyrus, decoding accuracy was related to verbal but not nonverbal memory

performance. In addition, a functional connectivity analysis found that, as memory load increased, the left temporal cortex involved in speech perception became more strongly connected with the left inferior parietal region involved in maintenance. Thus, converging evidence from both univariate and multivariate approaches provided greater support for a buffer than an embedded processes account for pSTM, with a region in the left supramarginal gyrus serving as a buffer for maintaining phonological representations.

B53 Auditory Cortex Represents Abstract Phonological Features: A Mismatch Negativity Study of English Voicing

Philip Monahan[1], Jessamyn Schertz[1]; [1]University of Toronto

Understanding how speech sounds are represented in auditory cortex has important implications for neuro-cognitive models of spoken word recognition (Hickok, 2014; Hickok & Poeppel, 2007; Obleser & Eisner, 2009). Neurophysiological evidence for abstract phonological features has been equivocal. While recent EEG/MEG findings provide support for monovalent distinctive features (Eulitz & Lahiri, 2004; Hestvik & Durvasula, 2016; Scharinger, Monahan, & Idsardi, 2016; Schluter, Politzer-Ahles, & Almeida, 2016b), participants were not required to abstract over distinct phonetic implementations of a phonological feature, leaving open the possibility that response patterns were driven by acoustic, not phonological, similarity. We report mismatch negativity (MMN) findings that suggest a representation for the abstract phonological feature [voice] that encompasses acoustically distinct implementations in English: voice onset time (VOT) in stop consonants and laryngeal excitation in fricatives. Moreover, results suggest that only voiceless sounds have a stored feature for voicing. Eighteen native English speakers heard two blocks of naturally-produced consonant-vowel syllables (voiced /ba, da, ga, va, za/, voiceless /pa, ta, ka, fa, sa/), one block with voiced standards and voiceless deviants, and the other with voiceless standards and voiced deviants in an oddball paradigm. Each block also included sham deviants that shared the same voicing as the standard but differed in their vowels (e.g., voiced /vu/, voiceless /po/). EEG recordings were acquired with a 32-channel system (Brain Products GmbH, Germany). Mean ERP amplitudes averaged over fronto-central electrode sites were submitted to a linear mixed effects model with the fixed effects Condition (Standard, Deviant, Sham) and Block (Voiced Standard, Voiceless Standard). Analyses were performed in three time-windows (Early: 100-170ms, Middle: 170-250ms, Late: 250-550ms). Significant Condition by Block interactions were found in all three time windows. Pairwise interaction comparisons were performed to assess the effect of Condition in each block separately. Early window: In the Voiceless Standards block, there was a difference between Standards and Deviants ($X2(1)=10.9$, $p < 0.01$). Middle window: In the Voiceless Standards block, there was again a difference between Standards and Deviants ($X2(1)=7.78$, $p < 0.05$). In the Voiced Standards block, the Sham condition was different from both Standard ($X2(1)=29.37$,$p<0.001$) and Deviant ($X2(1)=22.55$,$p<0.001$) conditions. Late window: In the Voiced Standards block, the Sham condition was different from both Standard ($X2(1)=10.97$,$p<0.01$) and Deviant ($X2(1)=14.69$,$p<0.001$) conditions. The Sham stimuli, which differed from Standards and Deviants in vowel quality, elicited differences only in the Late window. This is expected given that acoustic cues to the vowel emerge later. Standards differed from Deviants, however, in earlier windows, as consonantal information emerges earlier. Given that Standards consisted of tokens with distinct articulatory and phonetic implementations, unified only by their phonological category, the systematic response to Deviants suggests that listeners construct an abstract phonological representation of the standards, including both stops and fricatives. An MMN was observed only when the standard was voiceless, suggesting that only voiceless sounds have a stored feature for voicing (see Lahiri & Reetz (2010)), consistent with recent MMN findings (Hestvik & Durvasula, 2016; Schluter, Politzer-Ahles, & Almeida, 2016a) and primary linguistic research (Avery & Idsardi, 2000).

B54 Neural encoding of T3 sandhi in Mandarin Chinese speakers in speech production

Caicai Zhang[1,2], Xunan Huang[1], Stephen Politzer-Ahles[1], Jie Zhang[3], Gang Peng[1,2]; [1]The Hong Kong Polytechnic University, [2]Shenzhen Institutes of Advanced Technology, [3]The University of Kansas

Mandarin Tone 3 (T3) sandhi refers to the substitution of T3 with Tone 2 (T2) when followed by another T3 syllable in speech production. For instance, the phrase “mai3 ma3” (“to buy a horse”) is ultimately pronounced “mai2 ma3”. T3 sandhi is generally believed to be subserved by a phonological computation mechanism in which the sandhi pattern is applied according to the phonological context regardless of whether it is a real word or not [Zhang, C., Xia, Q., and Peng, G. 2015. Mandarin third tone sandhi requires more effortful phonological encoding in speech production: Evidence from an ERP study. Journal of Neurolinguistics, 33, 149-162]. However, it is unclear whether high-frequency and low-frequency T3 sandhi words are produced via the same computation mechanism. It is possible that both are subserved by the phonological computation mechanism, such that both high- and low- frequency words would elicit similar neural activities during the encoding prior to articulation. Alternatively, it is possible that high-frequency words may be stored in the lexicon in their post-sandhi forms which can be directly accessed for speech production, whereas low-frequency words would rely more on phonological computation that changes T3 to T2 online. On the other hand, such differences should not be observed on words that do not involve T3 sandhi. To adjudicate between these computation-based and storage-based accounts,

we examined event-related potentials (ERPs) elicited during the covert production of high- and low-frequency sandhi-undergoing and non-sandhi-undergoing words in Mandarin Chinese. 17 Mandarin-speaking subjects participated in the experiment. Eighty high-frequency and eighty low-frequency disyllabic words were selected, comprising equal numbers of T3+T3 (sandhi-undergoing) and non-T3+T3 (non-sandhi-undergoing) words. The stimuli were recorded and presented as two isolated syllables in citation form with a brief pause in between. Subjects were asked to covertly produce the two isolated syllables as a single word for which tone sandhi would apply, followed by overt production when prompted later. To ensure that the onset of covert production is aligned to the appearance of a visual sign, a second task—loudness judgment, cued by a different visual symbol—was randomly intermixed with the production task in a single block. ERPs were time-locked to the onset of the visual sign for overt production. We observed significantly more negative amplitude elicited by sandhi-undergoing words than by non-sandhi-undergoing words in the time-window of the N200 (250-350 ms). Besides, there was a significant interaction effect between tone sandhi and frequency in the time-window of a late negativity (LN; 450-800 ms). In this late time-window, low-frequency non-sandhi-undergoing words elicited significantly more negative LN amplitude than high-frequency non-sandhi-undergoing words, whereas no frequency effect was found in sandhi-undergoing words. These results suggest that the encoding of sandhi-undergoing and non-sandhi-undergoing words might be subserved by different neural mechanisms, the former primarily engaging phonological computation irrespective of the lexical frequency, and the latter primarily engaging lexical processes. These findings have implications for understanding how phonological knowledge such as tone sandhi is represented in the brain, and encoded in speech production prior to articulation.

Perception: Speech Perception and Audiovisual Integration

B55 Lexical tone processing with and without awareness in Cantonese-speaking congenital amusics: Evidence from event-related potentials

Caicai Zhang[1,2], Jing Shao[1]; [1]The Hong Kong Polytechnic University, [2]Shenzhen Institutes of Advanced Technology

Congenital amusia (amusia hereafter) is a neurodevelopmental disorder that impacts the perception of music negatively. Despite the well-studied behavioral deficits, a full understanding of the neural underpinnings of amusia remains to be achieved. It has been found that pre-attentive pitch processing was normal or nearly normal in amusics, as indicated by normal mismatch negativity (MMN) to pitch deviations, whereas attentive processing exhibited impairment, as indicated by the absence of P300 to the same pitch deviations. Many studies have found that amusia affects the perception of lexical tones in tonal language speakers behaviorally. The current study examined how lexical tones are processed with and without attention in a group of tonal language speakers with amusia, a question that has not be investigated before. Event-related potentials (ERPs) to Cantonese tone pairs with small pitch differences (mid level-low level, or T3-T6; high rising-low rising, or T2-T5) and large pitch differences (high level-low falling, or T1-T4) were examined in pre-attentive (MMN) and attentive (P300) conditions. Twenty-four Cantonese-speaking amusics and 24 controls participated in the experiment. The three tone pairs were presented in forward and backward order: /ji33/-/ji22/ (T3-T6), /ji22/-/ji33/ (T6-T3), /ji25/-/ji23/ (T2-T5), /ji23/-/ji25/ (T5-T2), /ji55/-/ji21/ (T1-T4), and /ji21/-/ji55/ (T4-T1). Each pair was presented in an oddball paradigm, with the first stimulus serving as the standard and the second stimulus as the deviant. The same set of stimuli was presented to the subjects in the pre-attentive (MMN) and attentive (P300) conditions. In the pre-attentive condition, amusics and controls exhibited similar MMN responses to all tone pairs. There was also a significant effect of tone pair, where the MMN elicited by T1-T4 and T3-T6 was significantly larger than that elicited by T2-T5. In the attentive condition, significant group differences were found in the time-windows of P3a (350-450 ms after auditory onset) and P3b (500-800 ms after auditory onset), where reduced P3 amplitude was elicited in the amusics. For the P3a amplitude, apart from the group effect, there was a significant effect of tone pairs, where T1-T4 elicited significantly larger amplitude than T3-T6, followed by T2-T5, but no interaction effect of group by tone pair. For the P3b amplitude, there was a significant group by tone pair interaction. Post-hoc analyses revealed that the significant group difference was mostly attributable to tone pairs with small acoustic differences. There was a significant group difference for T2-T5, and a marginally significant group difference for T3-T6, but no significant difference for T1-T4. In summary, the results revealed that without attention, normal MMNs were shown for the lexical tone pairs in the amusics; however, when required to actively detect the same tonal changes, the amusics showed reduced P3 amplitude, especially to the acoustically similar ones. These findings suggested that the amusic brain responds to lexical tone differences normally pre-attentively, but showed impairment at consciously detecting the same lexical tone differences, which are consistent with that the findings reported on non-tonal language speakers. These findings provide further insights on the neurodynamic functioning of the amusics in lexical tone perception.

Phonology and Phonological Working Memory

B56 Lesion Localization of a Shared Phonologic Representation Deficit on Reading, Rhyming, Repetition, and Short-Term Memory Tasks

Sara Pillay[1], Peter Kraegel[1], Colin Humphries[1], Diane Book[1], Jeffrey Binder[1]; [1]Medical College of Wisconsin

Many tasks have been used to assess phonologic processing, including speech output, silent rhyming, and verbal short-term memory tasks. Despite differences in input modality, memory load, and response procedures, it is sometimes assumed that these various tasks all depend on a shared phonologic representation, i.e., an abstract representation of an ordered sequence of phoneme codes. Prior lesion correlation studies have focused on single tasks. Here we test for the first time whether there is a common lesion localization for impairments on phonologic short-term memory, oral reading, repetition, and silent rhyming tasks. We hypothesized that lesions affecting phonologic processing, regardless of input modality, production demand, or phonologic memory load, would localize to a common region in the posterior perisylvian cortex. Voxel-based lesion-symptom mapping (VLSM) was used in 57 patients with chronic left hemisphere stroke. All patients were right-handed, native English speakers and at least 6 months from stroke onset. The patients completed four tasks used to assess phonologic processing in different modalities: (#1) a visual pseudoword rhyming task in which patients matched a sample pseudoword to one of two choices based on phonologic similarity, (#2) a spoken pseudoword repetition task, (#3) an auditory phonologic delayed match-to-sample (DMS) task in which patients indicated whether two auditory natural CV syllable trains containing 1-5 syllables, separated by 5 seconds, were the "same" or "different", and (#4) an overt reading task, where the rate of phonologic paraphasias was the variable of interest. To control for non-specific attention and executive control processes in measures #1-3, patients completed a semantic judgment task where they matched pictures based on meaning. Common lesion overlap across the four measures was examined using VLSM. Accuracy on the DMS (81%), pseudoword rhyming (75%), and pseudoword repetition (62%) tasks were strongly correlated (all $p < .001$). These three measures were also strongly correlated with the rate of phonologic paraphasias (mean 19%) made on the overt reading task (all $p < .005$). VLSM localized the responsible lesions in each of the tasks to the posterior perisylvian region. Overlap of these maps revealed a common lesion location involving the posterior medial planum temporale, junction of posterior superior temporal gyrus and supramarginal gyrus, parietal branch of the superior temporal sulcus, and white matter underlying these structures. There was variable involvement anterior to this core region in anterior supramarginal gyrus, inferiorly in the posterior temporal STS, and posteriorly in the inferior angular gyrus. The results confirm a common lesion location impairing performance on a range of phonologic tasks differing in input modality, output modality, and memory load. This overlap is unlikely to be due to nonspecific executive control deficits, which were controlled for in the VLSM analysis. The results suggest that all of the measures depend on a common phonologic representation, and they provide further support for an "emergent" view of phonologic short-term memory, in which activation of long-term phonologic representations and the "phonologic store" used for short-term memory are one and the same.

B57 Processing Demands of Word Frequency on Verbal working Memory as measured by functional near-infrared spectroscopy (fNIRS)

Amy Berglund[1], Julia L. Evans[1], Andrea W. Fung[1], Chen Song[1], Fenghua Tian[2], Holly Watkins[1]; [1]University of Texas at Dallas, [2]University of Texas at Arlington

A learner's ability to hold words in working memory impacts their ability to learn language. This working memory dependency is due to its characteristic of constantly updating information with temporally incoming input (Baddeley, 2003; Szmalec, Brysbaert, & Duyck, 2012). Behavioral data suggests that low-frequency words (those words that occur rarely in language) place greater processing demands on working memory than high-frequency words (those words that occur frequently in language) (Polich & Donchin, 1988). The question of how neural activity varies with changes in cognitive processing demands has been the focus of considerable research partly because understanding these dynamics may provide insights into how mental activity is organized in the cortex. Functional magnetic resonance imaging (fMRI) studies show greater cortical activity, as measured by increased task-related cerebral blood flow, in left-prefrontal blood-oxygen-level-dependent (BOLD) signal changes when processing low-frequency words as compared to high-frequency words, suggesting low-frequency words have greater processing demands than high-frequency words (Chee, Hon, Caplan, Lee, Goh, 2002; Diana & Rder, 2007). 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). fNIRS has been shown to effectively measure cerebral hemodynamic changes resulting from cognitive processing demands during n-back working memory tasks. Thus proving an effective means of quantifying mental work load and resulting cognitive fatigue with changes in lexical processing demands (Herff et all, 2014). As reviewed by Owen et al. (2005), the n-back tasks primarily activate the frontal poles, dorsolateral, and ventrolateral

prefrontal cortex (Owen et. al., 2005). In this study we used fNIRS to record the prefrontal cortex activity in eleven neurologically typical adults engaging in an auditory 2-back task. Word frequency was manipulated by alternating 7 blocks containing high-frequency words with 7 blocks containing low-frequency words. By using the auditory 2-back task to control task demands while simultaneously manipulating the lexical processing demands of word frequency, we were able to examine both the cognitive processing demands and resulting fatigue effects of word frequency on working memory in typical adults. Raw fNIRS data was collected using a CW-6 system (TechEn, Inc.) and processed using HOMER software (Huppert et al., 2009b). Behavioral measures were collected using E-prime. The preliminary results indicated large cortical responses from both the left and right dorsolateral prefrontal cortices. Additionally, low-frequency words evoked higher cortical activation as compared to high-frequency words. Participants showed patterns of fatigue both within individual blocks and over the course of the entire session. Despite the general fatigue trend, analysis revealed no influence of fatigue on individuals' overall accuracy. In summary, the results from this study support the theory that cognitive load requirements differ to process low-frequency words versus high-frequency words. Interestingly, despite the differing requirements of cognitive load and increasing fatigue, accuracy appears to not be influenced by cognitive difficulty or fatigue in typical adults.

Speech Motor Control and Sensorimotor Integration

B58 Enhancing Speech Motor Learning With Noninvasive Brain Stimulation

Adam Buchwald[1], Mara Steinberg Lowe[1], Holly Calhoun[1], Rebecca Wellner[1], Stacey Rimikis[1]; [1]New York University

Introduction. The potential to enhance human performance using non-invasive brain stimulation has been the topic of active research and controversy. Motor learning has been the domain that has most consistently revealed enhancement from combining training with noninvasive neuromodulation provided by transcranial direct current stimulation (tDCS; Brunoni et al., 2012), with some evidence that the stimulation should be applied prior to the training task (Giacobbe et al., 2013). While tDCS has been studied as a tool to facilitate word production in aphasia and unimpaired speakers with mixed success (Marongolo et al., 2016; Westwood et al., 2017)), it has not been previously tested as a tool to facilitate speech motor learning. We report a study successfully using tDCS as an adjunct to a speech motor learning protocol to enhance speech motor learning, although increased learning is only significant when stimulation is applied prior to the learning task. Methods. 80 participants with no history of impairment completed a two-day protocol. Speech Motor learning task. L1 English participants produced nonwords with 8 different nonnative onset clusters (e.g., /fm/, /gd/). Following brief pre-practice with detailed feedback, participants performed 18 minutes of structured practice producing nonwords with auditory and orthographic presentation (e.g., audio: /fmiku/, written: FMEEKOO). Short-term retention (R1; 30 mins after practice) and long-term retention (R2; 2 days after practice) tested both trained and novel nonwords. Neuromodulation. For active tDCS, a 1x1 Soterix battery-driven current stimulator delivered 20 minutes of 1mA current. The anode was placed over the left motor cortex (C3) and the cathode over the right supraorbital area. Sham tDCS used the same the electrode montage with current ramped up to 1mA over 30 seconds and then immediately decreased. Stimulation was administered before or during the practice session, with participants randomly assigned to one of four groups based on timing (before-during) and type (active-sham) of stimulation. Results. The primary outcome measures were change in word and cluster accuracy (assessed with perception and acoustics) between the first half of practice (P1) and: P2 (second half of practice); R1; and R2. Logistic regression mixed effects models were used to examine changes in whole-word accuracy and cluster accuracy. All groups improved on the task. There was a significant 3-way interaction for both measures, in which participants receiving active stimulation prior to the task improved more from P1 to R1 (word: 10%; cluster: 8%) than other groups (all <4%; word: β=.47, z=3.20, $p < .002$; cluster: β=.39, z=2.57, $p < .01$). There was no effect of whether a stimulus item had been trained. Summary and Conclusion. This research represents a novel approach of using tDCS to facilitate learning of novel sound structure sequences in a motor learning paradigm. This work also highlights the importance of considering the various parameters involved in using tDCS, and suggests a link between settings that facilitate motor learning in speech and non-speech domains. Possible extensions to impaired speakers will be discussed.

Perception: Orthographic and Other Visual Processes

B59 Orthographic priming for tactile Braille alphabet in the ventral Occipito-Temporal cortex of congenitally blind

Katarzyna Rączy[1], Aleksandra Sadowska[1], Jakub Szewczyk[1], Paweł Hańczur[2], Ewa Sumera[3], Marianna Boros[1], Maksymilian Korczyk[1], Anna Bereś[1], Marcin Szwed[1]; [1]Jagiellonian University, [2]Warsaw University of Technology, [3]Institute for the Blind and Partially Sighted Children

Several recent experiments, both in sensory-deprived subjects and in subjects with their senses intact have suggested that sensory-independent task specialization is a comprehensive principle shaping brain (re)organization (Amedi et al., 2017). For example, when blind or sighted subjects read Braille, a tactile alphabet, they activate the

same brain area as sighted readers reading visual words, the Visual Word Form Area in the ventral Occipito-Temporal cortex (vOT). The blinds' visual cortex, however, undergoes massive plasticity. Unlike the sighteds' cortex, it is massively activated by memory and spoken language tasks (e.g. Lane et al., 2015). Here we sought to determine whether the response pattern in the vOT of the blind is indeed deeply similar to the VWFA of the sighted, or alternatively, whether this similarity is superficial, and the blind's vOT is not a reading area, but a multimodal language area. A hallmark of the VWFA is its sensitivity to orthography: using fMRI orthographic priming (repetition suppression) Glezer et. al, (2009, 2015) have shown that the vOT contains neurons with selectivity to orthographical representation. We tested 15 right-handed congenitally blind adults with a repetition suppression paradigm. Subjects either read Braille prime-target pairs of 4-letter pseudowords in three experimental conditions (same, 1-letter different, different) or heard the same pseudowords in two experimental conditions (same, different) while undergoing an fMRI scans. In the same condtion, the same stimulus was presented twice. In 1-letter different condition, the first and second stimulus differed by one letter. In the different condition, the second stimulus shared no letters with the first. For both modalities, we used a task focusing on the physical aspects of the stimulus: for Braille, participants were asked to indicate whether the target pseudoword has one a two-dot Braille letter. For spoken stimuli, they were asked to indicate whether the target was spoken by a male or a female voice. Behavioral performance in the two task was similar, and slightly higher for tactile stimuli (92 vs. 84 %correct). Preliminary whole-brain and ROI analyses revealed an orthographic priming effect in the tactile modality (Braille) in the left ventral Occipito-Temporal cortex of the blind (peak MNI: -39, -70, -17). Crucially, and in a line with the VWFA in the sighted, the above-mentioned region showed only a weak response to auditory stimuli (same, different, spoken) with no orthographic priming effect for spoken letter strings. Conversely, orthographic priming effects for spoken letter stings, but not for Braille letter stings were observed in the STS. Neuroimaging studies in blind Braille readers consistently show a much weaker selectivity for tactile reading in the vOT (e.g. Burton et al., 2002, Bedny et al., 2010, Kim et al., 2015) and more sensitivity to linguistic information in the blind's vOT than in the sighted. However, the existence of orthographic priming effects in that region indicate that it does contain an orthographic representation for Braille words. This suggests that the function of the vOT in the blind, although not identical, nevertheless overlaps to a large extent with the function of the VWFA in the sighted.

B60 Lexical Decision with Emotional Words: A Pupil Dilation Study

Sahura Ertuğrul[1], Didem Gökçay[2]; [1]Cognitive Science, Middle East Technical University, Ankara, [2]Medical Informatics, Middle East Technical University, Ankara

Introduction: Written words are not just black remarks but they enable human beings to connect with the environment via the help of their semantic features. Word frequency and emotion are the most studied semantic features which are known to effect word recognition both behaviorally and physiologically. In this study, the effect of interaction between word frequency and emotion on word recognition was investigated in Turkish. Participants: Data were collected from 20 right handed, native Turkish participants (10 female, 10 male) between ages of 21-32 (M = 26.75, SD = 4.20). Stimuli: Stimulus material consisted of 120 Turkish nouns selected from the TUDADEN (Affective Norm Database for Turkish Words, Gökçay & Smith, 2012). The words were positive (M = 7.81, SD = 0.37), negative (M = 1.97, SD = 0.54), or neutral (M = 5.16, SD = 0.30) in valence and of high (M = 149.53, SD = 62.74) or low frequency (M = 9.49, SD = 3.43), resulting in six categories. The arousal ratings were high (M = 7.14, SD = 0.52) for emotional words while it was neutral (M = 4.51, SD = 0.30) for neutral words. For lexical decision task, 120 pseudowords were generated by Turkish plug in for Wuggy Software (Erten, Bozşahin and Zeyrek, 2013) with OLD20 values (M= 2.32, SD = 0.65). Procedure: The experiment was conducted in dimly lit, sound attenuated chamber. The stimuli were presented in light gray uppercase letters (Arial font, font size 26) on the center of gray screen (R: 106 G: 106 B: 106) in pseudorandomized fashion. In a single trial, a fixation cross (+) appeared at the center of the screen for 1500 ms. After the fixation cross, the stimulus was displayed on the screen for 3000 ms. The stimulus did not disappear with the response; it stayed on the screen throughout 3000 ms. During stimulus presentation, reaction times and pupil diameters were collected with TOBII T120 eye tracker, data rate of 60 Hz, tracking distance of 60 cm. Results: The results show that emotional words have shorter reaction times than neutral ones, $F(2, 38) = 6.22$, $p = .005$, $r = .87$. Meanwhile, high frequency words get faster responses than low frequency words, $F(1, 19) = 82.01$, $p < .0001$, $r = 1.00$. Thus, these reaction time results replicate the main effect of emotion and word frequency on word recognition. Furthermore, there exists a significant interaction between emotion and word frequency which indicate that high frequency, negative words get shorter reaction times than positive and neutral words while low frequency, positive words get the shortest reaction times, $F(1.39, 26.43) = 10.19$, $p = .002$, $r = .97$. However, the pupillary responses support neither the main effect of word frequency, $F(1, 19) = .36$, $p = .56$, $r = .09$, nor emotion, $F(2, 38) = .19$, $p = .83$, $r = .08$. In short, these results suggest that although semantic features

have critical influence on behaviors; they are not effective enough to activate pupilllary responses during word recognition.

B61 Do Different Types of Script Induce Differences in Hemispheric Lateralization During Reading? Evidence from a Cross Linguistic MEG Study.

Kefei Wu[1], Diogo Almeida[1]; [1]New York University Abu Dhabi

Despite many different scripts being actively in use today, they can be roughly divided into two different categories depending on the type of information about words they privilege: sound, as in alphabetic (e.g.: English) and abjad (e.g.: Arabic) scripts, or meaning, as in logographic scripts (e.g.: Chinese). These different types of scripts are sometimes reported to induce different patterns of hemispheric brain activity early in the visual pathway. A large body of evidence in this debate pertains to findings of hemispheric asymmetries in the N/M170 response during reading of alphabetic versus logographic scripts. Left lateralization effects in the N/M170 are commonly observed during reading of alphabetic scripts, and have been attributed either to the process of mapping the visual form of words to their pronunciation (a script-to-sound mapping hypothesis), or to a more general expertise acquired in the visual domain (a visual familiarity hypothesis). The findings regarding the reading of logographic scripts are more equivocal, with some studies reporting a bilateral N/M170 response (as predicted by the script-to-sound mapping hypothesis, since the process of mapping script units to sound units is not engaged by the nature of logographic scripts) whereas others observe a left-lateralized N/M170 response (as predicted by the visual familiarity hypothesis). In order to test these two different putative mechanisms, we conducted an MEG study using a cross-linguistic design comparing the reading of Chinese, a logographic script, with English. In order to isolate script differences from the language difference, we also tested the reading of Pinyin, an auxiliary alphabetic system for transliterating Chinese words into the Latin script. In addition, in order to test the plasticity implied by the visual familiarity hypothesis, we also recruited a group of native speakers of English who had been learning to speak and read Chinese for at least one year. The experiment employed a 3 (group: English, Chinese, and Chinese-learner) x 3 (stimulus type: English words, Chinese words and Chinese words written in pinyin) factorial design, and used an occasional one-back repetition detection task in which participants were asked to passively view the stimuli on the screen unless prompted for a one-back repetition detection stimulus. Left-lateralized responses were obtained in all conditions involving alphabetic stimuli (English words and Chinese words written in Pinyin) across all three groups of participants. Bilateral responses were obtained in the Chinese word condition for the English-speaking and Chinese-learner groups, but not for the Chinese group, which showed a left-lateralized response to Chinese words. These results are more in line with the visual familiarity hypothesis.

B62 Using Representations from Artificial Neural Network Models of Reading to Reveal Neural Activation Patterns for Different Reading Computations

William Graves[1]; [1]Rutgers University - Newark

Despite decades of research into the brain basis of reading, there is still fundamental disagreement about how cognitive models of reading map onto neural function. Neurally inspired computational models offer precise predictions, yet until recently, established methods were lacking for testing if these predictions corresponded to brain activation patterns. We used standard methods to train an artificial neural network model to map from visual word form input (orthography) to word sound output (phonology) across a single intermediate (hidden) layer. During functional magnetic resonance imaging, participants read aloud 465 words. Representational similarly analysis was used to test for cortices in the left hemisphere where the modeled similarity structure across the words corresponded to their neural similarity structure. Orthographic representations corresponded to activation patterns in early visual cortex, ventral occipito-temporal (vOT), anterior temporal lobe (ATL), and inferior frontal cortex (IFC). Hidden unit representations corresponded to activation patterns in IFC, vOT, and areas of ATL partially distinct from orthography. Phonological representations corresponded to activation in the ATL and IFC also distinct from orthography and hidden units. These results provide direct computational evidence for existing accounts of the neural basis of reading, and provide novel evidence for diversity of reading-related function in the ATL.

B63 Uncovering the cascade of computations involved in ambiguity resolution using MEG decoding

Laura Gwilliams[1,2], Jean-Rémi King[1]; [1]New York University, [2]NYUAD Institute

Ambiguity is ubiquitous in language — common to phonetic features, part of speech, lexical meaning and syntactic constructions. The Hierarchical Bayesian Inference (HBI) framework provides a formal description of the computations required to resolve such ambiguity. The aim of the present study is to test whether the human brain implements an architecture like this framework in deriving a stable interpretation of ambiguous input. Seventeen participants discriminated between 1960 ambiguous visual symbols, constructed from 8-step morphs of letter/digit pairs, while magneto-encaphalography (MEG) was recorded concurrently. Six putative computations derived from the HBI framework were modelled: stimulus location, number of visual edges, stimulus identity, stimulus contrast, stimulus ambiguity and response button. Linear multivariate pattern analyses (MVPA) were used to decode, track and source-localise the dynamics of each of these computations. Our analyses uncover three main

findings. First, sensory features associated with each computation are sequentially decodable from the MEG signal, and continue to be maintained in parallel thereafter. Second, neural activity correlates with objective sensory information up to ~300 ms; after, neural responses become progressively categorical and correlated with subjective reports. Third, these computations are generated by a cortical hierarchy spanning across the visual, parietal and motor cortices respectively. Together, our findings reveal that a cascade of neural computations unfolds within and across cortical regions to resolve perceptual ambiguity. This study provides a stepping stone to link computational accounts of inference to the neural bases of perceptual decision making at the meso- and macroscopic level, and provide insight into how sensory information is extracted, maintained and integrated over time.

B64 Dynamics of Brain Functions and Reading in Different Languages OR Why is it hard to read Arabic?

Zohar Eviatar[1]; [1]University of Haifa

Writing systems developed in order to allow the reproduction of spoken language. Different cultures have developed different ways of doing this, resulting in different typologies of orthographies. I will report upon differences between reading in English, as it is represented by an alphabetic orthography, and reading in Hebrew and in Arabic, which are represented by abjad orthographic systems. I will then focus more closely on Arabic because it is interesting for both practical and theoretical reasons. Although Arabic is the 4th most spoken language in the world, and is one of the most popular segmental scripts used to write other languages (e.g., Urdu, Farsi), the study of reading in Arabic has only lately become a focus of research. I show data revealing that reading acquisition of Arabic by children is slower than in a typologically similar language, Hebrew, and that skilled reading in Arabic is slower than skilled reading in Hebrew by university undergraduates. I present two possible sources for these phenomena from both a psycholinguistic and a neuropsychological perspective. The first is the diglossia in Arab society, where the language that is written and read is different from the language that is spoken. I show that this difference is great enough to result in bilingual-like performance among Arabic-speaking children when they encounter literary Arabic while learning to read, and that this affects the course of reading acquisition. The second source of difficulty is in the visual characteristics of the Arabic writing system, which together with the complex relationship between graphemes and phonemes, affects the involvement of the right hemisphere in letter and word identification, and in the access to meaning. I present data from both divided visual field paradigms and an imaging study that support this hypothesis. The case of reading in Arabic as an example of the interaction of brain functions, specific language structure, and the language experience of the individual, outlining the seam between universal and specific attributes of the reading process.

B65 The rhythm of semantics: Temporal expectancy and context-based prediction in a picture association paradigm

Cybelle M. Smith[1], Kara D. Federmeier[1]; [1]University of Illinois at Urbana-Champaign

People are able to use context to inform their expectations about what they might experience next, as well as when they might experience it. To explore the interaction between temporal expectancy and contextual congruency effects on semantic priming, we used a nonverbal picture association paradigm in which stimuli could be presented at a wider range of SOAs than is natural for linguistic stimuli. We explored how the amount and variability of predictive preparation time (i.e., the time between display of a visual scene cue and its recently associated novel object target) would modulate the timing, nature and amount of visuo-semantic processing facilitation at the target. We recorded EEG as 84 participants learned paired associations between visual scenes and novel objects from novel object categories. To examine context-based prediction at varying degrees of contextual specificity, each novel object category was only ever studied with a particular scene type (e.g. category 1 with beaches, 2 with offices, etc.). At test, participants indicated whether an object matched a previously viewed scene. The object either matched the scene, matched the scene type (but not the specific scene), or mismatched the scene type. Critically, at test, the scene was previewed for either 200ms (N=24), 2500ms (N=24), or a variable 0-2500ms (N=36) prior to object onset. When the temporal relationship between prime and target was fixed, ERPs time-locked to object onset at test displayed a graded pattern of facilitation: match > within-category mismatch > between-category mismatch. The time-course of this sensitivity, but not its gradedness, varied with preview duration. With consistently long previews, graded facilitations emerged during the N300 time window. Instead, when participants had little time to develop predictions, graded facilitation effects emerged only later, beginning at ~300-400ms. This latency shift suggests that visual image predictions carry more visually detailed (but not necessarily more context-sensitive) information and affect processing earlier in the visual processing stream with greater preparation time. We next varied the preview time pseudorandomly and continuously (0-2500 ms). By treating preview time as a continuous covariate, we were able to further assess the amount of preparation time necessary to observe effects of visual prediction. N300 effects of prediction emerged at ~500-1000ms preview time and remained stable thereafter, placing an approximate lower bound on the time to preactivate global visual structure of an image. Furthermore, when the participant could not be sure precisely when in time the object target would appear, facilitation effects were no longer graded but equally large for between and within category mismatches. This suggests that knowing precisely when in time a stimulus will appear, and not simply that it's coming next, facilitates full exploitation of predictive

context for pre-activating visual and semantic features. This builds on more general findings that priming effects are larger in cases of high temporal expectancy – we add to this that the degree of predictive sophistication is also enhanced. Thus, the characteristic rhythmicity of language, and not merely predictability of its sequential order, may play a role in facilitating semantic access during language comprehension.

Language Therapy

B66 Areas predicting tDCS effects in primary progressive aphasia (PPA)

Kyrana Tsapkini[1], Kim Webster[1], Bronte Ficek[1], Chiadi Onyike[2], Brenda Rapp[3], Argye Hillis[1], Constantine Frangakis[4]; [1]Department of Neurology, Johns Hopkins University, Baltimore, MD, [2]Department of Psychiatry and Behavioral Sciences, Johns Hopkins University, Baltimore, MD, [3]Department of Cognitive Science, Johns Hopkins University, MD, [4]Department of Biostatistics, Johns Hopkins School of Public Health, Baltiomore, MD

Introduction: Recently there has been a great interest and several positive outcomes using tDCS in patients with neurodegenerative diseases and in particular in PPA (Cotelli et al., 2014; Tsapkini et al., 2014). We have present the results of a large cohort of PPA participants 28 participants from all 3 variants of PPA. We tested the additive effects of 15 sessions of anodal tDCS over the left inferior frontal gyrus (a main language production area) coupled with written language production/spelling therapy, in a sham-controlled, double-blind, within-subjects crossover design. Here we present preliminary data from our study of 28 participants evaluating whether the volumes of language network areas predict therapy outcomes. Methods: Language therapy on written language production (written naming/spelling) was delivered for 15 daily sessions (45 min) by a speech-language pathology clinician 5 days/week. Electrodes were positioned on the F7 area of the participant's scalp to simultaneously deliver either anodal tDCS or sham for the initial 20 min. Outcomes were assessed at multiple time points using graphemic scores, i.e., percent letters correct on trained and untrained words. Each outcome score was converted to a gain score by subtracting the outcome from the baseline score from the same period. For each follow-up time, we estimated the tDCS vs. Sham effect δ(T vs. S) based on the Generalized Estimating Equation approach (Liang & Zeger, 1986: Biometrika). Volumetric data for all language network areas and their right homologues as well as learning and memory areas were analyzed. The ROIs were: inferior frontal gyrus (IFG), supramarginal gyrus (SMG), middle temporal gyrus (MTG), superior temporal gyrus (STG), fusiform gyrus (FuG), anterior temporal pole (ATP), angular gyrus (AG) and hippocampus. MPRAGE (T1-weighted) scans were used and data were analyzed using mristudio.org software (Oishi et al., 2009: Neuroimage). We estimated the degree to which the additional tDCS effect over sham in therapy outcomes was associated with ROI volumes by a regression evaluating the interaction of treatment with volumes using the L1 (Lasso) penalty (Tibshirani, 1996: J R Stat Soc Ser B Method). We obtained significance levels by comparing the estimates with the distribution calculated by permuting the order of treatment assignment (tDCS then sham, or reverse) across patients. Results: Overall we found more beneficial effects of tDCS over sham in 28 participants with differential effects for each variant. Only the volumes of the left hippocampus and the left fusiform predicted performance on trained and untrained items in writing/spelling. Most importantly, a larger left hippocampus significantly predicted better performance in trained and untrained items. Additionally, tDCS helps therapy gains to maintain and generalize to untrained items only for those with larger left hippocampal and fusiform volumes. This finding shows that maintenance and generalization of therapy gains depend both on the hippocampus (learning substrate) and cortical regions specialized for the task (written naming).

Meaning: Prosody, Social and Emotional Processes

B67 The ATL causally mediates the expansion of working memory capacity for famous faces

Rocco Chiou[1], Matthew A. Lambon Ralph[1]; [1]University of Manchester, United Kingdom

Visual working memory (WM) is the mnemonic buffer that keeps visual information in an active state, making it accessible for high-level cognitive systems to operate on. It has been long known that WM is restrained by a capacity limit (typically at a maximum of 3 to 4 items for most individuals). In the present study, we demonstrate that (1) such capacity constraints do not hold for human faces, a type of visual stimuli crucial for social interaction and bestowing survival advantage, particularly for famous faces and (2) the right anterior temporal lobe causally mediates the facilitatory effect of famous faces on WM. In the first psychophysical experiment, participants performed a delayed-match-to-sample task, a well-established paradigm that probes WM capacity. We found that the number of colour patches remembered plateaued with less than 250-ms encoding time, replicating previous estimates of capacity limit. By contrast, the number of faces remembered continued to accumulate with more encoding time, and the rate of accumulation was more effective for famous than unknown faces. In the second transcranial magnetic stimulation experiment, we used theta-burst stimulation to investigate the neural locus that underpins the advantage of famous faces. Our stimulation target included the middle frontal gyrus (MFG), an executive region known for its role in generating top-down signal to bias WM, and the anterior temporal lobe (ATL), a semantic region known for representing face identity, as

well as the vertex (control site). Results showed that ATL stimulation significantly disrupts the facilitatory effect of famous faces, whereas MFG and vertex stimulation left the effect unaffected. Our data adds crucial evidence to the understanding of the neural architecture of WM, demonstrating that this fundamental cognitive faculty depends on existing semantic knowledge about people and engages the ATL, which causally expands the WM buffer when visual information carries semantic information.

Writing and Spelling

B68 Investigating the functional neural circuitry for spelling using graphical models

Kulpreet Cheema[1], Dr. William Hodgetts[1,2], Dr. Jacqueline Cummine[1]; [1]Faculty of Rehabilitation Medicine, University of Alberta, [2]The Institute for Reconstructive Sciences in Medicine

Background: Writing skills are imperative to successful academic and social functioning in today's literate society. Yet, literature exploring the underlying mechanisms associated with written communication, namely spelling, is limited. Although substantial work has been done to develop neuroanatomical models of reading, the same is not true for spelling. Further, while spelling has been reported to activate a large network of brain areas, there are no studies that examine the connectivity among the brain regions in this distributed network. An understanding of the dynamic nature of the distributed neural systems associated with spelling is critical for the development and advancement of theoretical models of written communication. Objective: This study will examine the functional connectivity patterns, using graphical models (a statistical approach for assessing relationships between brain regions of interest), associated with spelling in skilled adults. Methods: Skilled adults (N = 15) were recruited to take part in a functional magnetic resonance imaging (fMRI) study. After their behavioural testing, participants completed the spelling-based fMRI task called letter probe task (LPT) in MRI. During LPT, the participant first hears the word, then sees a letter on the screen and then is asked to indicate if the letter they just saw was in the spelling of the word that they just heard. Participants completed three conditions of LPT: 1) retrieval of the whole word spelling representations is required (exception words e.g. pint), 2) retrieval of the whole word spelling representation is optional (regular words e.g. hint), and 3) retrieval of the whole word spelling representation is impossible thus they must generate the spelling (nonwords e.g. bint). Left hemisphere brain regions were delineated based on previous work: orthographic processing (fusiform gyrus; FFG), speech input (inferior frontal gyrus; IFG), articulatory processing (supplementary motor area (SMA), putamen, cerebellum, precentral gyrus (PCG)) and phonological processes (superior marginal gyrus (SMG), caudate and superior temporal gyrus (STG)). Graphical modelling was applied to assess the functional connectivity between these regions in general spelling network and separately for each condition. Results: IFG, being the main speech input area, emerged as the hub for the general spelling network, as well as for the other spelling conditions. These functional network patterns changed as a function of word types. During the retrieval of exception words, a more extensive network involving brain areas associated with orthographic, phonological and articulatory processing. Retrieval of regular words activated a comparatively restricted network consisting of brain areas related to phonological and orthographic processing. The nonword spelling condition activated an extensive network, with connections to brain areas associated with articulatory and orthographic processing. Significance: Given the increased reliance on written communications skills in today's society, advancement of neuroanatomical models for spelling is critical. The results from the proposed work will increase the current state of knowledge regarding the underlying neurobiology of spelling performance.

B69 Ventral occipito-temporal responses to written texts and fingerspelling in congenitally deaf adults

Tae Twomey[1], Dafydd Waters[1], Cathy Price[1], Mairéad MacSweeney[1]; [1]University College London

Previous studies have shown greater activation for fingerspelling relative to sign language stimuli in the left ventral occipito-temporal (vOT) cortex – an area considered to be important in reading. This effect has been shown for the perception (semantic judgement, Waters et al., 2007; Emmorey et al., 2015) and the production (translation from English text, Emmorey et al., 2016) of fingerspelling. Although this effect has been attributed to orthographic processing, fingerspelling has never been directly compared to written text, partly due to the inherent difference in movement between the two orthographic forms. Demonstrating that fingerspelling is processed in vOT in the same way as text would provide further support to the possible role of fingerspelling in reading acquisition. Here we controlled for movement by presenting texts sequentially and investigated the vOT responses to fingerspelling and text in congenitally deaf adults, using functional magnetic resonance imaging (fMRI). Deaf native signers of British Sign Language, who scored more than 80% (Mean= 91%) on a fingerspelling test, were invited to participate. We manipulated input form (fingerspelling/sequentially presented text), lexicality (words/letterstrings) and task (linguistic/perceptual), resulting in a 2 x 2 x 2 factorial design. In the linguistic task, participants decided whether the item was a word or not. In the perceptual task, participants decided if any portion of the model's right hand touched the palm of her left hand (fingerspelling) or if the stimulus contained a letter with an ascender (sequential text). Both accuracy and reaction times showed significant main effects of task, input form and lexicality. The accuracy data also showed a significant interaction of task and lexicality. Post-hoc tests confirmed that participants were more accurate on letterstrings than words during the linguistic

task while accuracy did not differ between words than letterstrings during the perceptual task. The reaction time data showed a significant interaction of input form and lexicality. Post-hoc tests confirmed that participants took significantly shorter time to respond to letterstrings than words when the stimuli were presented as sequential text but there was no difference for fingerspelling. Given the effects of all the experimental factors, RTs were included as a covariate in the fMRI analyses. Greater activation for fingerspelling relative to sequential text was found in the occipital regions bilaterally, the left posterior middle temporal gyrus and the right precentral gyrus. There were no regions where activation was greater for sequential text than fingerspelling. The perceptual task elicited stronger activation than the linguistic task in bilateral middle occipital gyrus and the right angular gyrus. The opposite contrast showed no significant activation. Within a pre-defined, a priori anatomical region-of-interest mask in vOT, there was a significant main effect of lexicality (words>letterstrings). There were no significant effects of task, input form or interactions in vOT. The presence of a main effect of lexicality without interactions in vOT suggests that this region responds similarly to fingerspelling and sequential text despite very different perceptual properties. The finding supports the argument that fingerspelling may be a useful tool to support reading acquisition in deaf people.

Perception: Speech Perception and Audiovisual Integration

B70 Dynamic Adaption During Lexically-Guided Perceptual Learning in People with Aphasia

David Saltzman[1], Kathrin Rothermich[1], Emily Myers[1]; [1]University of Connecticut

Adapting to unfamiliar speech input in everyday conversation is an integral part of speech processing, and is accomplished with seemingly minimal effort in typical populations. In Lexically-Guided Perceptual Learning (LGPL) paradigms (e.g. Kraljic & Samuel, 2005), listeners are exposed to an ambiguous token embedded in an unambiguous lexical context, which subsequently biases their perception of phonetic contrast. Phonetic recalibration through LGPL is associated with increased activity in known language areas (left MTG) as well as executive areas (left IFG, Myers & Mesite, 2014). This activation may reflect the interaction of the top-down lexical information with the bottom-up acoustic characteristics of the stimuli (Myers & Blumstein, 2008). What is not known, however, is how necessary each of these areas, specifically left frontal (MTG and IFG) and left STG, are for listeners to adapt to novel speech input. The dorsal stream, connecting posterior temporal regions with frontal systems, has been highlighted as a crucial route for language learning, but it remains to be seen whether the same route is utilized when listeners adapt to variance in their native language. In the present experiment, ten people with aphasia (PWA) were recruited to participate in an LGPL experiment in which they were exposed to four interleaved blocks of a lexical decision task and a phonetic categorization task in which the lexical decision blocks were designed to bias perception in opposite directions of a "s"-"sh" contrast. While traditional LGPL studies use between-subjects designs, this within-subjects paradigm allows for the degree of learning to be assessed by comparing the size of the boundary shifts incurred by the "s"-biasing and "sh"-biasing blocks. PWA also underwent a battery of cognitive assessments and tests of language function to be added as covariates. Preliminary data from ten participants suggests that while bottom-up processing of the "sign"-"shine" continuum tested in the phonetic categorization task appears intact (as indicated by generally good categorization response functions), adaptation as a result of the phonetically biasing information in the lexical decision task is highly variable, and overall weaker than in typical undergraduates. Voxel Lesion Symptom Mapping will be applied to better dissociate the brain regions that predict an individual participant's ability to adapt to the novel speech input in this paradigm.

B71 Speech processing with one hemisphere: word repetition in a patient with right hemisphereotomy

Chad S. Rogers[1], Michael Jones[1], Jacqueline M. Hampton[1], Catherine Hoyt Drazen[1], Matthew D. Smyth[1], Jarod Roland[1], Nico Dosenbach[1], Jonathan E. Peelle[1]; [1]Washington University School of Medicine

Introduction A recurring discussion in the neurobiology of language pertains to the degree to which speech processing shows hemispheric lateralization. In the current study, we examined speech-related activation in a participant recovering from right hemisphereotomy, a surgical procedure used to treat epilepsy in which the vascularized right hemisphere is disconnected from the rest of the brain by severing white matter tracts. Given that the right hemisphere contributes to many aspects of language processing, our goal was to assess the degree to which cortical language networks may have reorganized to support these functions with a single hemisphere. Methods The hemispherotomy patient was a 24 year old female native speaker of English who was scanned 32 days following surgery. Immediately post-surgery, she was unable to walk, speak, or use her left arm. She was eventually able to walk with a cane, use her left arm with assistance, and her language abilities returned. At the time of her scanning session, she was able to comprehend and communicate with members of the research team, as well as able to comprehend and verbally repeat auditory stimuli. The hemisphereotomy patient and healthy right-handed controls (n=17, 14 female, age range 19-30, mean age = 24) each took part in a 2 hour scanning session in which structural and functional MRI scans were performed. fMRI scanning was performed using a sparse imaging protocol in which stimuli were presented during

a silent gap between volume acquisitions. Four runs of fMRI scanning were performed (TR 3070 ms, TA 800 ms, voxel resolution 2.04 x 2.04 x 2 mm). The stimuli were audio recordings of 300 monosyllabic consonant vowel consonant (CVC) English words. As a control condition, sixty words were made unintelligible via single channel white noise-based vocoding. On half of trials participants were asked to say out loud the word they had just heard, for the other half of trials, participants were asked to listen carefully to the words. Results Figure 1 displays speech-related fMRI activation in the patient, healthy controls, and regions where the patient showed greater activation than controls (voxelwise FWE $p < .05$) for repetition trials. The cluster of greater activation for the patient rather than controls in the superior temporal gyrus (STG) is consistent with hemispheric reorganization of the speech perception network. Conclusions The results of the current study validate decades of prior behavioral post-operative studies that have shown remarkable recovery of verbal abilities in patients following hemisphereotomy. However, the region of greater activity in the superior temporal gyrus of the patient suggests a degree of cortical reorganization, with neuroplasticity compensating for the loss of the right hemisphere during speech processing.

B73 The visual representation of lipread words in posterior temporal cortex studied using an fMRI-rapid adaptation paradigm, functional localizers, and behavior

Lynne E. Bernstein[1], Silvio P. Eberhardt[1], Xiong Jiang[2], Maximillian Riesenhuber[2], Edward T. Auer[1]; [1]Department of Speech, Language, and Hearing Sciences, 550 Rome Hall, George Washington University, Washington, District of Columbia 20052, USA, [2]Department of Neuroscience, Georgetown University Medical Center, Research Building Room WP-12, 3970 Reservoir Rd. NW, Washington, District of Columbia 20007, USA

Visual speech stimuli are necessarily processed through visual pathways. But a fundamental question is to what extent the stimuli are represented qua speech in visual areas. We have shown that a more anterior region of the left posterior superior temporal sulcus/posterior middle temporal gyrus (pSTS/pMTG) responds preferentially to visual speech motion in nonsense syllables, and in contrast, a more posterior pSTS/pMTG region responds to both speech and non-speech face motion stimuli [Bernstein et al., 2011. Hum. Brain Mapp. 32, 1660-1676]. We dubbed the speech-selective area the "temporal visual speech area" (TVSA). Here, using an fMRI-RA (rapid-adaptation) paradigm, we investigated whether TVSA represents the visual forms of spoken words. In addition, regions of interest (ROIs), including the TVSA, the visual word form area (VWFA), and the fusiform face area (FFA), were individually localized using separate localizer scans. During fMRI-RA scanning, 19 young adults with normal hearing and good lipreading ability viewed visual spoken word-pairs that were the same (but different videos), or different, with perceptual differences that were near, near+, or far. The TVSA localizer scan was used to define bilateral TVSA and non-speech face motion area (NSFMA) ROIs. Left TVSA demonstrated the predicted pattern of release from adaptation: Far and near+ stimulus word-pairs demonstrated significant release from adaptation that was similar in signal level, suggesting that words that were perceptually far and words that were more similar to the adapting stimulus (near+) but still discriminably different (demonstrated with behavioral discrimination results) were represented differently within the TVSA. Release from adaptation was similar across same and near word-pairs, and was significantly below that of far and near+ word-pairs. The NSFMA demonstrated significantly lower signal levels than TVSA for all fMRI-RA pair types and did not demonstrate release from adaptation as a function of word-pair perceptual distance. Right TVSA did not demonstrate release from adaptation as a function of word-pair type: Activation was similar in the right TVSA and FFA, and their activity levels were significantly higher than in the right NSFMA, suggesting that right TVSA and FFA are activated by talking faces but are not selective for the forms of spoken words. Left MT/V5 had high signal level that was similar to that of left TVSA, but it did not demonstrate release from adaptation as a function of word-pair dissimilarity. Left FFA signal levels were similar to TVSA levels, but same, near+, and far pairs resulted in similar activation levels, suggesting that left FFA also does not represent the forms of visual spoken words. Right FFA and MT/V5 were also not selective for visual spoken word-pairs. The left VWFA signal levels were overall significantly lower than left TVSA levels but, interestingly, similar in response pattern to those of the left TVSA. D-prime behavioral discrimination values across different stimulus pairs were, in order, near < (near+) < far. These results support the existence of high-level visual representations of visual spoken word forms. (NIH DC012634)

B74 Alpha and beta oscillations in the language network, motor and visual cortex index the semantic integration of speech and gestures in clear and degraded speech

Linda Drijvers[1,2,3], Asli Ozyurek[1,2,3], Ole Jensen[4]; [1]Radboud University, Centre for Language Studies, Nijmegen, The Netherlands, [2]Radboud University, Donders Institute for Brain, Cognition, and Behaviour, Nijmegen, The Netherlands, [3]Max Planck Institute for Psycholinguistics, Nijmegen, The Netherlands, [4]School of Psychology, Centre for Human Brain Health, University of Birmingham, United Kingdom

Oscillatory dynamics are thought to subserve the integration of information from multiple modalities. This is particularly relevant during face-to-face communication, which integrates auditory (e.g., speech) and visual inputs (e.g., gestures). Under adverse listening conditions, speech comprehension can be improved by the semantic

information conveyed by these gestures. However, when gestures mismatch speech, audiovisual integration might be hindered, especially when speech is degraded and the semantic information from gestures cannot aid to resolve the remaining auditory cues. Here, we used MEG to investigate how oscillatory dynamics support the semantic integration of speech and iconic gestures in clear and degraded speech. Participants were presented with videos of an actress uttering an action verb, accompanied by a matching (e.g., a mixing gesture + 'mixing') or a mismatching gesture (e.g., a drinking gesture + 'walking'). Speech in the videos was presented clear or degraded by using 6-band noise-vocoding. Semantic congruency and speech degradation modulated oscillatory activity in the alpha (8-12 Hz) and beta (15-25 Hz) band. Source analyses revealed larger alpha and beta power suppression in LIFG and visual cortex when speech was accompanied by a mismatching as compared to a matching gesture, but only when speech was clear. This indicates that the visual system is more engaged to allocate attention to mismatching than matching gestures when speech is clear. The observed congruency effects in the LIFG are likely to reflect an increased semantic processing load to resolve the conflict. This conflict reduced when speech was degraded, due to the lack of auditory cues. In clear, but not degraded speech, beta power was more suppressed in (pre)motor cortex when a gesture mismatched than matched the speech signal, suggesting that a listener might simulate the mismatching gesture to re-evaluate its fit to speech. Beta power was less suppressed in MTG/STG, MTL and AG when speech was degraded and gestures mismatched as compared to matched speech. This suggests that listeners try to resolve the speech signal, but that semantic audiovisual integration might be hindered when the mismatching gesture fails to aid retrieval of the degraded input. Our results provide novel insight by revealing how low-frequency oscillations support semantic audiovisual integration in clear and degraded speech: when gestures mismatch and speech is clear, listeners engage the extended language network to process the mismatching gesture. In degraded speech, the extended language network is less engaged, possibly reflecting the hindered coupling of gestures and the degraded signal.

B75 Inferior frontal gyrus activation is modulated by phonetic competition: An fMRI study of clear and conversational speech

Xin Xie[1], Emily Myers[2]; [1]University of Rochester, [2]University of Connecticut

The speech signal varies naturally in phonetic ambiguity. For instance, conversational speech, is spoken with less articulatory precision than clear speech, leading to greater potential for confusability at the phonetic level (Ferguson & Kewley-Port, 2007). Current psycholinguistic models assume that ambiguous speech sounds activate more than one phonological category, and that competition at prelexical levels cascades to lexical levels of processing. Previous research (e.g., Myers et al., 2009; Poldrack et al., 2001) suggests that phonetic competition modulates activity in the left inferior frontal gyrus (LIFG), yet these studies have often used artificially manipulated speech and/or metalinguistic tasks that may tap a different set of cognitive processes than those necessary for natural language processing (Hickok & Poeppel, 2007). In the current study, we exploited the natural variation in phonetic competition (PC) in the speech signal in order to investigate neural sensitivity to PC as listeners engaged in a receptive language task. Fifteen healthy adults heard nonsense sentences spoken in either a Clear or Conversational register (all highly intelligible; pre-equated in pitch and duration) as neural activity was monitored using fMRI. Conversational sentences contained greater PC, as estimated by measures of vowel confusability ($p < .001$). A post-scanner probe matching test revealed longer RTs to Conversational sentences than to Clear sentences ($p = .05$), suggesting that higher PC led to greater perceptual difficulty. Critically, Conversational sentences elicited greater activation in a region in the LIFG, whereas the opposite pattern was observed in the temporal lobe (left STG and Heschl's gyrus; $p < 0.05$, FWE corrected). Sentence-level PC metrics also uniquely correlated with LIFG activity ($p < 0.05$, FWE corrected), explaining variance not shared by RT or intelligibility or lexical properties of words (word frequency and neighborhood density). Conclusion: Our findings reveal a critical role of LIFG in the resolution of phonetic competition that is inherent to spoken language processing, consistent with the notion that recruitment of this region does not require an explicit phonological judgment.

B76 N400 modulated by word onset duration but not information content during spoken word recognition

Jonathan Brennan[1], Emma Saraff[1], Max Cantor[2], Dave Embick[3]; [1]University of Michigan, [2]University of Colorado, [3]University of Pennsylvania

Computational models of spoken word recognition emphasize the role that word onsets play in guiding lexical activation rapidly and incrementally. These models predict, correctly, that overall reaction times will be faster for more informative onsets. They also predict that initial word activation will vary as a function of either the first phoneme's duration (e.g. COHORT) or its information content (TRACE), but these finer-grained predictions have not been tested. The amplitude of the N400 event-related potential (ERP) component is sensitive to word frequency and other factors that affect the ease of word recognition. For spoken words, the N400 begins about 200-300 ms after stimulus onset, notably before word offset, and consistent with the timing of early stages of lexical activation. Delayed phonological cues to lexical identity show N400 latency effects. We examine the ERP response to time-dilated words to test, first, whether the N400 is modulated by word-duration when semantic content is held constant. We then test whether N400 latency is sensitive to the duration of the first phoneme or to its

information content as quantified via surprisal. Methods: N=17 participants listened to spoken words while electroencephalography (EEG) data were recorded. Stimuli were 100 high frequency mono-syllabic target nouns (mean length: 492 ms) and 68 filler words. Target words were dilated to 80% ("compressed") or 120% ("expanded") of their original duration using the pitch-preserving PSOLA algorithm (Fig. 1A). Dilated and non-dilated stimuli were presented at 45 dB HTL (ISI 900--1100 ms) in 12-item mini-blocks to avoid mixing speech rates. Non-dilated stimuli were binned according to first phoneme characteristics: (1) based on a median split of first phoneme duration (Fig. 1B), or (2) based on a median split of first phoneme surprisal (-log_2(Pr(phoneme | word boundary)), probability estimated from the English Lexicon Project; Fig. 1C). These bins minimally overlap: r(duration, surprisal) = -0.13. Participants made a semantic judgment on 16% of trials. EEG data were recorded at 500 Hz from 61 active electrodes. Epochs spanning -300--1000 ms around word onset were re-referenced to linked-mastoids, cleaned of artifacts with visual inspection and ICA, band-pass filtered from 0.5--40 Hz, and baseline-corrected. A non-parametric statistical analysis was conducted across all electrodes from 0--800 ms. Results: Time-dilation significantly modulates the N400 such that "compressed" words show an earlier negativity on central electrodes (Fig. 1D, 264--432 ms, $p < 0.05$). The effect is predominant on the leading edge of the deflection such that the latency difference at the 25th percentile is 46 ms. Non-dilated words with shorter initial phonemes also modulate the leading edge of the N400 (Fig. 1E, 258--480 ms, $p < 0.05$); the latency difference at the 25th percentile is 52 ms. There are no significant effects for first phoneme surprisal (Fig. 1F). These data indicate that the the N400 is modulated by the speed with which lexical information unfolds. We extend prior work to show sensitivity to first phoneme duration, consistent with the COHORT model, but not to first phoneme information content, contra TRACE.

B77 Phoneme Perception Deficits from Unilateral Left Hemisphere Stroke: A Voxel-Based Lesion Correlation Study

Jeffrey Binder[1], Sara B. Pillay[1], Colin J. Humphries[1], Peter Kraegel[1], Diane S. Book[1]; [1]Medical College of Wisconsin, Milwaukee, WI, USA

Introduction: Severe phoneme perception impairment ("pure word deafness") from stroke is rare and typically follows bilateral cortical auditory system damage. Cases with unilateral left hemisphere lesions have occasionally been reported, but the precise lesion correlate is unclear, as are the incidence and severity of phoneme perception deficits arising from unilateral lesions. Methods: 57 patients with chronic unilateral left hemisphere stroke performed an AB discrimination task in which they judged whether two consecutively presented nonwords contained the same consonants and vowels. Stimuli were natural recordings of CV, VC, CCV, and VCC syllables. The 160 trials included 80 minimal pair contrasts of vowel color, manner, place, or voicing. To focus attention on phoneme identity, the 80 "same" trials were always acoustically different recordings of the same syllable. As a control for non-specific executive deficits and phonological short-term memory processes, patients performed a visual nonword rhyme matching task in which they judged which of two printed nonwords (e.g., bix and fise) rhymes with a third (e.g., fricks). Voxel-based lesion-symptom mapping (VLSM) was performed after labeling lesions on high-resolution T1-weighted MRI scans. Results: Accuracy on the phoneme discrimination task averaged 91.7% (SD 7.9, range 66.9 to 99.1). Thirteen patients (23%) performed more than 2 SD below the mean of an age-matched control cohort (n = 24, mean 96.3%, SD 4.8). Relative to controls, performance was worst on place contrasts (mean Z score = -4.4; 32 patients impaired), followed by voicing contrasts (mean Z score = -1.6; 18 patients impaired), manner contrasts (mean Z score = -1.2; 14 patients impaired), and vowel contrasts (mean Z score = -0.2; 8 patients impaired). Lesioned voxels associated specifically with impaired phoneme discrimination (after removing variance associated with the nonword rhyming task) were in the mid-portion of the left middle temporal gyrus and adjacent superior temporal sulcus (centered around -28 on the stereotaxic Y axis), extending medially into deep temporal lobe white matter and the retrolenticular internal capsule. Conclusions: Unilateral left hemisphere lesions can impair phoneme perception. The incidence in this unselected sample was 23%, although the severity of the deficit was generally mild. We included performance on a visual phonological task as a covariate in the VLSM analysis because the phoneme discrimination task inevitably depends on executive and short-term memory processes in addition to the phoneme perceptual process of interest. Damage correlated specifically with phoneme perception impairment occurred in high-level association cortex of the auditory ventral stream and deep temporal white matter pathways. The white matter lesions likely affect auditory radiations projecting from the ipsilateral medial geniculate body as well as auditory transcallosal tracts carrying information from the right hemisphere, effectively disconnecting the left-lateralized, mid-temporal phoneme recognition system from auditory input, analogous to the visual disconnection that occurs in some cases of pure alexia.

Signed Language and Gesture

B78 Trial-by-trial N400 variability reflects temporal gesture-speech integration

Laura Morett[1,2], Nicole Landi[1,3], Julia Irwin[3,4], James McPartland[1]; [1]Yale Child Study Center, [2]University of Alabama, [3]Haskins Laboratories, [4]Southern Connecticut State University

In natural conversation, beat gesture (i.e., simple rhythmic manual gesture) and pitch accent (i.e., speech intonation) are tightly linked. Previous research indicates that the N400 event-related potential (ERP), which reflects prediction, shows sensitivity to contingencies in presence between beat

gesture and pitch accent (Wang & Chu, 2013). Currently, it is unknown whether the N400 ERP shows sensitivity to contingencies in timing between beat gesture and pitch accent. Because the N400 ERP is typically measured as an average response, and trial-by-trial variability contains information concerning response stability (Dinstein, Heeger, & Behrmann, 2015), N400 variability has the potential to be particularly informative about temporal beat gesture-pitch accent integration. In light of this, the current research examined N400 response variability to determine how it reflects temporal beat gesture-pitch accent integration. In this study, the N400 response was recorded in neurotypical adults (n=24) as they watched videos featuring the torso of a speaker producing sentences in which a word in a specific grammatical role (patient) was pitch accented. In one block, the speaker did not produce a beat gesture (no beat condition) in half of the sentences and produced a beat gesture concurrently with the pitch accented word (synchronous beat condition) in the other half of the sentences. In the other block, the speaker produced a beat gesture 500 ms after the pitch accented word (asynchronous beat condition) in half of the sentences and produced a beat gesture concurrently with the pitch accented word (synchronous beat condition) in the other half of the sentences. No behavioral response was required during the task, and the N400 response was measured in relation to the onset of pitch accented words. In the channel showing the largest N400 response, trial-by-trial variability in amplitude was compared between the no beat and temporally asynchronous beat conditions to examine the impact of temporal asynchrony on the N400 response. As in prior work, variability of N400 responses was computed using two measures: median amplitude of deviation (MAD) and inter-trial phase coherence (ITPC) in the alpha range (11 Hz). Across trials, MAD of N400 response amplitude was greater in the temporally asynchronous beat condition than the no beat condition ($t=2.88$, $p=.004$). In addition, across time points, ITPC at 11 Hz was greater in the no beat condition than in the asynchronous beat condition, ($t=53.81$, $p<.001$). These results were consistent with comparisons of N400 response variability in the asynchronous beat and no beat conditions with the synchronous beat condition. Together, these results indicate that trial-by-trial variability in the N400 response reflects temporal synchrony of beat gesture and pitch accenting. In particular, they provide evidence of greater variability in N400 responses to beat gestures temporally asynchronous with pitch accents than to beat gestures absent from pitch accents. These results show that N400 response variability is a potential indicator of temporal processing in language comprehension that may be able to serve as a biomarker of impairment in communication disorders in which cross-modal integration is abnormal, such as autism spectrum disorders.

Computational Approaches

B79 Electrophysiological correlates of statistical features of word sequences in natural spoken language

Hugo Weissbart[1], Katerina D. Kandylaki[1], Tobias Reichenbach[1]; [1]Imperial College London

Research on electrophysiological correlates of language processing often employs simplified stimuli such as single words or short sentences. However, such an approach cannot assess neural responses to statistical features of word sequences in longer narratives. To overcome this limitation, we measured cortical responses to natural spoken language. Continuous speech has recently been shown to yield cortical responses that partly reflects acoustic processing since they occur for incomprehensible reversed speech as well. Here we show how a hierarchical model of acoustic and linguistic features of spoken language can disentangle neural responses to the acoustic and linguistic aspects of a continuous spoken language. We employed electroencephalography (EEG) to measure neural responses of native English speakers to continuous English speech. Linguistic features were extracted from the text that corresponded to the speech signals and were aligned to the acoustic signal through forced alignment. As a first feature, the frequency of each word in large corpus was obtained using Google Ngrams. This feature is independent of the word sequence. Second, we employed recurrent neural networks for language modelling to obtain two statistical features of word sequences. In particular, we obtained the probability for each word in a sequence conditioned on the previous words in the sequence. The negative logarithm of that probability is the surprisal of that word in its context (Nelson et al. 2017). The posterior estimate of all probabilities yields a measure of the entropy at each word location. To control for neural responses to the acoustic properties of speech, we determined the onset of each word and used that feature as a control variable. We then employed linear regression with regularization to correlate the EEG responses to the linguistic and acoustic features. As an additional control, we performed the same analysis for EEG responses to a foreign language, namely Dutch, which has similar acoustic properties as English but was incomprehensible to the participants. Results: We found that both the acoustic feature as well as the linguistic features elicited distinct neural responses. In particular, we obtained specific electrophysiological correlates of the surprisal of a word in its sequence as well as of the associated entropy. Both neural responses could not be explained by the acoustic properties or by word frequency. The neural responses to the linguistic features were absent when participants listened to the foreign language. Our study reveals electrophysiological correlates of statistical features of word sequences that emerged when analyzing neural responses to long sequences of natural spoken language. In particular, we show how statistical features of natural language that were extracted through applying

recurrent neural networks to text have corresponding neural responses. The cortical response to the surprisal of a word may support the predictive coding hypothesis where a sequence of words leads to the prediction of the next word. As this analysis discriminates conditions (English or Dutch), we can assess comprehension such that our findings may be applied to better understand and characterize types of aphasia that yield a difficulty with speech comprehension.

Poster Session C

Thursday, November 9, 10:00 – 11:15 am, Harborview and Loch Raven Ballrooms

C1 The Effects of Background Noise on Native and Non-native Spoken Word Recognition: An Artificial Neural Network Modelling Approach

Themis Karaminis[1], Florian Hintz[2], Odette Scharenborg[1,3]; [1]Centre for Language Studies, Radboud University, Nijmegen, the Netherlands;, [2]Max Planck Institute for Psycholinguistics, Nijmegen, the Netherlands, [3]Donders Institute for Brain, Cognition, & Behavior, Radboud University Nijmegen the Netherlands

Introduction. How does the presence of background noise affect spoken word recognition? And (how) do these effects differ when one listens to a native compared to a non-native language? We address these questions using the artificial neural-network modelling framework. We implement a series of neural network architectures, which acquire 'native' and 'non-native' lexicons of English and Dutch words. We use these architectures to simulate two spoken word recognition experiments and to systematically investigate the effects of background noise on native and non-native spoken word recognition. Method. Our model is based on 'deep' autoencoder neural network, which is trained on composite representations of words, consisting of phonological forms (feature-based) and their meanings. The training set comprises 121 English and Dutch translation equivalents compiled from stimuli in Scharenborg et al. (in press). Exposure to the English and the Dutch lexicons is varied so as to implement 'native English/monolingual' (trained only on English), 'native English/non-native Dutch' (English : Dutch = 3 : 1), 'native Dutch/non-native English' (English : Dutch = 1 : 3), and 'native Dutch/monolingual' (Dutch only) versions of the model. Using 'native English' and 'non-native English' versions, we simulate human performance (accuracy rates, number of erroneous responses per incorrectly identified word) in an offline spoken-word recognition experiment (Scharenborg et al., in press), in which English and Dutch students listened to English words masked with background noise, either word-initially or word-finally. Using the 'native Dutch' version of the model, we simulate looking preferences in an online visual-world paradigm (Hintz & Scharenborg, 2016). In this experiment, Dutch participants listened to Dutch target words while attending to pictures of the target words, phonological onset competitors of these, or words semantically related to the onset competitors (each presented along with unrelated distractors). Results. The model captures several characteristics of human performance in the two experiments. In offline spoken word recognition, the presence of background noise causes accuracy rates and the number of different erroneous responses to decrease/ increase, respectively. This effect is more pronounced in word-initial compared to word-final masking conditions and in higher levels of noise, and holds for both native- and non-native listening, despite the fact that accuracy/ the number of different erroneous responses are generally lower/ higher in non-native listening. In the online visual world paradigm, the presence of background noise attenuates and delays looking biases to onset phonological competitors of target words and words semantically related to the onset phonological competitors in native listening. Simulations with 'non-native Dutch' versions of the model predict that noise affects similarly the looking biases of non-native listeners (which are also less strong than the looking biases of native listeners). Novel data from non-native Dutch listeners completing the visual word experiment are consistent with this prediction. Conclusion. Our model unifies a wide range of empirical effects in native and non-native spoken word recognition. Our simulations suggest that the effects of noise on word recognition are largely similar in native and non-native listening and can be accounted for within the same cognitive architecture for spoken word recognition.

Grammar: Syntax

C2 Neural synchronization of syntactic priming during face-to-face communications

Wenda Liu[1], Xialu Bai[1], Hui Zhao[1], Yuhang Long[1], Lifen Zheng[1], Chunming Lu[1]; [1]Beijing Normal University

Syntactic priming is a unique manifestation in psychological linguistics and has been proven in many experimental paradigms and in or across several languages, but the neural mechanism behind this phenomenon remains unclear. In this study, functional near infrared spectroscopy (fNIRS)-based hyperscanning was employed to measure brain activities of two communicators simultaneously during face-to-face communication with eye contact, face-to-face communication without eye contact, and back-to-back communication. The two communicators either produced the same syntactic structure [Double-Object(DO) or Prepositional-Object(PO) separately]] or different syntactic structures (DO and PO alternately, as a control task). Results showed that, in both face-to-face with eye contact condition and without eye contact condition, there was a significant increase of interpersonal neural synchronization (INS) in the DODO task relative to the control task in the left pSTC. The face-to-face with eye-contact condition additionally recruited the left SMC, whereas the task without eye contact additionally recruited the right TPJ. There was no significant increase

of INS in the back-to-back condition. Also, no significant results were found for the POPO task in any conditions. In addition, the increase of INS correlated significantly with the accuracy of task performance in the DODO task, but not in the POPO task. These findings suggest that neural synchronization may underlies the alignment of syntax representation during communication, and different types of syntax representation corresponds to different level of neural synchronization. Thus, the neural synchronization can be considered as a neural marker of syntax representation in communications.

C3 Both syntactic and prosodic cues guide sentence processing in the left inferior frontal gyrus *Constantijn L van der Burght[1], Tomás Goucha[1], Angela D Friederici[1], Jens Kreitewolf[1,2], Gesa Hartwigsen[1]; [1]Max Planck Institute for Human Cognitive and Brain Sciences, [2]University of Lübeck*

In everyday conversation, various types of information need to be integrated. Both word forms and speech melody (prosody) establish which words belong together, creating syntactic boundaries between different parts of a sentence. For example, words can be grouped by syntactic cues (a particular word form) or by prosodic boundaries (a sentence pause and pitch modulation). The neural correlate of how these different types of information contribute to sentence comprehension is yet to be specified. We used fMRI to address this issue, hypothesizing that if a prosodic boundary is processed as a syntactic boundary rather than only as a prosodic event this would lead to left hemispheric activation, possibly in the inferior frontal gyrus (IFG). In our experiment, we measured the processing of different types of spoken utterances in healthy, young participants. In each stimulus condition, the verb-argument structure was disambiguated by either case marking (a syntactic cue), an intonational phrase boundary (IPB; a prosodic cue), or a combination of these. Subsequently, participants made a decision about which role a particular agent fulfilled in the action in the sentence, basing their response either on the syntax or the prosody. Our results show that the contribution of the left IFG to speech processing depends on the information that is available and required for sentence comprehension. We found that task-related activity in the left IFG was increased when the syntactic boundary was marked by only one cue (either syntactic or prosodic), as contrasted to sentences in which both syntactic and prosodic elements were marking the boundary. In accordance to the literature, a strong contribution of the left IFG was revealed when the syntactic cue was decisive for sentence meaning. As hypothesized, when a sentence boundary was indicated by a prosodic boundary only, the main activation was also found in the left IFG, as opposed to the right hemispheric activity commonly found for purely prosodic events. Our results suggest an involvement of the left IFG in function of the processing demands during sentence comprehension, regardless of whether a listener relies on syntactic or prosodic information.

C4 Beyond Speech Entrainment: Delta-Band Oscillations Align Neural Excitability with High-Level Linguistic Information *Lars Meyer[1], Matthias Gumbert[1,2]; [1]Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany, [2]University of Trento, Trento, Italy*

Electrophysiological synchronization of neural oscillations with the paces of phonemes and syllables is an established mechanism of speech perception. Recently, oscillatory cycles were also found to align with syntactic phrases, in spite of lacking phonetic cues. The functional purpose of electrophysiological alignment with syntactic phrases for information transmission via language is entirely unclear. We hypothesized here that the alignment between oscillatory cycles and syntactic phrases results in an implicit alignment between the resulting gradient in oscillatory phase—mirroring neural excitability—and syntactic information within syntactic phrases. In our auditory electroencephalography study, we uniformly distributed morpho-syntactic violations across syntactic phrases of natural sentence stimuli, such that violations would occur at points differing in syntactic informativeness (i.e., syntactic surprisal) as quantified by probabilistic computational modeling. Subjects were required to detect the violations via button press. In support of our hypothesis, behavioral and electrophysiological responses (i.e., reaction times and amplitudes of the left anterior negativity, respectively) to morpho-syntactic violations increased with decreasing syntactic informativeness along syntactic phrases—in correlation with a progression of delta-band oscillatory phase, which had synchronized to the syntactic phrases of the stimuli. Our findings indicate that electrophysiological alignment between neural delta-band oscillations and syntactic phrases could be a functional mechanism that optimizes the extraction of syntactic information from within syntactic phrases, facilitating language comprehension.

C5 Priming sentence production and comprehension in aging *Grace Man[1], Emily Hosokawa[1], Holly Branigan[2], Jiyeon Lee[1]; [1]Purdue University, [2]University of Edinburgh*

Structural priming, or the tendency to repeat structure across otherwise unrelated sentences, is thought to reflect life-long language learning (Chang et al., 2006). A distinction is made between lexically-dependent (same verb between primes and targets) and lexically-independent (different verb between primes and targets) priming. It is posited that the former involves the activation of item-specific representations that may involve explicit memory, while lexically-independent priming involves abstract implicit learning (Pickering & Ferreira, 2008). Priming is significantly enhanced by verb repetition between primes and targets in both children and young adults, because of the item-specific boost in explicit memory ('lexical boost'), although the effect is not always long-lived (Branigan & McLean, 2016; Pickering, McLean &

Branigan, 2013; though see Rowland et al., 2012; Peter et al., 2015). Little is known about whether and how structural priming is affected in aging. In healthy aging, explicit memory declines while implicit memory remains relatively stable (Daselaar et al., 2003; Graf, 1990). Accordingly, if the lexical boost effect involves explicit memory, we should expect older adults to demonstrate an attenuated or absent lexical boost due to their reduced explicit memory. We report two ongoing studies designed to test this hypothesis in sentence production (Study1) and comprehension (Study 2). Ten older adults (age M (SD) = 74.1 (7.6) years) were tested in both studies. Prime structure (preferred vs. non-preferred) and verb type (same vs. different) were within-subject variables. In Study 1, participants played a card game in which they took turns describing pictures with an experimenter, who described their pictures using either a preferred (active, prepositional dative) or non-preferred (passive, double-object dative) prime. Results showed a significant priming effect ($p < .001$), but no prime by verb type interaction. Older adults produced more preferred structures following preferred vs. non-preferred primes in both same (95.42% vs. 65.54%) and different (95.74% vs. 77.58%) verb conditions. In Study 2, comprehension of sentences with an ambiguous prepositional phrase (e.g., the doctor is poking the chef with an umbrella) was examined in a written sentence-picture matching task. Participants were first "primed" with either a verb-modifier (preferred) or object noun modifier (non-preferred) interpretation in a prime trial where only one of the two pictures was the correct choice. Then, the target sentence was presented with two pictures that matched both alternative interpretations of the sentence. Only the priming, not interaction, effect was significant ($p = .017$). Older adults chose the preferred interpretation more frequently following a preferred than a non-preferred prime in both same (55% vs. 40%) and different (53% vs. 42%) verb conditions. Hence our study did not find a lexical boost effect in sentence production or comprehension, different from what has been shown in children and young adults using similar methods (Branigan & McLean, 2016; Pickering et al., 2013). These results suggest that with aging, formation of explicit memory traces based on recent lexical-syntactic experiences may become weaker. Further theoretical implications and data on the time course of lexical boost will be presented.

C6 Frontotemporal connectivity during syntactic movement processing

Eduardo Europa[1], Darren R Gitelman[2,3,4], Swathi Kiran[5], Cynthia K Thompson[1,2,6]; [1]School of Communication, Northwestern University, [2]Feinberg School of Medicine, Northwestern University, [3]Advocate Lutheran General Hospital, [4]Rosalind Franklin University of Medicine and Science, [5]College of Health & Rehabilitation, Boston University, [6]Cognitive Neurology and Alzheimer's Disease Center, Northwestern University

Linguistic theory suggests that noncanonical sentences subvert the dominant agent-verb-theme order of arguments in English, such that the theme precedes the verb, via displacement of sentence constituents to argument (NP-movement) or non-argument positions (Wh-movement). The neural model of sentence comprehension by Friederici et al. (2012) proposes that an anteroposterior dorsal pathway, i.e., superior longitudinal fasciculus/ arcuate fasciculus, subserves noncanonical sentence processing, with phrase structure building in the left inferior frontal gyrus (IFG) preceding thematic role re-analysis in the left temporo-parietal junction (TPJ) (also see Thompson & Meltzer-Asscher (2014) for a similar model for processing verb argument structure). On the contrary, the sentence comprehension model proposed by Bornkessel-Schlesewsky & Schlesewsky (2013) suggests that all sentences, regardless of complexity, begin with lexical processing in the posterior temporal cortex. Posteroanterior dorsal and ventral projections, subserving syntactic and semantic combinatorial processes, respectively, terminate in the left IFG, where structural and thematic analyses are integrated. These two hypotheses were tested in the present study using Dynamic Causal Modeling (DCM) with 15 cognitively healthy adults during an fMRI auditory sentence-picture verification task using passive and active sentences, contrasted to isolate NP-movement (i.e., Psv>Act), and object and subject cleft sentences, contrasted to isolate Wh-movement (i.e., OC>SC). Noncanonical sentence processing (Psv>Act + OC>SC) elicited peak activation in the left IFG (LIFG), posterior superior temporal gyrus (LSTGp), and the medial superior frontal gyrus (LSFGm), and these regions were used in the DCM analysis. Random-effects family-wise Bayesian Model Selection indicated that models in which neural network activity was driven by the LIFG's response to sentence stimuli best fit the fMRI data; exceedance probabilities = 0.73 and 0.82 for Wh- and NP-movement, respectively. One-sample t-tests of subject-specific parameters derived from Bayesian Model Averaging suggest that both movement types were associated with a significant increase in connectivity between the LIFG and LSTGp and between the LIFG and LSFGm, $p<0.05$ corrected for multiple comparisons using false discovery rate. No significant difference in modulation by either movement type was found between the LIFG-LSTGp and LSTGp-LIFG. These findings suggest that Wh- and NP-movement similarly modulate connectivity between regions involved with syntactic movement processing and are in line with previous accounts of Wh-movement modulating fronto-temporal connectivity (den Ouden et al., 2012). Results support the models proposed by Friederici et al. (2012) and Thompson & Meltzer-Asscher (2014), which predict sentence input into the LIFG for phrase structure building, and syntactic movement modulating the LIFG-LSTGp connection for thematic re-analysis in the LSTGp. While the LSTGp-LIFG modulation supports the Bornkessel-Schlesewsky & Schlesewsky (2013) model, given the nature

of the task, it more likely reflects response selection in the LIFG (Swick et al., 2008) following thematic re-analysis in the LSTGp. The present study supports the idea that comprehension of noncanonical sentences involves phrase structure building followed by thematic re-analysis, but increased complexity of Wh-structures compared to sentences with NP-movement requires greater engagement of cognitive resources via increased neural activity in LIFG and LSTGp (Europa & Thompson, 2016).

C7 Conceptual number agreement processing and coreference establishing in Brazilian Portuguese: An ERP study.

Juliana Andrade Feiden[1,2], Srđan Popov[2], Roelien Bastiaanse[2]; [1]International Doctorate for Experimental Approaches to Language and Brain (IDEALAB), Universities of Groningen (NL), Newcastle (UK), Potsdam (DE), Trento (IT), Macquarie University (AU), [2]Center for Language and Cognition Groningen (CLCG), University of Groningen, Groningen, The Netherlands

Number agreement depends mainly on two kinds of information: morphosyntactic/grammatical and semantic/conceptual (Bock, Eberhard, & Cutting, 2001; Eberhard, Cutting, & Bock, 2005). For most nouns, morphosyntactic and conceptual numbers coincide (Schweppe, 2013; e.g., the girlSG – one girl and the girlsPL – more than one girl). Conversely, for collective nouns, syntactic and conceptual number do not match (e.g., the gangSG – a group of criminals). When nouns with conceptual number are involved in coreference establishing, the pronoun agrees with the noun's conceptual number, thus creating an agreement mismatch in grammatical number (e.g., The bandSG played last night. TheyPL were talented). Our study investigates the role of conceptual number in coreference establishing by using Even Related Potentials, since they are differentially sensitive to syntactic and semantic information. We also aim to verify the processes and ERP components that are elicited by noun-pronoun number violations while manipulating the number type (grammatical vs. conceptual). Our hypothesis is that conceptual number agreement relies more on conceptual information when compared to grammatical number processing (only grammatical information). This reliance on conceptual information is expected to be reflected in an N400 effect, since coference establishing is happening at the semantic/conceptual level. Therefore, we predict that sentences containing a conceptual number violation (collective noun – singular + personal pronoun – singular) will elicit a N400 effect, while sentences that present a grammatical number violation will elicit a P600 effect (collective noun – singular + personal pronoun – plural). We tested 27 native speakers of Brazilian Portuguese on a passive reading task while recording EEG. The experimental materials comprised 240 experimental sentence pairs split into 2 lists, with an additional 80 fillers per list. In the experimental sentence pairs, the antecedents in half of the introductory sentences were collective nouns (conceptual number condition), and in the other half the antecedents were plural nouns with grammatical number (grammatical number condition). The number violation was created between a singular pronoun of the second sentence, and a collective or a plural noun in the first sentence. Forty collective nouns were used, of which twenty masculine and twenty feminine. In the collective number condition, the N400 was elicited for conceptual number violation, but on the verb following the pronoun. In the grammatical number condition, the Nref effect was observed on the pronoun. Our results show that conceptual number and grammatical number are processed differently. The Nref effect for the grammatical number violation indicates that the parser is in search of a proper antecedent. Furthermore, since there is a grammatical number mismatch, this process seems to take place at the syntactic level. In the case of conceptual number agreement, the violation elicits the N400 on the element following the pronoun – the verb. Such result indcates that conceptual number is accessed and integrated at the conceptual/semantic level. Curisously, the parser seems to need the additional information from the singular verb following the pronoun in order to establish the intended coreference with the collective noun.

C8 An fMRI Study of Syntactic Complexity Effect of Chinese Relative Clauses

Yanyu Xiong[1], Chunglin Yang[1], Sharlene Newman[1]; [1]Indiana University

The previous neuroimaging research about neural substrates of syntactic processing of complex sentences has found that the complexity effect is influenced by both syntactic integration cost and working memory. However, earlier research paradigm of comparing subject-modifying object-gap relative clauses (SO) with object-modifying subject-gap relative clauses (OS) conflated the external working memory load arising from main clause context (center-embedded vs. right-branching) with the internal processing load within the relative clause region. The results of this group of PET studies almost exclusively reported more activation of Broca's area for SO. Other fMRI studies using only center-embedded minimal contrast of relative clauses found a more distributed network of syntactic complexity effect with inconsistent involvement of the inferior frontal region across different languages. The present study expanded upon the previous research by introducing another pair of minimal contrast of left-branching relative clauses. The experiment used 2 by 2 design with filler-gap dependency (object-gap vs. subject-gap) and external working memory load (center-embedded vs. left-branching) as two conditions. By utilizing the linguistic feature of pre-modification in Chinese, we reversed the subject-modifying and object-modifying conditions of English studies, that is, object-modifying relative clauses for the center-embedded condition and subject-modifying relative clauses for the left-branching condition, and were able to test: (1) whether left-branching pair showed the same activation pattern as the center-

embedded pair does; (2) whether Broca's area was activated for processing more complex object-gap relative clauses across both pairs; (3) whether there is universal syntactic processing preference for subject-gap clauses over object-gap clauses. We used a slow event-related fMRI paradigm including four blocks of sentences with each block including eight sentences for each type of four relative clauses plus nine filler sentences. 22% sentences were followed by comprehension questions. Subjects were required to make the semantic congruency judgment based on the previous sentence. The results of our study showed that Chinese relative clauses exhibited more brain activation for subject-gap clauses compared with object-gap clauses for both center-embedded and left-branching conditions, indicating that the claim of universal preference for subject-gap clauses does not hold. This opposite scenario of English relative clauses has already been supported by other self-paced reading, eye-tracking and ERP studies. Our investigation further revealed that the neural substrates for this object-preference in Chinese were different. In the left-branching condition, the left posterior precuneus was more activated for subject-gap clauses relative to right-gap clauses, indicating more retrieval of contextual information, whereas in the center-embedded condition, two clusters in the bilateral prefrontal cortex were involved. One is the middle frontal gyrus including Brodman area 6 and 9 and the other is the superior inferior opercularis. This pattern of activation indicated that with equal working memory load from the preceding sentential context before relative clauses, the longer filler-gap distance in subject-gap relative clauses increased integration cost. The inconsistent involvement of the inferior frontal gyrus across the left-branching and center-embedded conditions showed that Broca's area was more modulated by the working memory load than the syntactic feature of clauses per se.

C9 Left-lateralized syntactic category processing is modulated by interhemispheric inhibition in healthy young right-handers with familial sinistrality background

Yi-Lun Weng[1], Min-Hsin Chen[1], Chia-Lin Lee[1]; [1]National Taiwan University, Taiwan

Left-hemisphere (LH) specialization for syntax is often viewed as a key example of functional lateralization, however, recent studies have demonstrated that the right hemisphere (RH) is capable of initiating processes similar in nature. To better understand factors modulating this functional lateralization, we examined the hypothesis that LH-equivalent language capabilities in the RH are masked by transcallosal interhemispheric inhibition from the dominant LH. In particular, we focused on a participant population previously found with reduced language lateralization—healthy young right-handers with a history of familial sinistrality (FS+). Event-related potentials (ERPs) were recorded from 25 participants while they judged grammaticality of Chinese two-word phrases. Following a central syntactic cue predictive of either a noun or a verb, target words were laterally presented to either visual field (VF), matching or mismatching the syntactic category expectancy (e.g., Grammatical: li□ng-dòng fáng-zi "two houses"; jí-shí bang-máng "to immediately help". Ungrammatical: jí-shí fáng-zi "immediately house"; li□ng-dòng bang-máng "to two help"). Target-locked ERPs revealed a reliable P600 grammaticality effect (600-1100 ms) with both VF presentations, replicating reduced syntactic lateralization in FS+ individuals previously found in studies based on English. In the same participants, we assessed their transcallosal interhemispheric inhibition using a bilateral flanker task, in which participants judged the direction of an arrow in the attended VF while ignoring distracting information from the other VF. Reaction times between the incongruent and neutral distractors were calculated for attend-RVF and attend-LVF conditions separately to index processing costs for inhibiting distracting information from the RH and LH respectively. Sizes of the P600 responses with each VF presentation were then regressed against the inhibition indices derived from the flanker task. Results showed that larger LVF/RH P600 responses were associated with less effective LH-on-RH inhibition (indicated by larger attend-RVF congruency effect)($r = 0.46$, $p < .05$). However, no systematic relation was found between the RVF/LH P600 responses and the RH-on-LH inhibition cost (indicated by the attend-LVF congruency effect) ($p = .71$). These results thus support the hypothesis that callosal inhibition, especially the inhibition from the dominant LH on the RH, modulates the lateralization pattern of structural analysis in syntactic category processing reflected by P600s, rendering the more bilateral responses in FS+ young adults a consequence of reduced interhemispheric inhibition.

C10 The (non-)satiation of P600/SPS effects to distinct grammatical violations

Emma Nguyen[1], Jon Sprouse[1]; [1]University of Connecticut

The P600/SPS ERP effects that arise to syntactic violations are widely assumed to index the re- analysis processes that the parser deploys to correct those violations. Our goal in this project is to expand the work in the literature that has sought to differentiate subtypes of P600/SPS effects (e.g., Gouvea et al. 2010) in the hopes of constructing a mapping between P600/SPS effects and theories of reanalysis (which could then help unite online measures of reanalysis with offline measures such as acceptability judgments, which are undoubtedly influenced by reanalysis). In this experiment we primarily intended to study the satiation of P600/SPSs. Hahne & Friederici (1999) found that P600/SPSs disappear when the composition of the experiment is 80% violations and 20% gram- matical sentences. Crucially, Hahne & Friederici used only one violation type in their experiment (a phrase structure violation similar to (1) below). This suggests that reanalysis processes satiate, but raises the question of whether distinct violations can cause satiation in each others reanalysis processes. To test this, we created an experiment containing multiple violation

types that add up to 80% throughout the experiment, but with no single violation accounting for more than 30% of the items (310 sentences total, with violations roughly evenly spaced). We focused on three distinct violation types, each taken from the P600/SPS literature (Neville et al. 1991, Newman et al. 2007, and Kim & Osterhout 2005, respectively): (1) Phrase structure violation (PSV): *The boys enjoyed Eds about stories the battle. (2) Agreement violation (AGR): *The agents discovers Freds tobacco from Cuba. (3) Semantic P600s (SEM): *The hearty meal was devouring by the kids. We also included 30 case violations and 30 island constraint violations to increase the mix of violation types. For PSVs, we used a pre/post design: 30 violations early in the experiment, and 30 violations late in the experiment, with no PSV violations in between. This allowed us to look for explicit satiation of PSVs by other violations. For AGR and SEM, the 30 violations of each were distributed throughout the middle and end of the experiment, which only allowed us to ask whether the P600/SPSs were present/absent. We used the same experimental parameters as Kim & Osterhout (2005) to ensure that the semantic P600 was potentially present. Crucially, we found P600/SPS-like effects for all three violation types, suggesting that distinct violations cannot satiate each others P600/SPSs. This corroborates the idea that distinct violations trigger distinct reanalysis processes. Furthermore, given the presence of all three P600s, we are able to do a within-participants comparison of their latency and scalp distribution (expanding the findings of Gouvea et al. 2010). We found that PSV has an earlier and longer P600/SPS than the other two; AGR includes a LAN in the 800-1000ms window; and the SEM P600 has a much broader scalp distribution than the other two. In short, these results suggest that the P600/SPS effects to PSV, AGR, and SEM are distinct in all possible dimensions: satiation, latency, and scalp distribution.

C11 The time-course of statistical learning in patients with left hemisphere stroke

Kathryn D. Schuler[1,2], Mackenzie E. Fama[1,2], Peter E. Turkeltaub[1,2], Elissa L. Newport[1,2]; [1]Georgetown University, [2]Center for Brain Plasticity and Recovery

A fundamental aspect of learning involves extracting patterns from the environment via statistical learning (Saffran, Aslin & Newport, 1996). Research investigating the neural correlates of this mechanism for language suggests that the left inferior frontal gyrus, left arcuate fasciculus, and bilateral caudate/putamen may underlie this process (Karuza et al, 2013). Recent work suggests that damage to some of these left hemisphere (LH) language areas from stroke results in diminished ability to perform on statistical language learning tasks (Fama et al, 2015). Importantly, this prior study demonstrated impairment in the outcome of learning, via behavioral measures after exposure. Here, we ask whether the learning process (i.e. the computation of these statistics) is itself impaired. In addition, we ask whether damage to LH language areas will also impair non-linguistic statistical learning. To address these questions we developed a serial reaction time (SRT) task that was an exact analog of the original word-segmentation experiment, allowing us to assess statistical learning of nonlinguistic sequence learning via on-line RT measures as well as in the traditional post-exposure test. In the original word-segmentation experiment, learners acquired the groupings of syllables into words from a stream of speech by computing transitional probabilities (TPs) between syllables (Saffran et al., 1996). Within words, TPs between syllables were high, whereas TPs across word boundaries were low. In our SRT paradigm, sequences of syllables were converted into sequences of locations on a touch screen. Participants were asked to touch a mole that moved from one location to the next as quickly and accurately as possible. Unbeknown to the participants, the mole in this task moves in a pattern in which, across the exposure period, the probability of movement for some transitions is high (1.0) and for others is low (0.33). Learning these patterns is measured by comparing reaction times (RTs) to high probability transitions versus to low probability transitions over the course of the exposure. After exposure, learners performed the traditional post-test assessment of learning, rating sequences that occurred during exposure (high and low probability) and sequences that did not occur during exposure. Participants were fifteen patients with LH stroke (mean age=58.677.93) and 13 age-matched controls (mean age=65.237.92). Consistent with previous findings, post-test results demonstrated impaired learning in patients: controls distinguished exposure sequences from those not presented during exposure; patients did not make this distinction. However, during learning, all participants extracted the underlying regularities, showing faster RTs for high probability than low probability transitions (estimate =-58.72ms, se=6.43, $p<0.001$). Patients exhibited slower RTs overall (estimate=59.72ms, se=24.51, $p<0.05$), but there was no effect of participant group on learning overall (estimate=4.39ms, se=8.66, $p=0.63$) or on any part of the learning curve ($p>0.05$). Our findings suggest that an implicit RT task provides a sensitive measure of residual statistical learning abilities in patient populations. Patients with LH stroke retain the ability to compute language-like statistics during learning, at least for non-linguistic stimuli. Perhaps while recognition of previously learned statistical regularities is impaired in patients after LH stroke, the computation of underlying statistics during learning may remain.

Signed Language and Gesture

C13 The cortical organization of syntactic processing in American Sign Language: Evidence from a parametric manipulation of constituent structure in fMRI and MEG

William Matchin[1], Agnes Villwock[1], Austin Roth[1],

Deniz Ilkbasaran[1], Marla Hatrak[1], Tristan Davenport[1], Eric Halgren[1], Rachel Mayberry[1]; [1]University of California San Diego

INTRODUCTION: Neuroimaging research on spoken languages has mapped basic lexical access and combinatorial processing onto posterior and anterior temporal lobe regions (Hickok & Poeppel, 2007; Pallier et al., 2011). Despite the fact that American Sign Language (ASL) uses a different sensory-motor modality of communication than spoken languages, it has the same linguistic architecture. This suggests that higher-level lexical access and syntactic processing in ASL could involve the same cortical systems as spoken languages. Previous research has also shown that the areas activated by ASL and spoken languages are similar for both lexical-semantic access and sentence comprehension (Neville et al., 1998; Mayberry et al 2011; Leonard et al., 2012). However, the neural basis of combinatorial processing has not been clearly established. Previous research has yet to identify combinatorial effects in the anterior temporal lobe for signed sentences compared to lists (MacSweeney et al., 2006, for British Sign Language). Additionally, it is unclear whether ASL shows the same tight correlation with constituent structure in language-related brain regions as has been demonstrated in written French (Pallier et al., 2011). In order to identify the neural networks involved in lexical access and combinatorial syntactic processing in ASL, we performed a parallel functional magnetic resonance imaging (fMRI) and anatomically-constrained magnetoencephalography (aMEG) study with a parametric manipulation of syntactic structure. METHODS: Subjects were 13 right-handed, native deaf signers of ASL. Stimuli were all sequences of six signs presented at three levels of syntactic complexity: (i) unstructured word lists consisting of nouns, (ii) simple two-word sentences consisting of nouns and verbs, and (iii) six-word complex sentences. Stimuli were presented in blocks of three sequences of the same condition. Subjects determined whether a probe picture presented following an entire block for fMRI and each sequence for MEG matched a sign in the preceding sequence. To control for basic visual stimulation and attention in the fMRI experiment, subjects watched a still image of the signer and detected the intermittent presentation of a fixation cross. To identify brain regions involved in lexical access, we subtracted activation to the still image condition from the unstructured word lists. To identify brain regions involved in combinatorial operations, we looked for brain areas where activity correlated with constituent size. RESULTS: The fMRI results showed that the contrast of unstructured word lists to the control condition elicited activity in bilateral occipital-temporal regions involved in motion, object recognition, and lexical access. Our parametric analysis of sentence structure in fMRI revealed activity in the left posterior and anterior portions of the superior temporal sulcus, with overlap between lexical access and syntactic processing in the posterior temporal lobe. In aMEG, six-word sentences minus unstructured word lists showed increased activity for sentences in the temporal pole within the N400 time window (300–500 ms). Our results demonstrate that the cortical organization of ASL parallels that of spoken language. The underlying neural basis of abstract lexical access and syntax does not appear to be altered by the sensorimotor channel of language comprehension.

Computational Approaches

C14 Localizing Structure-building and Memory Retrieval in Naturalistic Language Comprehension

John Hale[1], Shohini Bhattasali[1], Jonathan R. Brennan[2], Jixing Li[1], Wen-Ming Luh[1], Christophe Pallier[3], R. Nathan Spreng[1]; [1]Cornell University, [2]University of Michigan, [3]INSERM-CEA Cognitive Neuroimaging Unit

Introduction: Our human ability to comprehend natural language probably relies upon at least two cognitive processes. One involves retrieval of memorized elements, while the other encompasses some sort of structural composition. Despite a growing body of work on the brain's language network, the precise manner in which these hypothesized operations are realized across brain regions remains unknown. This study contributes a localization of them, using time-series predictors that formalize both retrieval and structure-building, applied to the analysis of data from a naturalistic listening scenario. Retrieval is formalized here using "multiword expressions" or MWEs. This term from computational linguistics refers very generally to non-compositional expressions. They are "expressions for which the syntactic or semantic properties of the whole expression cannot be derived from its parts." (Sag et al, 2002). In this study, MWEs were located using a statistical tagger trained on examples from the English web treebank (LDC2012T13). Structure-building is formalized using a standard bottom-up parsing algorithm (see Hale, 2014). We computed the number of parser actions that would be required, word-by-word, to build the correct phrase structure tree as determined by the Stanford parser (Klein & Manning 2003). We regressed the word-by-word predictors described above against fMRI timecourses recorded during passive story-listening in a whole-brain analysis. The results implicate bilateral STG for structure-building and AG for memory retrieval. Both regressors activate frontal regions as well, but without overlap. Methods: Participants (n=37, 24 female) listened to a spoken recitation of The Little Prince for 1 hour and 38 minutes across nine separate sections. Participants' comprehension was confirmed through multiple-choice questions administered at the end of each section. BOLD functional scans were acquired using a multi-echo planar imaging (ME-EPI) sequence with online reconstruction (TR=2000 ms; TE's=12.8, 27.5, 43 ms; FA=77 degrees; FOV=240.0 mm X 240.0 mm; 2X image acceleration; 33 axial slices, voxel size 3.75 x 3.75 x 3.8mm). Preprocessing was carried out with AFNI version 16 and ME-ICA v3.2 (Kundu

et al., 2011). Along with the parsing and MWE regressors of theoretical interest, we entered four nuisance variables into the GLM analysis using SPM12. One regressor simply marks the offset of each spoken word in time. Another gives the log-frequency of the individual word in movie subtitles (Brysbaert & New 2009). The last two reflect the pitch (f0) and intensity (rms) of the talker's voice. These regressors were not orthogonalized in any way. Results: The statistical map of the fitted coefficient for the bottom-up parsing regressor picks out areas in left posterior STG and left IFG ($p < 0.05$ FWE). Figure 1 shows both, with bottom-up parsing in orange and MWEs in blue. Conclusion: Memory retrieval for multi-word expressions evokes a pattern of activation that is spatially distinct from the pattern evoked by compositional structure-building. Consistent with previous work, this result underlines the multiplicity of brain systems that contribute to language comprehension (Hickok and Poeppel, 2007; Friederici and Gierhan, 2013; Hagoort and Indefrey, 2014).

Language Development

C15 Associating children's reading and mathematics subskills with resting-state functional connectivity

Alexandra Cross[1], Reshma Ramdajal[2], Christine L. Stager[3], Maureen W. Lovett[4,5], Karen A. Steinbach[4], Jan C. Frijters[6], Elizabeth P. Hayden[1], Lisa M.D. Archibald[1], Marc F. Joanisse[1]; [1]University of Western Ontario, [2]Erasmus University Rotterdam, [3]Thames Valley District School Board, [4]The Hospital for Sick Children, [5]University of Toronto, [6]Brock University

Reading disability (RD, sometimes termed 'dyslexia') affects approximately 10% of otherwise typically developing children. Variability in profiles of RD and response to intervention has led to difficulty characterizing the underlying impairments and the cause of RD. Many functional magnetic resonance imaging studies (fMRI) comparing the brains of struggling and typical readers rely on reading tasks, making it difficult to determine whether brain differences are due to differences in task-based performance or differences in underlying neural organization. The present study addresses these issues using resting-state fMRI, a technique that measures inter-regional correlations of spontaneous fluctuations in neural activity. Past studies have demonstrated that in typical readers, individual differences in single-word reading ability correlate with connectivity in subregions of the brain's reading network during resting states. However, much less is known about how functional connectivity relates to poor reading performance, especially with respect to cognitive subskills known to be related to reading success. The present study addressed this by correlating resting-state connectivity among reading network regions with children's reading subskills, including phonology, rapid serial naming, and comprehension, along with a more general measure of mathematical ability. Participants were children enrolled in grades 4-6 in local schools with a range of reading abilities, including a subset identified with RD. Children completed a resting-state scan at 3 Tesla, a high-resolution anatomical scan, and a behavioural testing session in which reading fluency, phonological decoding, reading comprehension, and mathematics were assessed. A regression model then assessed how connectivity patterns within the brain's reading network related to indicators of reading subcomponents including sight word reading, nonword decoding, rapid automatized naming and comprehension. Individual differences in sight word reading, nonword decoding and rapid automatized naming were all positively correlated with connectivity between thalamus and frontal cortex including left pre-central gyrus, supplementary motor area, and inferior frontal gyrus. In contrast, reading comprehension was related to increased connectivity within frontal, temporal, and parietal areas of the reading network. Math measures were positively correlated with connectivity in ventral temporal and inferior parietal areas previously implicated in studies of both numerical cognition and reading. Together, the results demonstrate how divergent subregions of the reading network independently relate to differences in the cognitive components of reading. They also indicate an overlap in neurocognitive substrates of reading and mathematics, suggesting similar processes may underlie these skills, and could explain the comorbidities of disorders of reading and math.

C16 ERP correlates of syntactic processing in cochlear implant users.

Luca Artesini[1], Mara Dighero[1], Valeria Giannelli[1], Debora Musola[4], Francesco Vespignani[2], Francesco Pavani[1,2,3]; [1]CIMeC - Center for Mind/Brain Sciences, University of Trento, Rovereto, Italy, [2]DiPSCo - Department of Psychology and Cognitive Sciences, University of Trento, Rovereto, Italy, [3]Centre de Recherche en Neuroscience de Lyon, Lyon, France, [4]Cooperativa Logogenia®, Italy

Studies on linguistic abilities of cochlear implant (CI) users revealed issues in complex syntactic structures rather than lexical, semantic and phonological knowledge (for studies in Italian see Guasti et al., 2012; Caselli et al., 2012). Previous studies on hearing monolinguals and bilinguals showed that ERPs are sensitive to differences in processing of syntactic relationship (e.g., Tanner & Van Hell, 2014) even when language proficiency is comparable. The purpose of our experiment is to use real-time and behavioral measures to evaluate how the CI impacts on language. To this aim we tested CI users and age-matched hearing controls with a rapid visual word-by-word sentence presentation while recording the EEG signal. Participants were presented with 320 sentences, half of them containing either a syntactic agreement (subject-verb) or a semantic violation. The experimental design was tuned to allow for subsequent analyses both at the single subject level and at group level. Participants also

underwent behavioral assessment aimed at evaluating their competence. This preliminary report focuses on the results of 7 CI users (aged: 12, 16, 16, 20, 33, 50, and 63 yo; 3 with pre-verbal and 4 with post-verbal deafness onset), and 35 normal hearing (NH) controls (N=5 aged 12-17 yo; N=13 aged 18-28 yo; N=11 aged 29-44 yo; N=6 aged 45-65 yo). Both CI users and NH controls showed N400 and P600 in response to semantic and syntactic violations respectively. Despite our small and non-homogenous CI group, CI users showed a different pattern in the early stage of detection of syntactic violations. While NH controls showed a LAN, CI users showed a larger P2 in an earlier time window (180-220 ms) at left-frontal sites ((DFn=2, DFd=80), F=3.601, p=0.003). P2 has been linked to attention-related processes (Luck & Hillyard, 1994) and its amplitude may reflect context-induced expectations (Su et al., 2016) or enhanced processing at an orthographic level. These results may provide initial indications that CI users pay more attention on upcoming morphological features of words. This might be due to their altered phonology which modifies the cerebral pathways that allow the processing of functional aspects of speech.

C17 Lesion Sites Associated with Apraxia of Speech: Report of a new case and implications for Neural Models of Speech Production

Venugopal Balasuramanian[1], Ludo Max[2]; [1]Seton Hall University,NJ, [2]University of Washington,Seattle

Introduction Luria (1966, 1970) proposed a category of afferent apraxic motor aphasia (AAMA) to account for the speech symptoms in cases with left hemisphere (LH) parietal lobe damage. According to Luria, the difficulty in speech articulation in such cases was in finding the appropriate articulatory movements for the production of individual sounds, and sound sequences, accompanied by positional apraxia of the speech organs. Thus, Luria's description of AAMA matches the contemporary definition of AOS but with an emphasis on the pivotal role of parietal lobe lesion. This point of view provides an important addition to the common perspective reflected in the Directions Into Velocities of Articulators (DIVA) model that AOS accompanies lesions in the left posterior inferior frontal gyrus and the premotor cortex, the site that stores speech sound maps (Guenther & Hickok, 2016). In the DIVA model, the parietal cortex of both hemispheres constitutes the neural substrate for the somato-sensory feedback circuit. Here, we report on a case with apraxia of speech (AOS) resulting from parietal lesion and we discuss implications for the role of the parietal lobe in apraxia of speech. Methods Subject. RL, a 58-year-old right-handed male high school graduate, had a stroke-induced lesion in the left mid parietal region (see Figure 1.). Procedure. Clinical evaluation one month post-onset consisted of the use of Minnesota Test for Differential Diagnosis of Aphasia (MTDDA), Apraxia Battery for Adults (ABA), and Boston Naming Test (BNT). At one year post-onset, RL 's speech was evaluated by administering ABA, BNT, and Boston Diagnostic Aphasia Examination (BDAE). Two additional tasks, namely, Oral reading of the Grandfather's passage, and spontaneous responsive speech elicited by the question "Tell me about the first job you ever had" were employed to gather additional data on speech production. Results RL's speech disruptions during spontaneous speech primarily included 20 part-word repetition (PWR), 10 whole word repetitions (WWR), 10 single interjections (SI), 14 repeated interjections (RI), and 1 sound prolongation (SP). During the reading of the Grandfather Passage RL produced 26 (PWR), 11 (WWR), 22 (RI), and one sound prolongation (SP). On the reading task, RL used seven types of phonological processes that altered the segmental characteristics of the target words. The types and frequency of occurrence of each type of process were as follows: six vowel changes (VC), five initial consonant deletions (ICD), five final consonant deletions (FCD), four cluster reductions (CR), two frontings (FR), two backings (BK), and two stoppings (ST). RL's spontaneous speech also evidenced such production simplifications. Discussion RL's simplification and positional apraxia of the lips and tongue suggest the involvement of both phonological as well as phonetic encoding deficits. (Galluzzi et al, 2015; Wolk, 1984).The current study provides additional empirical evidence for the possibility that multiple sites of lesions may be associated with AOS (Hickok et al, 2014). Luria's conceptualization of AAMA neatly accounts for RL's symptom profile.

C18 Literacy Environment Differentially Influences Brain Structural Covariance

Tin Nguyen[1], Stephanie Del Tufo[1,2], Laurie Cutting[1,2,3,4]; [1]Vanderbilt Brain Institute, [2]Peabody College of Education and Human Development, [3]Vanderbilt Kennedy Center, [4]Vanderbilt University Institute of Imaging Science

Socioeconomic status (SES), which includes household income and parental educational and occupational status, predicts children's success with reading-related skills, such as vocabulary knowledge and phonological sensitivity. In addition to SES, home literacy and school environment also shape the trajectory of children's academic success. Together, school and home activities compose literacy environments (LE) that may have an impact either simultaneously with or independently from SES to bolster children's aptitude for reading and/or other academic domains. While previous studies have focused on the influence of SES on the development brain morphology, few studies have comprehensively examined the impact of LE on cortical architecture. Here, we investigated whether LE influenced both global and regional cortical differences by examining various morphology indices, including cortical thickness, surface area, and folding. Cortical folding indices have been found to explain additional genetic and phenotypic variation, beyond other morphological cortical indices such as thickness and surface area. Data were collected from 4th to 9th graders (n = 177; 92 females). Standardized cognitive and reading

assessments included the Wechsler Abbreviated Scale of Intelligence (WASI), Test of Word Reading Efficiency (TOWRE), and Woodcock Reading Mastery Test (WRMT). Participants' parents completed questionnaires that captured SES (Hollingshead, 1976) and LE (e.g. if the child was taught with phonics instruction, how often s/he was read to, or if s/he received tutoring). Neuroimaging data were analyzed via an integrated pipeline (FreeSurfer and MATLAB) that reconstructed the images and derived metrics for cortical morphology using the Destrieux atlas (Fischl et al, 2004; Destrieux et al, 2010). Hierarchical linear regression analyses were used to determine the relationship between LE and different cortical features. The first step controlled for possible confounding variables, such as age, gender, and timed single-word reading, and then, SES was entered in the second step. After correcting for these factors and for multiple comparisons, findings revealed that LE influence both global and regional cortical morphology. LE corresponded to differences in cortical thickness in the fronto-temporal reading network hubs. In addition, LE measures were linked to cortical folding in left-lateralized regions of the frontal cortex. These results highlight the impact of LE on cortical thickness and cortical folding in areas that support reading-related skills and executive functioning.

C19 A window for word-learning: Measuring dynamic neural responses during statistical language learning

Nicolette Noonan[1], Lisa Archibald[1], Marc Joanisse[1]; [1]The University of Western Ontario

The role of statistical learning in segmenting words from fluent speech is well described, particularly for the role of transitional probabilities between syllables in speech segmentation. Previous examination of event-related potentials (ERP) related to segmentation has reported the emergence of N100 and N400 components following artificial language exposure (Cunillera et al., 2006; Sanders et al., 2002), indexing word segmentation, and a P200 (de Diego Balageur, 2007; Cunillera et al., 2006) to index word identification. However, little work has focused on neural indices of word segmentation during language exposure. To examine the process of word segmentation on-line, we measured participants event-related potentials (ERPs) during exposure to a novel artificial language using electroencephalography (EEG). Cortical EEGs were recorded during exposure to an artificial language, and during a post-exposure test phase. Twenty-four adults were exposed to the artificial language for 21-minutes. The language was a structured, unsegmented speech stream containing six tri-syllabic nonsense words (e.g.: babupu, pidadi; Saffran et al., 1997). ERP epochs were time-locked to the onset of each syllable throughout the exposure phase. Responses to the statistically-constrained word-final syllables were compared across the exposure phase. Behavioural and ERP responses to trained versus foil words were also assessed in a test phase that immediately followed the exposure phase. In response to the word-final syllables, we found a significant linear increase in the amplitude of a P200 component over the first five minutes of artificial language exposure. At the 7th minute of exposure, the amplitude of the P200 substantially decreased and did not differ in amplitude from the 1st minute. This return to baseline amplitude was consistent when measured across the 14th and 21st minutes of exposure. Following language exposure, ERPs in response to trained and foil words at test did not differ. The P200 component that emerged during the first five minutes of artificial language exposure may index processes related to the extraction of the within-word transitional probabilities (e.g.: de Diego Balaguer et al., 2007). Additionally, the dynamic nature of this component could reflect a readiness for word learning that dissipates over redundant language exposure. We hypothesize that the extracted acoustic forms are stored as potential lexical items by the 5th minute of exposure, but that given the language learning paradigm did not involve additional segmentation or semantic cues, participants are not retaining the segmented acoustic form. Thus, although transitional probability cues may help language learners to initially extract potential words from fluent speech and for temporary maintenance in memory, the absence of additional meaningful information to bootstrap word learning leads to rapid decay of this segmented token. Taken together, these findings provide key insights into both the dynamical nature of statistical language learning, and the limitations of word segmentation based solely on the statistical relationships among syllables.

C20 Development of the lateral lemniscus and its relation to receptive vocabulary: A diffusion-weighted imaging study

Anthony Dick[1], Dea Garic[1], Heidy Zetina[1]; [1]Florida International University

The lateral lemniscus (LL) is a bilateral fiber pathway comprised of the axonal projections from the superior olivary complex to the inferior colliculus (Naidich et al., 2009). It is thus the major conduit for the transmission of auditory perceptual information in the brainstem. Although the pathway is an important component of this early auditory system, its development has not been investigated using modern diffusion-weighted imaging (DWI) techniques. Our study aims to be the first, to our knowledge, to track the LL in vivo and to explore potential behavioral associations in a sample of typically developing invdividuals. In this study, we examined the LL in 129 participants (70 females, age = 0-18 years, M= 8.67 years) using DWI. Bilateral ROIs where manually drawn in the midbrain using the superior cerebral peduncle as an anatomical landmark. Tracking was successful in 94 participants. Fractional anisotropy (FA) increased linearly in the LL from infancy to late adolescence, which is consistent with extended development of the auditory system more broadly (Litovsky, 2015; $t(90) = 7.21$, $p < .001$; controlling for age, whole brain FA, and gender). We also assessed the LL's relation to vocabulary development. We

found that axial diffusivity (AD) of the LL is associated with improved Peabody Picture Vocabulary Test (PPVT) scores ($t(77) = 2.21$, $p < .05$, controlling for age, gender, and wholebrain AD). This study provides preliminary evidence of the development and behavioral associations of the LL. Successful tracking of this pathway is potentially important in the clinical treatment of auditory disorders in children.

C22 Insight into spoken word processing in young children using eye movements

Elizabeth Simmons[1,2], Rhea Paul[3], Rachel Theodore[1,2], Monica Li[1,2], James Magnuson[1,2]; [1]University of Connecticut, [2]CT Institute for Brain and Cognitive Sciences, [3]Sacred Heart University

Models of spoken word recognition (SWR) in adults highlight the importance of temporal order (Marslen-Wilson, 1987; McClelland & Elman, 1986) for recognizing words. Words that overlap completely at onset (cohorts) or mismatch only at onset (rhymes) compete for recognition as a function of phonetic similarity over time, with stronger, earlier competition from cohorts than rhymes (Alloppenna, Magnuson, & Tanenhaus, 1998). Theories make conflicting predictions about the relative time course of cohort and rhyme competition in very young children (pre-readers), but to date, they have not been assessed empirically. Some scientists have theorized that early on, children have underspecified representations, and process words in a holistic fashion, paying minimal attention to the sequence of phonemic information and that a gradual refinement of these representations takes place through age seven (Walley, 2003; Treiman & Baron, 1981). On this view, degree of competition would depend on degree of overlap, not temporal position of overlap between words. Another view is that phonemic-grained sequences are not accessible prior to explicit reading instruction (Liberman, Shankweiler & Liberman, 1989). Both theories predict that very young children who have not yet learned to read will not demonstrate adult-like patterns of cohort and rhyme competition. An alternative possibility is that patterns of cohort and rhyme competition observed in adults emerge as a natural consequence of processing words over time (Magnuson, Tanenhaus, Aslin, & Dahan, 2003). This study attempts to distinguish among these possibilities by measuring for the first time the fine-grained time course of SWR in a group of preschool children who are not yet reading. Twenty-three monolingual, typically developing preschool children (3-5 years) completed an eyetracking task using a developmentally-appropriate extension of the visual world paradigm (Tanenhaus et al., 1995). Participants heard a simple auditory instruction ("find the coat") and were asked to use a mouse to click on the named picture. The target object (e.g., coat) was paired with either a cohort competitor (e.g., comb), rhyme competitor (e.g., boat), or a phonologically unrelated object (e.g., bird). Participants' eye movements were recorded as fixations to the target or the competitor. Our results revealed that the time course of activation and competition among words was similar to that of adults (Allopenna et al., 1998), even among the youngest participants. While children exhibited increased latency compared to adults, competition effects were similar: cohorts competed early and strongly, while rhymes competed more weakly with a later peak, but were still significantly more likely to be fixated than unrelated words. These findings support the notion that even young children, who have yet to be exposed to formal reading instruction, have access to differentiated lexical representations and utilize subtle, temporal differences in the signal to access spoken words.

C23 Neurocognitive Correlates of Child and Adult Syntactic Processing: Evidence from Classroom Second Language Learners

Fatemeh Abdollahi[1], Janet G. van Hell[1]; [1]The Pennsylvania State University

Second languages (L2) are taught in many classrooms worldwide, but we know relatively little about the neural correlates of syntactic processing in L2 classroom learners, and the extent to which individual variation in cognitive abilities and first language (L1) fluency impact L2 processing, particularly in children (Pufahl & Rhodes, 2011; Van Hell & Tokowicz, 2010). The Competition Model (MacWhinney & Bates, 1989) emphasizes the role of transfer of knowledge from the L1 to L2 where grammatical structures are similar between languages, and competition between L1 and L2 in cases where grammatical structures are dissimilar. In this study, English adult (18+yr) and child (~10yr) intermediate learners of L2 Spanish read grammatical and ungrammatical L2 sentences where the L2 sentences had either similar morphosyntactic structures in L1 and L2, dissimilar morphosyntactic structures in L1 and L2, or had a unique morphosyntactic structure in the L2 that is not present in the L1 (Tokowicz & MacWhinney, 2005), as well as ungrammatical and grammatical L1 sentences, while Event-Related Potentials (ERPs) were recorded. This manipulation of L1-L2 grammatical similarity allowed for testing of impact of L1 on L2 processing. Several individual difference measures of affect and executive function were also gathered to examine how learners' background may influence neurocognitive correlates of syntactic processing in the L2. In the L1, adults, but not children, showed a robust P600 effect for all grammatical structures, indicating that processing of L1 syntax in 10yr olds may be distinctly different from that of adults. For the L2, traditional group-based ERP analyses showed that adult L2 learners' sensitivity to syntactic violations in the L2 (i.e., P600 or N400 effects) was related to their grammatical similarity with L1 structures. However, behavioral performance (accuracy in grammaticality judgment) was at chance. Group-level ERP-analyses showed that children were not significantly sensitive to L2 syntactic violations. In order to examine individual variation in language processing, Response Dominance (RDI) and Response Magnitude Indices (RMI; Tanner, McLaughlin, Herschensohn & Osterhout, 2013) were calculated for adults, dividing learners into profiles of N400 or P600 dominance, where

magnitude of response was calculated. Clear individual differences in response dominance during L2 processing emerged (RDI (N=20): 9 participants P600 dominant; 8 N400 dominant; 3 neutral RD), previously averaged out in traditional group-based analyses. Furthermore, greater variation was present in response magnitude in the L2 over L1, suggesting response magnitude may change with experience. Correlations between RDI, RMI and individual difference measures of affect, executive function and working memory revealed no clear patterns. These results show there is great variability in L2 learners, not captured in traditional group-based analyses. Finding distinctly different processing in child classroom L2 learners compared to their adult counterparts demonstrates a clear need for further investigation into both L1 and L2 processing of child learners. Ultimately, this variability may be critical in developing models of adult and child classroom learner L2 syntactic processing.

C24 Speeded grammatical processing in Tourette syndrome *Cristina Dye[1], Matthew Walenski[2], Adam Takacs[3], Karolina Janacsek[4], Andrea Kobor[4], Dezso Nemeth[4], Stewart H. Mostofsky[5], Michael T. Ullman[6]; [1]Newcastle University, United Kingdom, [2]Northwestern University, United States, [3]University of Glasgow, United Kingdom, [4]Eötvös Loránd University, Hungary, [5]Johns Hopkins University, United States, [6]Georgetown University, United States*

Introduction. Tourette syndrome (TS) is a neurodevelopmental disorder characterized by motor and vocal tics, and is associated with frontal/basal ganglia abnormalities. Whereas previous research has revealed various cognitive strengths in other neurodevelopmental disorders, less attention has been paid to potential strengths in TS. Additionally, there is very little evidence of strengths in the domain of language in any neurodevelopmental disorder. Here we examine the hypothesis that grammatical processing might be speeded in TS, and that this may be related to enhanced procedural memory, which underlies grammar. Methods. In a series of experiments, we tested grammatical processing and procedural memory in children with TS and matched typically developing (TD) children (Walenski et al., 2007; Dye et al., 2016; Takacs et al., under review). In Experiment 1, we tested TS and TD performance at morphology, specifically in the production of regular past-tense forms, which are posited to be combined with the grammatical/procedural system (e.g., walk + -ed), and matched irregular forms, which are posited to depend on memorized representations (e.g., dug). In Experiment 2, we tested phonology, specifically in a non-word repetition task (repetition of complex phonological sequences; e.g., /naɪt□o□veɪb/), which is thought to depend on the grammatical (de)composition of phonological segments. In Experiment 3, we comprehensively examined procedural learning, from memory formation to retention, in an implicit sequence learning task (Alternating Serial Reaction Time Task) performed over two days. Results. In Experiment 1, the TS children were significantly faster than TD children at producing rule-governed past-tenses (slip–slipped, plim–plimmed, bring–bringed) but not irregular (ized) past-tenses (bring–brought, splim–splam). In Experiment 2, the TS children showed speeded repetition of non-words, especially for longer forms, which require more (de)composition. There were no TS/TD accuracy differences at either the morphology or phonology tasks. In Experiment 3, the children with TS showed sequence knowledge advantages as compared to the TD children on both days, suggesting enhanced procedural learning and retention. Moreover, in Experiment 1, children with TS also showed speeded naming of manipulated (hammer) but not non-manipulated (elephant) items, suggesting that the processing of (procedural) motor skill knowledge may also be speeded in TS. Summary and conclusion. In sum, children with TS showed evidence for speeded grammatical composition in both morphology and phonology, suggesting the possibility that grammatical composition is speeded more generally in the disorder. Given independent evidence tying grammar to procedural memory (e.g., Ullman, 2004, 2016), and the evidence presented here that the learning, retention, and processing of (non-linguistic) procedural memory is enhanced in TS, the grammatical enhancements in TS may be related to underlying enhancements of procedural memory. In turn, we suggest that this pattern may be best explained by the same frontal/basal ganglia abnormalities that lead to tics, which are also characterized by their rapidity. Thus, it may be that pathological abnormalities leading to dysfunction may also lead to at least certain advantages.

C25 Sentence prosody cues object category learning at 6 months *Claudia Männel[1,2], Maria Teixido[3], Laura Bosch[3], Angela D. Friederici[1], Manuela Friedrich[1,4]; [1]Max Planck Institute for Human Cognitive and Brain Sciences Leipzig, [2]University of Leipzig, [3]University of Barcelona, [4]Humboldt-Universität zu Berlin*

In language acquisition, infants face the twin problem of segmenting the speech stream to extract linguistically relevant units and mapping these word-forms to their visual referents, the objects and events in the surrounding world. To complicate matters, infants need to grasp that this referential character extends to categories (e.g. different books are still called books). Behavioral research has revealed some evidence of infants' simultaneous segmentation and mapping under simplified input conditions, if prosody favors this process (Shukla, White, and Aslin, 2011). However, it is unclear whether infants' abilities hold for more ecological learning situations and whether infants can generalize their mapping abilities to category members. We evaluated 6-month-old infants' abilities of mapping sentence-embedded labels to object categories by measuring event-related brain potentials (ERP) in a familiarization-test paradigm. During each

familiarization phase, two pseudo-objects were followed by sentences containing a stressed pseudo-word as object label. Moreover, we manipulated the prosodic realization of object labels by placing them at different sentence positions. Infants (n = 64) either heard object labels in the beginning of the sentences (e.g. Dein Mukon ist wirklich schön [Your mukon is really pretty]) or at prosodically more salient sentence-end positions (e.g. Wir spielen mit dem Mukon [We are playing with the mukon]). During test phases, labels were either correctly or incorrectly combined with the pseudo-objects, thus testing whether infants had learned the previous label-object association. Crucially, we did not only present pseudo-objects seen during familiarization, but also new category members testing for generalization. Brain responses recorded during familiarization and test indicated that while label positioning in sentences did not affect infants' word-form segmentation during familiarization, it impacted on infants' mapping success at test. Only children, who had heard the object labels at the end of sentences, showed a main effect of mapping during test, apparent in more negative ERP responses at 300-700 ms to labels incorrectly versus correctly following the respective objects. In contrast, children who had heard the object labels at the beginning of sentences, did not show comparable test effects. These results imply that under prosodically salient conditions, infants not only learn previously presented label-object combinations, but also successfully apply this association to new category members. Thus, our study demonstrates for the first time that infants at 6 months can map labels to objects under ecological language learning conditions and, most importantly, show indications of object category learning.

Language Disorders

C26 Chinese dyslexic children's alteration in the large-scale brain functional network comparing phonological and semantic reading tasks

Jiali Hu[1], Xin Liu[1], Yue Gao[1], Yu Zhou[1], Li Liu[1]; [1]Beijing Normal University

Dyslexia is a specific reading difficulty, which showed parallel deficits in both orthography-to-phonology and orthography-to-semantics mapping. Previous functional connectivity studies suggest that dyslexia is a disconnectivity syndrome. However, traditional connectivity studies tended to focus on the selected seed regions instead of concerning interaction of whole brain regions by using graph theoretical analysis. In our study, we adopted a semantic relatedness rhyming judgment and a semantic relatedness judgment task to examine the Chinese dyslexic alteration of functional brain network during reading from a large-scale perspective. Sixteen typically developing children and fifteen dyslexic children were included. Participants were asked to perform reading tasks in fMRI scanners while their brain were imaged. The findings are as follows: First, typically developing children's brain connectivity was more similar to that of dyslexic children in semantic relatedness judgment task than in rhyming. Specifically, the two groups only shared 33 percentages of common hubs in rhyming task but shared 76 percentages of common hubs in semantic task, which indicates that Chinese dyslexia have larger alteration in phonological than in semantic processing. Of note, hubs were essential nodes in a brain. Second, only typically developing children showed between-task differences in inter-regional connectivity, whereas dyslexic children did not show any task difference, suggesting the topological organization of typically developing children's reading network is more specialized than that of dyslexia. Last, through comparing participants' performance between rhyming and semantic task, different brain network patterns were used in two groups. Typically developing children respectively showed stronger long-distance and stronger short-distance interregional connectivity during rhyming and semantic task. When it comes to dyslexic children, their brain network pattern did not show distinctly difference during different reading tasks. Supplementary motor area, rectus, hippocampus, precentral and frontal areas played important roles in both tasks. Some of the aforementioned brain network alterations of dyslexic children have been reported in previous studies using task-free resting state data, suggesting it may be domain-general. Taken together, our study suggests that Chinese reading dyslexia showed great alteration in brain connectivity properties, and some of these alterations may be domain-general while others may be modulated by different reading tasks.

C27 Comprehension of sentences with structurally defined gaps in primary progressive aphasia: Evidence from eye-tracking

Matthew Walenski[1], Jennifer E. Mack[1], M. Marsel Mesulam[2], Cynthia K. Thompson[1,2,3]; [1]Department of Communication Sciences and Disorders, Northwestern University, Evanston, IL, USA, [2]Cognitive Neurology and Alzheimer's Disease Center, Northwestern University, Evanston, IL, USA, [3]Department of Neurology, Northwestern University, Evanston, IL, USA

Introduction. Primary progressive aphasia (PPA) is a degenerative disease affecting language while leaving other cognitive facilities relatively unscathed (Mesulam, et al. 2012). Here we focus on logopenic (PPA-L) and agrammatic (PPA-G) subtypes of the disorder. The logopenic subtype is characterized by impaired repetition, naming, and word finding, whereas the agrammatic subtype presents with agrammatic language production and impaired comprehension of non-canonical syntactic structures, but spared single word comprehension (Gorno-Tempini, et al. 2011). Non-canonically ordered sentences subvert the dominant agent-verb-theme order of arguments in English, such that the theme precedes the verb. For example, in an object relative clause (The boy that the girl saw [gap] is …), the theme argument (boy) is extracted from the [gap] position, preceding its verb (saw) and the agent argument

(girl). In a subject relative clause (The girl that [gap] saw the boy is …), the dominant agent-verb-theme order is preserved. In this study we examine the comprehension of both sentence types in PPA by recording eye movements-while-listening. Method. Ten participants with PPA-G, 10 with PPA-L, and 15 matched healthy controls participated in the study. Participants listened to 32 four-sentence stories (1), with either a subject-relative (1a) or object relative clause (1b), comprising the final critical sentence. (1) One day a bride and groom were walking in the mall. The bride was feeling playful, so the bride tickled the groom. A clerk was amused. a) Point to the one that [gap] was tickling the groom in the mall. b) Point to the one that the bride was tickling [gap] in the mall For each story, we created an array with pictures of the sentence elements (e.g., bride, groom, mall, clerk). The correct picture choice corresponded to the gap-antecedent (e.g., bride in 1a; groom in 1b). Participants' eye movements to the critical sentence were recorded and they chose the correct picture by computer mouse. Results. For the subject relative sentences, looks to the extracted argument (e.g., bride) increased similarly in all three groups following the gap. For the object relative sentences, all three groups made anticipatory looks to the extracted argument (e.g., groom) before the gap, though the two PPA groups had a (similarly) delayed onset of these looks relative to controls. After the gap, controls and PPA-L participants showed an increased rate of looks to the extracted argument, whereas the PPA-G participants evinced an abnormal decrease in looks to the extracted argument. Conclusions. We argue that these results are consistent with previous work in stroke-induced agrammatic aphasia that gap-filling proceeds normally in PPA-G and further confirms the hypothesis that agrammatic comprehension deficits reflect impaired thematic integration (Thompson and Choy 2009). References Gorno-Tempini, et al. (2011). "Classification of primary progressive aphasia and its variants." Neurology 76: 1006-1014. Mesulam, M. M., et al. (2012). "Quantitative classification of primary progressive aphasia at early and mild impairment stages." Brain 135(Pt 5): 1537-1553. Thompson, C. and J. J. Choy (2009). "Pronominal Resolution and Gap Filling in Agrammatic Aphasia : Evidence from Eye Movements." Journal of Psycholingustic Research 38(3): 255-283.

C28 Atypical phonemic discrimination but not audiovisual speech integration in children with the broader autism phenotype, autism, and speech sound disorder.

Julia Irwin[1,3], Trey Avery[1], Jacqueline Turcios[1,3], Lawrence Brancazio[1,3], Barbara Cook[3], Nicole Landi[1,2]; [1]Haskins Laboratories, [2]University of Connecticut, [3]Southern Connecticut State University

When a speaker talks, the consequences of this can be heard (audio) and seen (visual). Visual information about speech has been shown to influence what listeners hear, both in noisy environments (known as visual gain) and when the auditory portion of the speech signal can be clearly heard (mismatched audiovisual speech demonstrates a visual influence in clear listening conditions, known as the McGurk effect). This influence of visible speech on hearing has been demonstrated in infancy; further, typical speech and language development is thought to take place in this audiovisual (AV) context, fostering native language acquisition. Individuals with autism spectrum disorder (ASD) and speech sound disorder (SSD) display marked deficits in communicative behavior, however those with SSD have primary problems in speech production and those with ASD have broader communicative deficits. Several studies from our lab and others have observed atypical AV speech processing in ASD, however limited work has examined this important aspect of communication in those with SSD. We use a novel visual phonemic restoration task to assess behavioral discrimination and neural signatures (using event related potentials or ERPs) of audiovisual speech processing in typically developing children with a range of social and communicative skill as well as children with ASD and children with SSD. Using an auditory oddball design, we presented two types of stimuli to the listener, a clear exemplar of an auditory consonant-vowel syllable /ba/ and a syllable in which the auditory cues for the consonant was substantially weakened, creating a stimulus which is more like /a/. All speech tokens were paired with either a face producing /ba/ or a face with a pixelated mouth, effectively masking visual speech articulation. In this paradigm, the visual /ba/ should lead to the auditory /a/ to be perceived as /ba/ (a phonemic restoration effect), creating an attenuated oddball response, but the pixelated video should not have this effect. Overall, we observed behavioral and ERP effects that are consistent with phonemic restoration across all groups (smaller P300 effects in the presence of face producing /ba/). However, participants diagnosed with ASD or SSD showed overall reductions in phonemic discrimination (reduced P300 effects), regardless of face context (audiovisual or pixelated mouth), suggesting that these developmental disorders are associated with impairments in speech processing but not AV speech integration per se.

C29 Oscillatory Abnormalities in Primary Progressive Aphasia

Aneta Kielar[1,3], Tiffany Deschamps[2], Regina Jokel[2,4], Jed Meltzer[2,3,4]; [1]University of Arizona, [2]Baycrest Health Sciences Toronto, Ontario, Canada, [3]Canadian Partnership for Stroke Recovery, Ottawa, Ontario, Canada, [4]University of Toronto, Toronto, Ontario, Canada

Introduction: Primary progressive aphasia (PPA) is a neurodegenerative disorder characterized by deterioration of language functions, with initial preservation of other cognitive processes. In dementia, functional disruption can extend beyond the regions of frank atrophy that can be detected with structural imaging. Electrophysiological abnormalities in structurally intact tissue may constitute a useful biomarker for early diagnosis and assessment of interventions. In the present study we evaluated

oscillatory responses to language stimuli and spontaneous brain electrical activity in patients with PPA compared to age-matched controls. 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. Results: In comparison to age-matched controls, oscillatory responses (8-30 Hz event-related desynchronization for anomalous vs. control words) for PPA patients had delayed peak latencies, attenuated amplitude, and in the left parietal region, reversed sensitivity to semantic anomalies, with greater event-related desynchronization for control words instead. Correlational analyses indicated that recruitment of right hemisphere temporo-parietal areas is associated with better semantic performance, demonstrating a compensatory role for right-hemisphere activation. Resting-state MEG analyses showed that patients with PPA exhibit altered spontaneous electrical activity, with a general shift to slower spontaneous dynamics. These abnormalities go in the opposite direction of changes seen in the healthy aging process, and were correlated with slowed neural responses to language stimuli, suggesting that degenerative pathology is linked with slower brain dynamics in both task-related and spontaneous activity. The task-related activity and the resting-state results showed little overlap with gray matter volume measures obtained with VBM analysis. This suggests that in PPA, the atrophied regions may not contribute to information processing in a significant way, but also that additional neural dysfunction may occur in regions far beyond the zone of frank atrophy. Conclusions: The present results indicate that neuropathological changes in the brains of PPA patients result in slowed information processing, which, in turn, is linked with progressive cognitive decline. Abnormalities in both resting-state and task-evoked oscillations can serve as sensitive indicators of neuronal damage associated with neurodegenerative conditions such as PPA. The combination of these measures can reveal the extent of the neural tissue that is not directly atrophied, but is functionally compromised.

C30 Examining gray matter differences in a single treatment non-responder with semantic variant primary progressive aphasia

Isabel Hubbard[1], Stephanie Grassp[2], Heather Dial[2], Maria Luisa Mandelli[1], Maria Luisa Gorno-Tempini[1], Maya Henry[1,2]; [1]University of California San Francisco, [2]University of Texas at Austin

Introduction: Semantic variant primary progressive aphasia (svPPA) is a neurodegenerative disorder characterized by a semantic deficit affecting naming and word comprehension (Gorno-Tempini, et al., 2011). Individuals with svPPA have benefited from interventions for naming that engage spared linguistic functions to promote word retrieval (e.g., Henry et al., 2013). Imaging studies have been used to monitor structural and functional changes from pre- to post-treatment in PPA (Beeson et al., 2011; Dressel et al., 2010). These analyses have documented neuroplasticity in the context of neurodegeneration for those responsive to treatment. No study, however, has identified neural factors that may contribute to failure to respond to treatment. In this study, we sought to explore structural imaging differences between responders and nonresponders to an established lexical retrieval treatment. Methods: Eight participants with svPPA underwent four to eight weeks of naming treatment (Henry et al., 2013). Effects sizes were calculated using d statistics in order to quantify the magnitude of change in naming performance and to identify participants who did not respond to treatment. One such participant (SE) was identified and voxel-based morphometry (VBM) was used to compare pre-treatment gray matter volumes in this participant relative to the group of svPPA treatment responders (n=7). The VBM analysis controlled for age and sex, with MMSE and total gray matter volume included as additional covariates in order to control for disease severity. Results: Effect sizes for the svPPA responder group ranged from 4.3-22.36 and SE was the only participant whose effect size (1.45) did not meet criterion for a "small" treatment effect (Beeson & Robey, 2006). On neuropsychological testing, SE showed poorer performance on the MMSE and a figure copy task at pre-treatment. VBM analysis of pre-treatment MRI scans revealed greater atrophy in bilateral prefrontal cortex in SE relative to the other participants. Atrophy was more pronounced in the left hemisphere, including portions of ventrolateral and dorsolateral prefrontal cortex. Conclusion: SE had greater bilateral prefrontal cortex atrophy compared to the responder group, suggesting that the integrity of gray matter in this region may be related to treatment outcomes. Two fMRI studies support this claim. Dressel and colleagues (2010) associated similar areas with successful response to treatment in one individual with svPPA. Comparing pre- and post-treatment fMRI using a naming task, they observed greater bilateral activation in middle and inferior frontal gyri at post-treatment. Beeson and colleagues (2011) found that, following successful naming treatment, one participant with logopenic variant PPA showed greater post-treatment activation in left dorsolateral prefrontal cortex. These regions are active in healthy controls during generative naming tasks (Meinzer, et al., 2009) and are implicated in lexical selection (Barde & Wagner, 2007; Warburton et al., 1996; Perani, 2003) and access to stored conceptual representations (Barde & Wagner, 2007). In conjunction with their established role in word retrieval, observation of pronounced atrophy in ventrolateral and dorsolateral prefrontal cortices in our single treatment non-responder provides preliminary evidence that cognitive processes supported by bilateral prefrontal cortex may be critical for response to naming treatment in svPPA.

C31 Watch your mouth: A Neuropsychological Case Study of Evoked Pupillary Responses to Profanity in Aphasia with Coprolalia

Alexandra Kelly[1], Ally Dworetsky[3], Helen Felker[1,2], Bonnie Zuckerman[4], Medha Raghavendra[1,2], Jordan Dawson[1,2], Rachel Bastomski[1,2], Jamie Reilly[1,2]; [1]Eleanor M. Saffran Center for Cognitive Neuroscience, [2]Department of Communication Sciences and Disorders Temple University, Philadelphia, Pennsylvania USA, [3]Washington University in Saint Louis, Saint Louis, Missouri USA, [4]Basque Center for Brain and Cognitive Science, San Sebastian, Spain

Many neurological disorders (e.g., Tourette Syndrome, frontotemporal degeneration) are characterized by the frequent and involuntary use of profanity (i.e., coprolalia). In global aphasia, profanity is often the only spared expressive language. Some hypothesize that profanity has cortical (or subcortical) representation that is neuroanatomically distinct from other forms of language. An alternative hypothesis is that profanity pathologically emerges with impaired inhibitory control processes (Van Lancker & Cummings, 1999). The inhibitory control hypothesis suggests an impairment in the gating of expressive language moderated by emotion dysregulation. This claim finds support in the fact that coprolalic patients often immediately apologize or express shame when producing profane language. Here we report a case study of a patient who challenges the inhibitory control hypothesis by showing a selective receptive deficit for profane words. We examined phasic arousal by contrasting evoked pupillary responses to profane words (e.g., dick) relative to non-profane but arousing related terms (e.g., penis), neutral nouns (e.g., arm) and nonwords. QH is a 65-year-old male with chronic aphasia and coprolalia secondary to a left posterior temporal intracerebral hemorrhage. QH's conversational production is self-described as excessively profane. He experiences behavioral disinhibition, right hemianopia, and dyslexia, although many of his original aphasia symptoms have resolved. We contrasted the pupillary response dynamics of QH with those of neurotypical controls (N=22). All participants completed an auditory lexical decision task comprised of word/nonword judgments for profane words (N=10), semantically matched technical terms (N=10), neutral words (N=10), and nonwords (N=20) while viewing an unchanging whitescreen. We continuously recorded fluctuations in pupil size using a table mounted infrared eyetracker with a 120 Hz sampling rate. We isolated word-evoked pupillary responses and divided the time series into 40 125ms bins, deriving change scores from baseline by subtracting each bin's average from 500ms of resting state data recorded prior to each trial. We then collapsed trials across each condition. The control group showed the predicted peak amplitudes for profane and technical terms, both of which eclipsed the amplitude observed for neutral words. Peak amplitudes were associated with offline ratings of arousal. QH in contrast demonstrated lower peak pupillary dilation for profane words relative to both technical and neutral words. QH's pupillary responses mirrored that of his time series for nonwords. We measured the pupillary responses of a patient with chronic aphasia as he heard profane words. Neurotypical adults showed amplitude spikes for profane words and similarly highly arousing terms. These results contrast with QH, who showed a largely flat pupillary response for profanity. These findings suggest that QH experiences dampened phasic arousal for profanity during a receptive language task. This input deficit is difficult to reconcile under the inhibitory control hypothesis of profanity. We interpret this result as supportive of an alternative hypothesis. Non-propositional profanity is lateralized within the right hemisphere with cortical-subcortical connections involving the basal ganglia that act as a braking mechanism.

C32 Morpho-lexical Recognition Ability and Related Brain Regions in Individuals with Mild Cognitive Impairment, Alzheimer's Dementia, and Cognitively Normal Elderly

JungMoon Hyun[1], Alexandre Nikolaev[2,3], Yawu Liu[4], Eve Higby[5], Minna Lehtonen[6], Sameer Ashaie[1], Tuomo Hänninen[4], Merja Hallikainen[4], Hilkka Soininen[2,4]; [1]Northwestern University, [2]University of Eastern Finland, [3]University of Helsinki, [4]Kuopio University Hospital, [5]University of California, Riverside, [6]Abo Akademi University, Turku, Finland

Language functions are differentially vulnerable to normal aging and Alzheimer's disease (AD). Word finding ability and semantic processing show early decline, whereas the syntax of language production is relatively preserved in AD. Changes in morpho-lexical processing in normal aging and dementia have not been extensively studied. To address this gap, we devised a Finnish lexical decision task that included words that differ in the number of stem allomorphs and inflectional productivity. Finnish is ideal for measuring changes in morpho-lexical knowledge because of its morphological complexity in lexicon. To better understand the neural basis of morpho-lexical processing and its changes with AD, we investigated the association between complex word recognition and brain atrophy in AD, Mild Cognitive Impairment (MCI), and healthy aging. In the lexical decision task, we employed 177 real words, and 177 pseudowords that follow the phonotactic rules of Finnish and tested Finnish individuals with AD (n=21), MCI (n=24) and age-matched cognitively healthy elderly (n=17). Participants read each word and pressed a button to indicate whether it was a real word or not. Structural MRI data were used for the average cortical thickness in our ROIs, and analyses were conducted with FreeSurfer. Brain regions that significantly predicted the reaction time (RT) for words were identified, controlling for age and education. In the accuracy analyses, there were no significant differences among groups for either real words or pseudowords (Real words: AD - 95.6%,

MCI - 94.4%, Control - 97.2%; Pseudowords: AD - 94.7%, MCI - 93.9%, Control - 98.7%; F(2,59) = 1.67, p = .197) indicating patients with MCI and AD continue to maintain morpho-lexical processing ability. In the RT analyses, the three groups showed significant group differences for real words (F(2,59) = 4.28, p = .018) and pseudowords (F(2,58) = 3.81, p = .028). The AD group was significantly slower than healthy controls (real words, p = .019; pseudowords, p = .032). The difference between MCI and controls approached significance (Real words, p= .065; Pseudowords, p= .071). No difference was found between the AD and MCI groups (Real words, p = .803; Pseudowords, p = .889). These results suggest an important interaction between increased processing time and speed-accuracy trade-off in the patient groups. Analyses of cortical thickness and RT revealed that a thinner left superior temporal lobe (posterior) and right inferior temporal gyrus (real words-right pars orbitalis; pseudowords-right pars triangularis) predicted slower responses in the AD group. The left lingual gyrus was the only region related to word recognition RTs in healthy controls. In sum, the speed of healthy elderly's recognition of morphologically complex words was associated with brain regions related to visual/letter processing and identification of words. On the other hand, the speed of AD patients' recognition depends on regions associated with language and executive functions. These results reflect the increased cognitive effort in patients to achieve a high level of accuracy on the recognition task. More detailed clinical information, analysis methods, and potential clinical implications of these findings will be discussed.

C33 Structural Brain Differences in Good and Poor Comprehenders Identified through a Regression-Based Quantitative Method

Kayleigh Ryherd[1], Clint Johns[2], Andy Jahn[2], Julie Van Dyke[2], Landi Nicole[1,2]; [1]University of Connecticut, [2]Haskins Laboratories

Specific Reading Comprehension Disorder (S-RCD) is characterized by poor reading comprehension despite intact decoding ability (for review see Landi & Ryherd, 2017). To date, only one study has examined neurostructural differences related to S-RCD. Bailey et al. (2016) reported reduced gray matter volume (GMV) in right prefrontal cortex for S-RCD relative to typically developing (TD) readers, consistent with previous findings of impaired executive function in S-RCD readers. However, like most studies of S-RCD, Bailey and colleagues used a cutoff-based approach to determine group classification. Under this approach, readers classified as S-RCD must exhibit a discrepancy in their performance on standardized measures of word decoding and reading comprehension. Specifically, they achieve a standard reading comprehension score below some criterion, coupled with standard decoding performance that meets or exceeds an age-appropriate norm. Consequently, because this approach relies on dichotomizing continuous variables, individuals with quantitatively similar scores (i.e., scores close to the cutoff criterion) are treated as qualitatively different. Further, this practice is also associated with numerous statistical problems, including distorted effect sizes, reduced power, and increased Type 1 error (MacCallum et al., 2002). To address these weaknesses, some researchers have adopted a regression-based method to identify groups of readers differing on comprehension ability, but not on subcomponent measures (e.g., Tong et al., 2011, 2013). Under this approach, reading comprehension ability is predicted from theoretically justified component skills, e.g., nonverbal IQ, decoding ability, and vocabulary knowledge. Readers are classified as S-RCD if their comprehension scores are much lower than their predicted scores; TD if comprehension is commensurate with model predictions; and as unexpected good comprehenders (UGC) if their comprehension scores are much higher than predicted. Thus, this approach tailors group selection criteria to the individual by comparing reading comprehension skill to a predicted value based upon the individual's known cognitive abilities, rather than relying on population norms. Our investigation is the first to capitalize on these advantages in an investigation of potential relations between comprehension skill and brain structure. In this study, we assessed cortical structural differences between three groups of comprehenders (TD, UGC, S-RCD), classified via the regression-based quantitative method. We predicted reading comprehension scores using age, decoding ability, nonverbal IQ and vocabulary. TD readers' comprehension scores fell within the 15% CI around the regression line. S-RCD readers had scores below the lower 65% CI of the regression line, while UGC readers' scores were above the upper 65% CI. From a sample of 172 participants (ages 13-24), this method identified 20 TD, 22 S-RCD, and 25 UGC. Exploratory whole-brain analysis of GMV revealed group differences, in which TD readers showed reduced GMV relative to UGCs in the left superior parietal lobule (SPL), a region which has been functionally implicated in improved comprehension ability following remedial instruction (Meyler et al., 2008). Our findings highlight the importance of studying UGCs (who, like S-RCD readers, have discrepant comprehension and decoding profiles) in addition to TD and S-RCD readers to gain a broader perspective on how brain structure may relate to reading comprehension skill profiles.

C34 Mapping Both Lesion and Behaviour Structures in Stroke Aphasia

Ying Zhao[1], Ajay Halai[1], Matthew Lambon Ralph[1]; [1]Neuroscience and Aphasia Research Unit, School of Biological Sciences, University of Manchester

Acquired language and general cognitive deficits are common symptoms after stroke to the left hemisphere. Research has focussed on mapping these impairments onto neural substrates; classically this work relied on post mortem studies (in the late 19th century) and subsequently on soldiers returning with head injuries after the World Wars in the 20th century. Advances in medical technologies (e.g., CT and then MRI) have allowed for

detailed in vivo examination of brain injuries, which have radically improved lesion-symptom mapping methods. Whilst spatial specificity has improved over history, from large areas of damage to millimetre precision, there is an underlying issue that is rarely addressed in lesion-symptom mapping research, which relates to the fact that damage to a given area of the brain is not random but constrained by the brain vasculature. Standard lesion-symptom mapping does not take this inherent statistical structure of patients' lesions into account. The aim of this study was to uncover this lesion statistical structure and to relate it to the language and cognitive impairments in a group of seventy left hemisphere, post-stroke, chronic aphasic cases. We applied a data reduction method, varimax rotated principal component analysis, to the patients' brain lesion maps. The underlying structure in the lesion maps revealed 20 components of which 17 were interpretable, with most of them reflecting the distribution of middle cerebral artery (MCA) sub-branches. In addition, we extracted the underlying statistical structure from a neuropsychological test battery that consisted of 21 language and cognitive assessments, revealing a four factor behavioural solution, reflecting: phonological ability, semantic ability, executive-demand and speech fluency. We used stepwise regression in order to predict behavioural factors from the principal lesion components and found significant models for all four core abilities (all p's < 0.001). For each model, we projected the beta weights into the brain space. Phonological ability was predicted by two components, which were located in the inferior longitudinal fasciculus, posterior segment of the arcuate fasciculus and inferior frontal gyrus. Three components significantly predicted semantic ability and were located in the anterior temporal lobe extending to the medial temporal lobe, supramarginal gyrus, and angular gyrus. Executive-demand was predicted by two components covering dorsal edges of the MCA, while speech fluency was predicted by two components that were located in the middle frontal gyrus, precentral gyrus, and subcortical regions (putamen and thalamus). The identified lesion territories map very closely with detailed angiography studies and, for the first time, we have linked these to core behavioural deficits.

Meaning: Prosody, Social and Emotional Processes

C35 No Acoustic Evidence from RHD for a Right Hemisphere Role in Prosody Production: A Meta-Analysis

Ethan Weed[1], Riccardo Fusaroli[1]; [1]Aarhus University

The right hemisphere (RH) is often thought to have a special role in prosody comprehension and production in general, and affective prosody in particular. If RH structures support prosody wholly or in part, we would expect acoustic differences between the productions of people with right hemisphere damage (RHD) and non brain-damaged (NBD) controls. Such differences have been reported, but the literature is mixed, and spans many years and experimental design types. To get perspective on the scope of these results, we conducted a systematic review and meta-analysis of acoustic measures of prosody production in people with RHD. We searched PubMed, PsychINFO, Web of Science and Google Scholar with the terms: (prosody OR intonation OR inflection OR intensity OR pitch OR fundamental frequency OR speech rate OR voice quality) AND (RHD OR right hemisphere) AND (stroke) AND (acoustic). Of the resulting articles, we selected only empirical studies with an N>2 that quantified acoustic measures of production and included a control group of non brain-damaged (NBD) participants. From the remaining articles, we calculated standardized mean differences (d) for fundamental frequency (F0), Intensity, Speech Duration, Pause Duration, Speech Rate, and Vowel Duration. We also noted whether the task was free speech production or constrained production, and whether the task targeted linguistic or emotional prosody. Our search produced 47 papers. Of these, only 10 met our inclusion criteria, and of these 2 reported from the same study. Mean sample N's were: RHD: 12.15 (SD 10.92), NBD: 14.35 (SD 11). Mean age in years was: RHD: 58.94 (SD 16.7), NBD: 51.76 (SD 14.58). We found no significant impact of RHD on acoustic measures of F0 (d = -0.35, se = 0.29, p = 0.23, N = 9), nor of Intensity (d = -2.98, se = 2.84, p = 0.29, N = 4). No other features had enough papers (N > 3) to warrant a meta-analysis. Of the moderating factors (Task and Prosody Type) only Task had a significant impact (d = -13.08, se = 2.89, p < 0.0001), but this only for intensity, and a single study with a small N (RHD = 8, NBD = 7) and no age-matching drove this surprisingly large effect (Cook's d = 0.9). There was no evidence of publication bias measured by regression analysis of funnel plots for F0 (z = 1.5937, p = 0.1110). Intensity did show evidence of publication bias (z = -4.1582, p < .0001), but this result was driven entirely by a single study out of 4 total. Taken at face value, the literature does not support a special role for the RH in prosody production. However, our study points to a greater problem in the field: studies with acoustic measures of prosody production in RHD are few, and sample sizes too small considering the heterogeneity of the population, to assess even medium effect sizes (power analyses indicate 30-100 participants per group required). We advocate responsible data sharing and standardized automated procedures for the extraction of acoustic features.

Writing and Spelling

C36 Selective involvement of posterior perisylvian regions in sublexical processing: Evidence from brain tumor patients

Fleur van Ierschot[1,2,3], Wencke Veenstra[3,4], Barbara Santini[5], Michiel Wagemakers[4], Hanne-Rinck Jeltema[4], Giampietro Pinna[5], Roelien Bastiaanse[1,3], Gabriele Miceli[1,2]; [1]International Doctorate for Experimental

Approached to Language and Brain (IDEALAB), [2]University of Trento, [3]University of Groningen, [4]University Medical Center of Groningen, [5]University of Verona

Introduction: Sublexical phoneme-grapheme conversion processes have been associated with left perisylvian regions. Functional neuroimaging studies have shown increased BOLD activity in the posterior superior temporal gyrus during non-word spelling in healthy controls (Ludersdorfer, Kronbichler, & Wimmer, 2015). In lesion studies, isolated damage to anterior (inferior frontal gyrus, precentral gyrus and insula) and posterior perisylvian regions (superior temporal gyrus and supramarginal gyrus) resulted in the inability to write novel words and non-words (e.g., Henry, Beeson, Stark, & Rapcsak, 2007; Mariën, Pickut, Engelborghs, Martin, & De Deyn, 2001). In addition, studies pointed at a distributed perisylvian network including both anterior and posterior regions as a critical neural substrate for sublexical processing (Rapcsak et al., 2009). However, most lesion studies are based on stroke patients with extensive brain damage. We investigate the functional roles of anterior and posterior perisylvian regions in brain tumor patients. Methods: Seven patients with a glioma in anterior or posterior perisylvian regions were included; 3 had an anterior glioma and 4 a posterior glioma. All patients were assessed in their native language with an extensive written language test battery specifically designed for neurocognitive assessment in gliomas, including word writing (controlled for length, frequency, grammatical class, morphology, orthography and imageability) and non-word writing (controlled for length and similarity to words). For each version (Italian and Dutch), normative data were obtained from 50 non brain-damaged individuals to calculate cut-off scores at 95%. Individual performance on writing tasks was evaluated as being above or below cut-off. Results on word vs non-word writing were contrasted using Fisher's Exact Test. Results: None of the patients with anterior perisylvian gliomas (0/3) scored below cut-off on non-word writing. Performance accuracy on word and non-word writing was comparable in all cases (p= 1, p= 1, p= 1, two-tailed Fisher's Exact Test). In posterior perisylvian glioma patients, non-word writing was below cut-off in 3/4 cases (75.0%). Non-word writing was significantly worse than word writing in 2/4 patients (50.0%) and marginally worse in 1/4 cases (25.0%) with posterior gliomas (p=.022, p=.039, p=.055, p=.564, two-tailed Fisher's Exact Test). Conclusion: A clear difference between patients with gliomas in posterior and anterior regions was observed. Data are relevant to the ongoing debate on the involvement of specific perisylvian regions in sublexical processing. Selective impairments in phoneme-grapheme conversion processes were frequently found following posterior perisylvian damage, while non-word writing was preserved in anterior gliomas. The results, albeit from a small sample, support the hypothesis that posterior perisylvian regions are crucial for phoneme-grapheme conversion. Anterior regions may play a more indirect role, via their subcortical connections with posterior regions. Damage to the arcuate fasciculus and/or to the superficial layer of the inferior fronto-occipital fasciculus may disrupt interactions between posterior and anterior perisylvian areas. In patients with anterior lesions, impaired non-word writing may result from subcortical damage that prevents interaction within an anterior-posterior perisylvian network, rather than from isolated damage to anterior perisylvian structures.

Language Disorders

C37 Individual differences in the cortical activity dynamics of auditory word processing in adolescents with SLI using anatomically constrained magnetoencephalography (aMEG)

Nicholas Walker[1], Julia L. Evans[1,2], Timothy T. Brown[2], Amy Berglund[1], Meredith Scheppele[1], Andrea W. Fung[1]; [1]University of Texas at Dallas, [2]UCSD

Behavioral and neurobiological evidence indicates that children with Specific Language Impairment (SLI) have atypical spoken word recognition. Behavioral studies show that children with SLI require more of the perceptual input to activate a lexical candidate and experience greater lexical decay as compared to typical children during real-time spoken word recognition (Mainela-Arnold, Evans, Coady, 2008; McMurray, Samelson, Lee & Tomblin, 2010). Magneto- and electro- encephalography (M/EEG) studies also show atypical N400-like event-related activity in children with Specific Language Impairments as compared to normal controls (Helenius, et al., 2014; Brown, et al. 2014). However, EEG signals cannot be precisely localized to their cerebral sources because of inherent biophysical limitations; electric potentials are smeared, distorted, and deflected as they pass through different tissue types (e.g., brain, dura, skull, scalp). MEG, in contrast, allows good localization precision but still depends on assumptions made about the complexity of the sources. This study examines event-related magnetic fields for spoken word recognition in adolescents with SLI and normal language using anatomically constrained magnetoencephalography (aMEG) and individual differences anaylses. aMEG integrates millisecond-wise neurophysiological data with individual cortical surface anatomy, providing noise-normalized, dynamic statistical parametric maps (dSPMs) of brain activity for each subject. Using high-density aMEG (Brown, et al., 2014), activity time courses were examined in the primary auditory cortex for a passive lexical processing task in three adolescents with SLI, seven age-matched typical developing controls (TD), and eight adults. Using functionally defined ROI's, we measured the amplitudes and peak latencies of cortical activity focusing on primary auditory areas bilaterally. Responses to novel, fast-repeated (1 sec), and slow-repeated (10 min) words were compared. Most notably, the SLI group showed lack of any high-amplitude early sensory response (~90

ms) within the left hemisphere (LH) for either novel or repeated words, in marked contrast to both the TD and adult groups. In addition, at 200 ms, SLI subjects showed no significant LH word repetition effect, which was comparable to TD children but in contrast with adults who showed significant repetition suppression. During lexical semantic latencies (~300-500 ms), the SLI group differed significantly from both TD and adult subjects by showing greater LH responses to novel words. Finally, within the right hemisphere (RH), the SLI group showed a repetition suppression effect at 70 ms, which was absent in both adult and TD children. Altogether, our results suggest there exist large differences in cortical responses between individuals with SLI and control subjects that begin at the very earliest stages of sensory auditory function. Using passive auditory word presentation, these effects represent a collection of potential aMEG biomarkers for SLI that differentiate them from both TD children and adults.

Meaning: Combinatorial Semantics

C38 Elementary composition in Language processing: an EEG study

Emilia Flo[1], Álvaro Cabana[1], Juan C Valle Lisboa[1]; [1]Facultad de Psicología, Universidad de la República

Combining words to represent a new concept is the basic combinatorial operation needed to generate and understand meaningful phrases. The elaboration of these complex structures of related concepts entail both syntactic and semantic composition processes which are difficult to disengage. Previous research in which stimuli were restricted to simple composition using MEG and fMRI have identified the left anterior temporal lobe to be involved in conceptual combinatory operations. In this work we aim at finding a simple composition marker in EEG using an adaptation of Bemis, D. K., & Pylkkänen, L. (2011) experimental design for Spanish. Contrary to English, Spanish noun phrases are constructed such that the adjective is preceded by the noun. Given this distinction and the original design, we decided to introduce a second task in order to establish the adequate control for the composition task. Stimuli for the three tasks were constructed randomly for each subject from a pool of 11 words denoting nouns, 11 words denoting colors, balanced for frequency and other psycholinguistic properties, and 11 consonant strings. The composition task consisted of 100 noun-adjective and 100 consonant string-adjective combinations, followed by an image congruent or incongruent to the verbal material. In one of the control tasks subjects were presented with combinations of noun-noun and consonant string-noun stimuli, as opposed to the second control task where participants were shown combinations of color-color and consonant string-color stimuli. In both control tasks the verbal material was followed by an image congruent to one of the presented words or incongruent to both. The purpose of these controls was to ensure that the difference in the composition task was not due to the amount of words presented in each condition. We performed a cluster permutation analysis to determine the spatial and temporal distribution of the neural activity related to composition. We show evidence of an activity specific to the composition task in a time window consistent with the literature.

C39 ERP effects for quantifier complexity, priming, and truth-value in an auditory/visual verification task

Aniello De Santo[1], Jonathan Rawski[1], John E. Drury[1]; [1]Stony Brook University

[INTRODUCTION] We examined the processing of quantified sentences in an auditory/visual verification task to probe: (i) truth-value/quantifier-type influences on the N400 ERP response, and (ii) ERP markers of quantifier complexity. Concerning (i): studies have demonstrated the N400 to be insensitive to truth-value/negation in verification paradigms (Fischler et al. 1983; Kounios & Holcomb 1992) while exhibiting modulations for subject/predicate relatedness (e.g., N400 for ROCK>BIRD in "A robin IS/IS-NOT a ROCK/BIRD). However, Nieuwland & Kuperberg (2008) argue such uses of negation are pragmatically unnatural, and when this is controlled, N400 amplitude can be modulated by truth-value (False>True). Concerning (ii): fMRI research (McMillan et al. 2005) has demonstrated that additional working memory resources are recruited in the processing of proportional quantifiers (MOST) which, unlike other quantifiers (ALL/NONE/SOME), requires maintenance/comparisons of the cardinalities of sets to evaluate truth. However, the time-course of complexity effects associated with MOST has not previously been investigated using ERPs. [METHODS] We presented quantified sentences (e.g., "All of the squares are blues") auditorily while participants simultaneously viewed arrays of colored shapes. Shape/color-combinations were used with four quantifier-types (ALL/NONE/MOST/SOME) to yield eight conditions varying quantifier/truth-value. Visual stimuli each consisted of fourteen colored shapes, with an even contrast ratio for ALL/NONE (7 yellow-circles/7 blue-squares) and opposing 2:5/5:2 ratios for MOST/SOME (e.g., 2 yellow-/5 blue-circles and 5 blue-/2 yellow-squares). False conditions used color/shape-predicates which were not present in the images (unprimed). These visual/auditory-pairs were presented to adult/native English-speakers (N=10) who provided (mis)match judgments following each trial. EEG was recorded continuously (32 channels, Biosemi-Active-2) and ERP mean amplitudes for successive 100 ms windows were examined for 1200 ms epochs (-200-0 ms baseline). Signals were time-locked to (i) the predicate onset to examine quantifier-type influences on truth-value and (ii) the onset of the quantifier to test for complexity effects for MOST. [RESULTS] Predicates showed opposite polarity N400 effects for ALL (False>True) relative to NONE (True>False), an earlier negativity for ALL (False>True) peaking ~200 ms, and subsequent P600s (False>True) for both ALL/NONE. MOST/SOME yielded a N400/P600 profile (False>True) and an early negativity (False>True;

~200 ms) obtained for SOME (but not MOST). Finally, N400 effects were larger for ALL/NONE than MOST/SOME conditions, while the opposite was true for the P600s (larger for MOST/SOME). ERPs time-locked to the onset of the quantifiers revealed a positivity for MOST relative to the three other quantifiers, beginning ~350-450 ms and sustaining for ~500 ms. [CONCLUSIONS] In pragmatically natural contexts N400s were driven by priming of the expected auditory continuation and were not modulated by truth-value, consistent with earlier findings (Fischler et al.). Consistent False>True effects were, however, obtained for the subsequent P600 response. We relate the early (~200 ms) negativity for ALL/SOME to Phonological Mismatch Negativities (PMMNs; Connolly & Phillips 1994), and discuss whether this should be regarded as continuous with the N400 or a perhaps a species of N200 (van den Brink et al. 2001). Our data also suggest complexity effects for MOST may reflect initial encoding, and may not arise downstream during verification.

C40 The effect of multimodal predictability on the N400

Christine Ankener[1], Maria Staudte[1], Heiner Drenhaus[1], Matthew W. Crocker[1]; [1]Saarland University

A word's predictability, derived from its cloze probability, affects the N400-component on the target word itself (e.g. Kutas, 2011). Further, increasing the predictiveness of the linguistic context reduces N400 amplitudes for visually depicted target words in referring expressions (Tourtouri et al, 2015). By combining stable linguistic stimuli with varying visual contexts, we show that predictability of a target word is also sensitive to the probability profile of a context, derived from multimodal information, which is reflected in a modulation of the N400. We presented 368 visual displays paired with 92 different plausible German sentences of the type "The man spills on saturday the water in the kitchen" in RSVP-style to 28 German native speakers (Ø age: 24,7). While the sentences were the same in each condition, the independent variable was the number of depicted objects that matched the verb constraint. Each display contained 4 clip- arts, out of which either 0, 1, 3 or all 4 were competitors (spill-able objects) for the upcoming target noun. Displays were presented 1000 ms prior to and throughout the whole sentence. As a result of the manipulation, the expectedness for the target noun was predicted to decrease as the number of competitors increased. That is, "the water" could be predicted with 0% (when no spill-able object was among the 4 clip-arts), 33 % (when 3 out of 4 objects were spill-able), 25% (when all 4 objects were spill-able) or 100% (when only the water was shown among 3 non-spillable objects) certainty. We expected a reduced N400 on the noun as fewer competitors are available so that prediction is more certain. We analyzed the influence of our manipulation (Nr. of competitors) on the N400 amplitude, time locked to the onset of the target noun phrase, including ROIs for electrode site (frontal/central/parietal) as within-subject factors. Repeated measures analysis of variance (ANOVA) using Greenhouse-Geisser correction and follow-up pairwise t-tests with Bonferroni corrected p-values assessed statistical significance. Results revealed the expected graded modulation in the N400 amplitude elicited by the target noun ("water"), as a function of the number of potential visual referents determined on the basis of the verb's selectional restrictions. Compared to the baseline condition (1) with the lowest N400, the amplitude was significantly larger for the conditions where 3 ($p < .05$) and 4 ($p < .05$) objects matched the verb constraint. Further, the N400 was largest in the 0 condition ($p < .001$) where no object matched the verb, i.e. the noun was least predictable. We attribute this effect to the sensitivity of the comprehender to the probability profiles that result, during situated sentence processing, from applying verb selectional preferences to a co-present visual scene such that uncertainty about upcoming words (nouns) can be reduced as much as possible. Our results are in line with studies showing that situated language processing is related to context-expectancy (e.g. van Berkum, 1999), even when derived by combining information from different modalities.

C41 Language and multiple demand regions jointly predict individual differences in sentence comprehension: Evidence from a network approach

Qiuhai Yue[1], Randi C. Martin[1], Simon Fischer-Baum[1], Michael W. Deem[1]; [1]Rice University, Houston, TX, USA

Recent neuroimaging studies have shown that domain-specific language regions (e.g., activated by a contrast of simple sentences vs. nonword processing conditions), which lie in the temporal and ventral frontal regions, dissociate with domain-general multiple demand (MD) regions (e.g., activated by hard vs. simple working memory conditions) in the dorsal frontal and parietal lobes (Fedorenko et al., 2011; 2013). Thus, some have claimed that the neural substrate for typical sentence processing does not involve MD regions, with domain-general regions only activated by complicated sentence structures (e.g., strong garden paths, object relatives) rarely encountered in natural conversation. The current project addresses these claims by examining whether individual differences in comprehension of unambiguous sentences with commonly encountered structures could be predicted by measures of brain network connectivity. Specifically, building on recent work linking lower network modularity to better performance on complex tasks (Yue et al., in press), we investigated whether modularity defined solely based on the language network or modularity defined by a network comprised of both language-specific and domain-general MD nodes better predicts individual differences in sentence comprehension. Our sentences contained a main clause and a subordinate clause (subject relative or sentence complement) that separated the subject and verb of the main clause (e.g., "The surgeon who operated with the difficult nurse last night complained"). Following Tan, Martin, and Van Dyke (2017), we manipulated sentence

difficulty by varying whether the noun in the subordinate clause was semantically plausible or implausible as the agent of the main clause verb (e.g., "tool" vs. "nurse"; low vs. high semantic interference) and whether the noun in the subordinate clause was a prepositional object or another subject (e.g., subject: "The doctor who said the nurse was difficult last night complained"; low vs. high syntactic interference). Reading times for sentences and RT and accuracy for comprehension questions were collected. For the brain network analysis, modularity was estimated for each of 40 subjects based on the correlation matrix for functional connectivity between nodes during resting-state from the language and MD networks separately, from the combination of the two, and from the whole brain. Replicating prior results (Van Dyke, 2007; Tan et al., 2017), significant semantic and syntactic interference effects were observed in sentence reading and question answering times. Importantly, better performance in resolving semantic interference in sentence reading times was associated with lower modularity derived from the network combining language and MD regions (r=0.407, p=0.009), but had no relationship with the modularity of the language network per se (r=-0.06, p=0.7). At the level of the whole brain network, lower modularity correlated significantly with better performance in resolving syntactic interference in sentence reading times (r=0.326, p=0.04), and marginally so with lower semantic interference in question RTs (r=0.295, p=0.06), implying that regions outside those in the language and MD networks are also recruited in sentence processing. Taken together, our findings argue against claims that only language-specific regions are involved in sentence comprehension. The current study provided a novel framework for investigating the neural basis of language processing from a network perspective.

C42 Extracting Single Word Voxel Patterns from Self-Paced Reading using Simultaneous Eye-Tracking and Multiband fMRI

Benjamin Schloss[1], Chun-Ting Hsu[1], Ping Li[1]; [1]Pennsylvania State University

When stimuli are highly similar in either sensory modality or word category, it becomes increasingly difficulty to differentiate elicited brain responses based on the activity of a particular region. Therefore, patterns of activity provide researchers with a more sensitive way to assess how physiological activity in the brain changes in response to more subtle changes in the external environment. For example, reading pseudowords may activate entirely different brain regions than reading real words (Dehaene et al., 2010). However, reading about different types of animals may only elicit slightly different patterns of information within the same regions. It has also been shown that pattern information changes as a function of learning (Bauer & Just, 2015), such that new information systematically changes the functional patterns elicited by a word over a matter of minutes during reading. In sum, the current research suggests that the adult brain is capable of updating complex and distributed information maps in an almost continuous fashion. However, relatively little is known about the online mechanisms that support this continuous information processing, especially in higher level, human specific cognition such as language. Traditionally, questions about fast online processing mechanisms and specific anatomical locations of certain brain functions have been pursued by independent lines of research due to methodological constraints (e.g., using eye-tracking or MEG or EEG to assess the temporal dynamics of reading, or fMRI to identify the spatial representation of meanings). In the current study, we asked whether it is possible to estimate spatially detailed patterns of brain activity in response to a single word during self-paced reading. On average, skilled readers fixate on a word for only 200-250 ms and semantic information is thought to be accessed around 400 ms after processing of a particular word begins (Rayner, 1998). Traditionally speaking, this level of speed falls outside of the temporal resolution of most fMRI experiments. Using representational similarity analysis techniques (Kriegeskorte et al., 2008), we provide visual and statistical evidence of methodological advancements which allow researchers to estimate the pattern of activity elicited by a single word during naturalistic reading across the entire cortex brain using a 3x3x4 mm voxel size. The current study had 50 participants. Using simultaneous eye-tracking and multiband fMRI, we achieve a 400 ms TR, and are able to accurately estimate the onset of individual word processing without controlling the timing of the experiment. In particular, we replicate a previous study (Anderson et al., 2015) which used slow event related design to estimate patterns of activity for concrete concepts, showing visual and linguistic organization of concepts along a number of regions in the what pathway as well as statistically reliable difference in the amount of visual and linguistic information present in respective regions in the visual and language networks. The current relevance of the methodological advancement is discussed in terms of its potential to inform theories of semantic learning as well as its potential for translating basic neurobiology of language research to more complex and realistic environments.

C43 Neural evidence for representationally-specific pre-activation: Evidence from Representational Similarity Analysis over time and space

Lin Wang[1,2], Gina Kuperberg[1,2], Ole Jensen[3]; [1]Department of Psychiatry and the Athinoula A. Martinos Center for Biomedical Imaging, Massachusetts General Hospital, Harvard Medical School, Charlestown, MA, USA, [2]Department of Psychology, Tufts University, Medford, MA, USA, [3]Centre for Human Brain Health, University of Birmingham, Birmingham, UK

Introduction: Previous studies have shown that people generate probabilistic predictions at multiple levels of linguistic representation during language comprehension. Here, we used MEG in combination with Representational

Similarity Analysis (RSA) over time and space to determine whether representationally-specific pre-activation can be detected in the brain under experimental conditions that bias strongly towards lexico-semantic prediction. Stimuli: We constructed 120 pairs of highly-constraining sentence contexts. Each member of a context pair was distinct (contained different content words) but constrained strongly for the same sentence-final word (SFW), e.g. "In the hospital there is a newborn …"; "In the crib there is a sleeping …", where both contexts constrain for "baby". We measured MEG activity as 32 native Chinese participants read these sentences, presented word-by-word in Chinese. Although each participant saw both members of each context pair, they only saw the predicted SFW (e.g. "baby") after one context; after the other, they encountered a plausible but unexpected SFW (e.g. "child"). Each word was presented for 200ms with a long interstimulus interval (ISI) of 800ms. Our analyses focused on anticipatory activity prior to the onset of the SFW. Analysis and Results: (1) RSA based on spatial similarity: At each time point within the anticipatory time window, we extracted the spatial pattern of neural activity across all sensors produced by all contexts. We first correlated these spatial patterns across contexts that constrained for the same SFW (within-pair correlations), and then across contexts that constrained for different SFWs (between-pair correlations). We found that, between 490-890ms before the onset of the SFW, the spatial similarity was significantly larger for the within-pair than the between-pair contexts. A cross-temporal matrix showed that this increase in spatial similarity was significant only along the diagonal (where the spatial similarity was calculated at corresponding time points), suggesting that representationally-specific pre-activation was dynamic rather than sustained in nature. (2) RSA based on temporal similarity: After projecting the sensor-level data to source space, we correlated the time series of neural activity at all voxels between 490ms and 890ms window prior to the onset of the SFW, across contexts that constrained for the same SFWs, and then across contexts that constrained for different SFWs. We found that the degree of temporal correlation (temporal synchrony) was greater for within-pair than between-pair contexts within the left anterior temporal region (with a medial temporal focus, but extending into the inferior, middle and superior temporal cortices). Conclusions: The brain can produce unique spatial patterns of activity associated with the pre-activation of specific lexico-semantic representations, prior to new bottom-up input becoming available. These patterns may reflect the mobilization of specific sets of highly distributed semantic representations across the cortex [1]. The anterior temporal region may play a role in instantiating lexico-semantic prediction [2], possibly by binding these highly distributed representations through temporal synchrony. [1] Patterson, et al (2007). Nature Review Neuroscience. 8(12), 976-987. [2] Lau et al., (2016). Cerebral Cortex. 26 (4): 1377-1387.

Meaning: Discourse and Pragmatics

C44 ERPs reveal listeners' sensitivity to discourse history in comprehension

Si On Yoon[1], Kara D. Federmeier[1]; [1]University of Illinois, Urbana-Champaign

Introduction: When designing referring expressions, speakers typically take into account not only the local context but also the discourse history. For example, speakers produce lexical differentiation: they elaborate their referring expressions with modifiers or use subordinate level nouns (e.g., "the striped shirt" or "the blouse") if a different exemplar from the same category ("the shirt") has previously been mentioned in the discourse. Surprisingly, although speakers have shown this sensitivity in prior work, listeners have not. In Yoon and Brown-Schmidt (2014), when participants in a referential communication task encountered expressions describing novel exemplars from a previously experienced category, their eye movement patterns showed no benefit for interpretation of appropriately lexically differentiated expressions. Here, we further examined listeners' sensitivity to discourse history by testing appropriately differentiated or under/over-differentiated expressions while recording participants' electrical brain activity. Method and Results: 32 participants performed two tasks alternating in a block. In the first task, participants looked at a series of pictures on a computer screen and listened to picture descriptions. On each trial, one picture was presented in the center of the screen followed 2 seconds later by a pre-recorded audio description. We manipulated the degree of differentiation with respect to the historical context. On critical trials, participants saw either the same or a different exemplar of a particular item type (e.g., dog1 vs. dog2) followed by either the same or a different pre-recorded description (e.g., "dog" vs. "poodle") compared to the earlier trial. This created four conditions (critical trials are in | |): a. differentiation (pictures: dog1–|dog2|; audio: "dog"–|"poodle"|), b. over-differentiation (pictures: dog2–|dog2|; audio: "dog"–|"poodle"|), c. under-differentiation (pictures: dog1–|dog2|; audio: "poodle"–|"poodle"|), d. repetition (pictures: dog2–|dog2|; audio: "poodle"–|"poodle"|). Pairs of synonyms (e.g., couch-sofa) and basic – subordinate level nouns were used in the pre-recorded descriptions. In the second task, participants were shown 4 pictures on the screen and asked to identify the picture that the audio described. We recorded the continuous electroencephalogram and extracted event-related potentials (ERPs) from critical trials during the first task (from 200ms prior to audio onset to 800ms after). We found electrophysiological effects associated with both types of inappropriate differentiation. Under-differentiation – i.e., having the same expression referring to two different objects – elicited an increase in the P2 compared to appropriate differentiation. In contrast, when the expression was over-differentiated, we saw an increase in the N1 and in the later LPC (Late

Positive Complex) compared to simple repetition. Conclusions: Listeners' brain responses revealed clear sensitivity to historical discourse context. Both under- and over-differentiation were associated with (different) effects on sensory potentials, suggesting modulations of attention associated with infelicitous repetitions (under-differentiation) or with unexpected novel referents (over-differentiation). In the latter case, in addition to attentional capture from the unexpected novel input, enhanced LPC responses point to the possibility that listeners attempt to recollect the prior referential expression. Thus, listeners clearly track the use of referential expressions across a discourse in communicative tasks, even if this does not always manifest in behavioral output (e.g., eye movement patterns).

C45 Linguistic cues modulate, but don't eliminate, the influence of event knowledge: Evidence from the N400

Elisabeth Rabs[1], Heiner Drenhaus[1], Francesca Delogu[1], Matthew Crocker[1]; [1]Saarland University

Previous ERP research has extensively studied the influence of linguistic context on language processing, demonstrating that the semantic expectedness of a word is negatively correlated with N400 amplitude (Kutas & Hillyard, 1984). Such findings have traditionally been interpreted as indexing compositional semantic integration, but can often be explained by simple lexical/semantic priming. Less is known, however, about use of script/event knowledge (Rumelhart, 1980) - a person's knowledge about structured event sequences - which has also been shown to modulate N400 amplitude (Metusalem et al., 2012). In two ERP studies on German we examine whether N400 modulation by a mentioned script event is due to priming alone, or is further sensitive to linguistic cues which would be expected to modulate script influence. In Experiment 1, participants (n=32, mean age=29) were presented with a 2x2 design, containing a context introducing either one script ("Roberta went to the pharmacy."), or two scripts, one of them marked as inactive by an "instead-of"-construction ("Instead of going to the post office, Roberta went to the pharmacy."). An introduction sentence ("Roberta's cold had gotten worse.") also served to reinforce the active script. The direct object of the word-by-word (SOA=400+100ms) presented target sentence was related to either the active or inactive/unmentioned script ("She stepped up and handed over the prescription/package with a smile."). Materials were normed in a plausibility judgement task. Fitted linear mixed models (300-500ms time window after target object onset) reveal a significant ($t > |2|$) main effect for active script fit, shown in a broadly distributed N400 for inactive script target vs. active script target, as well as an interaction with context size: Specifically, the N400 for the inactive target is attenuated in the 2-script condition. Our findings suggest that priming accounts cannot fully account for the N400 difference between active and inactive script targets in a 2-script context. Equally, however, the N400 difference between the two inactive script matching conditions demonstrates that linguistic cues like "instead of" cannot fully suppress the influence of the mentioned but inactive script. We take this partial modulation of the N400 provides further evidence for an interaction between event knowledge and linguistic cues (Metusalem et al., 2012). Importantly, however, an alternative explanation for the reduced influence of the inactive script appeals to the distance between script and target object (active script always mentioned last, hence closer to target compared to inactive script), meaning priming accounts cannot be fully ruled out. To address this, Experiment 2 replicates the Experiment 1 with one change: The order of scripts in the context sentence is reversed ("...she went to the pharmacy instead of going to the post office"). Preliminary analyses suggest a replication of findings from Experiment 1, hence further supporting linguistic script activation accounts over priming alone.

C46 On-line expectation management during discourse comprehension

Geertje van Bergen[1], Marlou Rasenberg[1,2], Joost Rommers[3]; [1]Max Planck Institute for Psycholinguistics, [2]Radboud University, [3]Donders Institute for Brain, Cognition and Behaviour

INTRODUCTION. Discourse markers are linguistic expressions that relate the sentence in which they occur to the surrounding discourse situation (e.g., Fischer, 2000; Levinson, 1983; Schiffrin, 1987). Discourse markers typically occur in spontaneous conversational interaction; they are overt linguistic indices of the cognitive, expressive and/or social organization of the discourse (e.g., Maschler & Schiffrin, 2015). While DMs have been analyzed theoretically and in terms of their licensing conditions in production, little is known about how they are processed in comprehension. The current study focuses on the Dutch discourse marker 'eigenlijk' (≈'actually'), which expresses an interpersonal relation between conversational partners: it encodes the non-alignment between what the speaker says and what the hearer is assumed to expect on the basis of the (extra-)linguistic context (van Bergen et al., 2011). We investigate to what extent the presence of this high-level, interactional common ground-managing device modulates predictions about incoming lexical input during incremental language comprehension. We concentrate on two event-related potentials (ERPs): (a) the N400, which is sensitive to the semantic predictability of a presented word, irrespective of the constraint of the preceding context (Federmeier et al., 2007; Kutas & Hillyard, 1984); (b) the Anterior Late Positivity, which is enhanced by words that disconfirm likely predictions in constraining contexts (Federmeier et al., 2007; Van Petten & Luka, 2012). METHOD. We performed an EEG experiment in which native Dutch participants read 216 short conversational interactions, consisting of an introductory context sentence (e.g., On a hot Summer day, Mark runs into Hanna on campus.), a question (e.g., Mark asks: "Are you joining us to the beach?") and an answer (e.g., Hanna says: "I

would very much/[eigenlijk] like to take a swim/nap this afternoon."). We manipulated (a) the contextual constraint of the conversations (as measured by cloze probabilities), (b) whether the critical word (CW) in the answer confirmed or disconfirmed a likely prediction, and (c) whether answers contained 'eigenlijk' or a control adverb. RESULTS. Preliminary analyses of the results (N=16) suggest that predictable CWs elicited the smallest N400 amplitude, whereas CWs in weakly constraining conversations yielded the largest N400 amplitude. For predictable CWs, N400 amplitude increased if the answer contained 'eigenlijk'; for unexpected CWs, we found no difference in N400 amplitude between answers with and without 'eigenlijk'. Initial analyses furthermore suggest that CWs disconfirming a likely prediction elicited a more positive Anterior Anterior Late Positivity in answers without 'eigenlijk' than in answers with 'eigenlijk'. At the same time, predictable CWs seem to yield a more positive Anterior Late Positivity if the answers contained 'eigenlijk' compared to answers without 'eigenlijk'. CONCLUSION. Our preliminary results suggest that, upon encountering 'eigenlijk', comprehenders rapidly alter their predictions about incoming words: they start anticipating unpredictable input, which reduces semantic facilitation of incoming predictable words, and possibly reduces processing costs incurred by disconfirmed predictions. These findings show that high-level, interactional pragmatic cues have immediate effects on lexical predictions, and that expectation-managing particles provide a useful means to investigate the nature of discourse-based expectations in language processing.

C47 Connecting events: an ERP study of causal connectives

Gina Kuperberg[1,2], Einat Shetreet[3]; [1]Tufts University, [2]Massachusetts General Hospital, [3]Tel Aviv University

During language comprehension, the sequence in which events unfold does not necessarily mirror their real-world sequence (where causes precede effects). Moreover, comprehenders may not receive explicit cues (e.g. discourse connectives) indicating event order. In two event-related potential (ERP) experiments, we asked how, despite these challenges, comprehenders are able to incrementally draw upon their stored real-world knowledge about causal relationships between events to maintain causal coherence during word-by-word discourse processing. In Experiment 1, 32 participants read two-clause sentences. We manipulated the canonicity of events, and their causal coherence. The second clause was linked to the first by a forward causal connective ("and so") or a backwards causal connective ("because"); the second clause contained a critical word that was causally coherent or incoherent (e.g., The river flooded and so/because the town was destroyed…; The town was destroyed because/and so the river flooded…). Experiment 1 Results: (a) ERPs at the connective revealed a larger frontal negativity between 350-500ms to "because" than "and so". At left frontal sites, this negativity effect remained significant on the subsequent word. (b) ERPs on the critical word revealed an effect of coherence on the N400. This effect was not modulated by type of causal connective ("and so" versus "because"). In Experiment 2, 30 different participants read a new set of two-clause coherent scenarios. We manipulated the canonicity of the event sequence and the presence/absence of a connective. The second clause was linked to the first either by "and so", "because" or by a semicolon (e.g., The cleaners mopped the floor and so/because/; it looked very tidy/slimy…). Experiment 2 Results: (a) Replicating Experiment 1, the first word of the second clause evoked a larger frontal negativity following "because" than "and so". Moreover, consistent with studies of non-canonical temporal connectives, this larger frontal negativity was sustained across all words in the second clause. In the no-connective scenarios, the words of the second clause also evoked a larger frontal negativity than in the "and so" scenarios. (b) On the critical word, the amplitude of the N400 was not modulated by the type of causal connective ("and so" versus "because") or by the presence/absence of a connective. Conclusion: We suggest that the sustained anterior negativity effect reflected the increased demands of retaining an event representation of the first clause within working memory while processing words of the second clause. These increased costs were incurred both when comprehenders were explicitly cued to predict non-canonical event sequences (following "because"), and when there was uncertainty about whether events would appear in canonical or non-canonical order (no causal connective), but not when comprehenders were explicitly cued to predict a canonical event sequence. We suggest that this ability to retain the event representation of the first clause over time within working memory is what allows comprehenders to quickly draw upon their stored real-world causal knowledge to facilitate processing of causally coherent incoming words (as reflected by N400 modulation), even when the sequence of upcoming events conveyed by upcoming linguistic input is non-canonical or uncertain.

C48 Cognitive Control Mediates Age-Related Reductions in Adaptation to Speaker-Specific Predictability

Shruti Dave[1], Trevor Brothers[1], Matthew Traxler[1], Tamara Swaab[1]; [1]University of California, Davis

Resource-based accounts of language processing (Kuperberg & Jaeger, 2016) posit that comprehenders flexibly adjust anticipatory processing in response to the effectiveness of prediction in a given environment. Recent electrophysiological evidence for the resource-based hypothesis has been found in young adults (Brothers et al., 2016), who showed significant differences in N400 effects of prediction as a function of speaker-specific statistics. Dave et al. (2017) further demonstrated that N400 effects of adaption to speaker-specific information were dynamically modulated by individual differences in cognitive control (CC; Stroop and Flanker tasks) and working memory

(WM; Listening Span task) resources. Here, we examined whether older adults as a group adapt their predictive processing across different speakers. In addition, we examined whether individual differences on measures of WM and CC influenced sensitivity to speaker-specific statistics in older adult listeners. Recent evidence suggests that older adults do not show specific impairments in predictive relative to contextual processing (Dave et al. [a], under review), but less is known about predictive adaptation to globally available cues. In our experiment, EEG was recorded from 40 young adults (aged 18 to 26) and 40 older adults (aged 61 to 75) while they listened to sentences spoken by two speakers. Half of the sentences were spoken by a reliable speaker, who completed 80% of their sentences with predictable final words (i.e., The dairy cow produced some [milk]) while the other half of the stimuli was spoken by an unreliable speaker (who ended 80% of sentences with plausible but unexpected words, i.e., The dairy cow produced some [noise]). In young adults, larger N400 effects of sentential constraint were found when comprehenders listened to reliable – as compared to unreliable – speakers. However, older adults did not show a significant interaction of speaker reliability and contextual predictability, suggesting that older adults are less sensitive to the global validity of predictive cues. Further, while WM and CC influenced young adults' adjustment of predictive strategies, only CC affected older adults' N400 effects of speaker adaptation. Interestingly, performance on CC measures fully mediated age-related changes in neural effects of speaker adaptation. Our results are in line with previous research (Dave et al. [b], under review; Federmeier et al., 2002) suggesting that generalized age-related declines in WM capacity weaken relations between WM and predictive processing. Importantly, these data also contribute that age-related reductions in CC explain age-related declines in adaptation of predictive processing in response to environmental cues.

Meaning: Lexical Semantics

C49 Orthographic influences on Chinese spoken language in the brain: task-dependent effects as revealed by event-related fMRI

Pei-Chun Chao[1], Wei-Fan Chen[2], Jie-Li Tsai[3], Chia-Ying Lee[1,2]; [1]National Yang-Ming University, Taiwan, [2]Academia Sinica, Taiwan, [3]National Chengchi University, Taiwan

The orthographic consistency effect on spoken word recognition is a well-established phenomenon to support that reading experience shapes the speech processing. However, it is still unclear whether this effect was resulted from the orthographic co-activation located in temporo-occipital visual cortex or the phonological restructuring located within the speech network. In Chinese, over 80% of Mandarin syllables can be mapped onto more than one character. Given the pervasive homophony of Chinese, one might expect a greater impact from orthography during speech in Chinese than that in the alphabetic writing system. Two types of orthographic effect have been demonstrated in Chinese spoken word recognition with ERP (Chen et al., 2016). One is the orthographic consistency (whether a set of homophones can be divided into subgroups based on their phonetic radicals) and the other one is the homophone density (the number of characters sharing exactly the same pronunciation). This study aims to examine these two orthographic effects on Chinese spoken language under semantic category and rhyming judgment tasks with event-related fMRI in order to explore the neural mechanisms underlying the orthographic effects and whether they are task-dependent. The monosyllabic Chinese spoken words used in the two tasks were sub-divided into three phonology-to-orthography mapping conditions based on their orthographic consistency (OC) and homophone density (HD) (1) low HD/ high OC; (2) high HD/ high OC; (3) high HD/ low OC. Twenty-four participants perform the Go/no go semantic categorization task with 108 critical stimuli for no-go trials and 60 animal names for go-trials. Additionally, twenty-eight participants perform rhyming judgment task with 90 critical stimuli paired with a rhymed or non-rhymed probe. In the semantic task, the brain activation for orthographic consistency effects were only localized to left inferior frontal gyrus (IFG), superior temporal gyrus (STG), and supramarginal gyrus for phonological and semantic processing, supporting the phonological restructuring view. Moreover, the homophone density effects occurred not only in the left IFG, insula, and STG for phonological processing, left posterior temporal-parietal regions for lexical/semantic processing, but also in left fusiform and lingual gyrus for orthographic processing, supporting the orthographic on-line activation view. These findings suggest that the two perspectives are not mutually exclusive. However, in the rhyming task, only orthographic consistency effects occurred within anterior perisylvian speech network were found. These results suggested that orthographic influences on speech may be task-dependent and imply that orthographic consistency and homophone density involve different mechanisms during Chinese spoken word recognition.

C50 The Loci of the Semantic Relatedness Paradox during Speech Production

Tao Wei[1], Tatiana Schnur[2]; [1]Beijing Normal University, [2]Baylor College of Medicine

Speech is affected by recent naming experience (i.e., what we have said before). In previous work, we found that the same naming experience (e.g., "cat") has opposite effects on future naming of semantically related pictures (e.g., "dog"). Facilitation was observed when semantically related pictures were named adjacently (lag0 condition), while the effect reversed into interference when semantically related pictures were named with unrelated intervening items (lag2 condition). There is ongoing debate about the stage(s) in the language system at which facilitation and interference take place (semantic vs. lexical processing; e.g., Belke, 2013; Biggs & Marmurek, 1990; Damian et al., 2001;

Wei & Schnur, 2016). Previous studies have attempted to answer this question using functional magnetic resonance imaging (fMRI), by localizing the neural locus of interference effects (e.g., de Zubicaray, McMahon, Eastburn, & Pringle, 2006; de Zubicaray, McMahon, & Howard, 2013). However, we do not know whether a brain region involved in facilitation and/or interference is in fact important for lexical or semantic processing without testing the cognitive function (semantic vs. lexical) of the region across subjects. In this study, we directly addressed this question by localizing in the same subjects the neural basis of specific stages in speech production (i.e., semantic vs. lexical processing) while concurrently testing the semantic relatedness paradox in naming (i.e., facilitation vs. interference). First, regions of interest (ROIs) subserving semantic and lexical processing were identified as brain regions where increased activity was correlated with decreasing concept familiarity and lexical frequency respectively (e.g., Graves, Grabowski, Mehta, & Gordon, 2007; Wilson, Isenberg, & Hickok, 2009). We identified semantic ROIs in the bilateral inferior temporal lobes, and lexical ROIs in the left posterior temporal gyrus and right occipitotemporal cortex. Then, within these semantic and lexical ROIs, we contrasted the brain activity when subjects named semantically related vs. unrelated pictures in the lag0 and lag2 conditions, respectively. The results revealed that for lag0, where semantic facilitation was observed, only semantic ROIs in posterior inferior temporal regions showed stronger activity in naming related vs. unrelated pictures, suggesting a semantic locus of facilitation in naming. In contrast, for lag2 where semantic interference was found, all semantic and lexical ROIs showed weaker activity in naming related vs. unrelated pictures, suggesting both semantic and lexical loci of interference in naming. These results show that previously naming semantically related words facilitates current naming at the level of semantic processing, whereas naming is slowed down because of changes at both semantic and lexical levels of processing. The next step is to understand the exact mechanism of the changes (e.g., short-lived changes in activation levels and long-lasting changes in connection weights) which result in facilitation vs. interference in naming dependent on level of processing.

C51 Developmental changes during semantic judgments to Chinese characters: A Longitudinal Study of Effective Connectivity *Li-Ying Fan[1,2,3], Tai-Li Chou[3,4,5]; [1]School of Linguistic Sciences and Arts, Jiangsu Normal University, China, [2]Collaborative Innovation Center for Language Ability, Jiangsu Normal University, China, [3]Department of Psychology, National Taiwan University, Taiwan, [4]Neurobiology and Cognitive Science Center, National Taiwan University, Taiwan, [5]Graduate Institute of Brain and Mind Sciences, National Taiwan University, Taiwan*

Previous cross-sectional studies have investigated neural correlates of semantic processing. However, it is little known whether the patterns of effective connectivity with semantic processing change developmentally in a longitudinal study. Thirty-five typically developing children (7- to 14-year-olds) were recruited in a functional magnetic resonance imaging (fMRI) study to examine the developmental changes of semantic processing over a two-year interval. Character pairs were arranged in a continuous variable according to association strength (i.e. strong versus weak), and participants were asked to indicate if character pairs were related in meaning during semantic judgments. Dynamic causal modelling (DCM) was used to investigate the effective connectivity over time. We set up a model with four cortical regions (left inferior frontal gyrus (IFG), left middle temporal gyrus (MTG), left inferior parietal lobule (IPL), and left fusiform gyrus (FG)) to evaluate dynamic interaction during semantic judgments. Our connectivity results showed that greater developmental changes (from time 1 to time 2) of the bottom-up effects from FG to other regions (IFG, MTG, and IPL) were stronger than other effects for strong association pairs. Taken together, the connectivity findings suggest developmental changes in bottom-up influences with a direct mapping from orthography to semantics, including access to semantic representations as well as links to working memory and cognitive control for processing Chinese characters.

C52 ANY ERP effects *Hongchen Wu[1], Jun Lyu[1], Aydogan Yanilmaz[1], John E. Drury[1]; [1]Stony Brook University*

[INTRODUCTION] English ANY lives a double-life. It can serve as a Negative Polarity Item (NPI) (e.g., "There wasn't ANYONE in the room") requiring the presence of a licensor like negation (cf. "There was *ANYONE in the room"). But ANY also can be a Free Choice Item (FCI) (e.g., "ANYONE can do that"). Within linguistic theory, the relationship between the NPI/FCI-variants of ANY is controversial. For example, accounts of FCI-ANY conflict, alternatively proposing that it introduces universal quantificational force (like EVERY; Dayal 1998), or that it is rather a type of indefinite (Kadmon & Landmann 1993; Horn 2000; Giannakidou 2001). [PRESENT STUDY] We examined ERP responses to EVERY/ANY in four embedded contexts, varying the presence/absence of a main clause subject licensor ((1a)/(2a) vs (1b)/(2b)) and whether the Target occurred in the embedded subject position (1a/b) or the "pivot" position of an existential construction(2a/b). Universals/definites are deviant in pivots positions (EVERY in (2a/b) is unacceptable; McNally 2011). (1a) {LICENSED/SUBJECT} None of us thought that EVERYONE/ANYONE was in the room. (1b) {NON-LICENSED/SUBJECT} All of us thought that EVERYONE/*ANYONE was in the room. (2a) {LICENSED/PIVOT} None of us thought there was *EVERYONE/ANYONE in the room. (2b) {NON-LICENSED/PIVOT} All of us thought there

was *EVERYONE/*ANYONE in the room. Previous ERP findings examining these types of logical semantic/pragmatic deviance (Drury & Steinhauer 2009) led us to predict that the ungrammatical cases (*) in (2) would elicit a P600 effect relative to licensed ANY in (2a). Our interest in the (1) cases was to observe whether ANY might (not) differ from (universal) EVERY. [METHODS] In a reading/judgment ERP study, adult native English speakers (N=18) viewed critical sentences RSVP (500 ms), providing acceptability judgments after every trial. EEG was recorded continuously (32 channels), and ERP mean amplitudes were examined for 100 ms time-windows for 1200 ms epochs, with -200 to 0 ms serving as the baseline. [RESULTS] EVERY/ANY subjects (1) revealed an N400 effect (300-500 ms) in Licensing contexts (ANY>EVERY in (1a)). Strikingly, there were no EVERY/ANY differences in the Non-licensing subject contexts (1b), although unlicensed ANY subjects were consistently rejected sentence-finally. As pivots (2), ANY yielded a larger N400 than EVERY in both Licensing and Non-licensing conditions (main effect of Target word only). Subsequently, however, we found Context x Target word interactions due to the presence of relative positivities for both EVERY conditions and for ANY in Non-licensing contexts relative to ANY when it was licensed. [CONCLUSION] Additional processing occurs whenever ANY is accessed/retrieved as an NPI (in the scope of a licensor in subject position, or in existential constructions), indexed by larger N400s. The absence of (Non-) Licensing differences for ANY subjects suggests that whether FCI-ANY is treated as an indefinite or a universal, in subject contexts it incurs no additional processing effort relative to universal EVERY (either in terms of retrieval or integration/composition operations). We discuss these patterns both in the context of current debates on NPI/FCI-ANY and in connection with theories/models of the etiology of the N400 and P600 ERP components.

C53 Incremental learning and lexical access: Evidence from aphasia

Julia Schuchard[1], Erica L. Middleton[1]; [1]Moss Rehabilitation Research Institute

Introduction. Incremental learning accounts of lexical access for speech production posit that each instance of word retrieval (e.g., naming an object) adjusts the strength of the word's semantic-lexical connections, facilitating its future retrieval. Here we hypothesized that a use-dependent, incremental learning mechanism operates at each of two stages of lexical access that involve retrieval of a word from semantics ("Stage 1"), followed by retrieval of its constituent phonemes ("Stage 2"). To examine this possibility, we investigated two naming treatment techniques expected to differentially strengthen the two stages of lexical access: retrieval practice (i.e., practice retrieving names from long-term memory) and errorless learning (i.e., patient hears the name and orally repeats it). Because producing a name during retrieval practice requires both Stage 1 and Stage 2, this technique should use and strengthen item-specific connections in both stages. Because errorless learning involves oral repetition of names, which circumvents semantically-driven retrieval, this technique should primarily use and strengthen item-specific connections in Stage 2. Method. In two experiments, we examined how naming training involving retrieval practice versus errorless learning impacted post-training naming performance. Using a case comparison design, Experiment 1 studied two individuals with aphasia (S1 and S2) who were selected based on evidence that S1's naming impairment primarily resulted from difficulty at Stage 1, and S2's naming impairment primarily resulted from difficulty at Stage 2. Experiment 2 tested the effects of the training conditions on items that elicited difficulty at Stage 1 or Stage 2 for each of ten additional individuals with aphasia. In both experiments, pictures of common objects that elicited naming errors in pretesting for each participant were divided in matched fashion to the retrieval practice and errorless learning conditions. Following initial familiarization of each picture with its associated name, opportunities were provided to retrieve the name (retrieval practice) or repeat the name (errorless learning), with correct-answer feedback following all trials. Retention tests of naming for the trained items were administered without feedback one day and one week after training. Naming accuracy on these tests was the primary outcome variable, analyzed with logistic regression. Results. The results showed significant interaction effects between the type of training (retrieval practice versus errorless learning) and the stage of lexical access at which items presented difficulty (Stage 1 versus Stage 2). In Experiment 1, retrieval practice resulted in significantly higher retention test accuracy than errorless learning for S1 (Stage 1-type impairment), whereas no significant difference between the two conditions was observed for S2 (Stage 2-type impairment). In Experiment 2, retrieval practice resulted in higher retention test accuracy compared to errorless learning for Stage 1 items, whereas the opposite pattern was observed for Stage 2 items. Discussion. The results suggest that retrieval practice strengthens item-specific connections in Stage 1 to a greater extent than errorless learning, whereas errorless learning primarily strengthens Stage 2 connections. These findings provide empirical evidence to motivate the integration of use-dependent, incremental learning mechanisms into a two-stage framework of lexical access.

C54 Direct Encoding of Semantic and Orthographic Neighborhood Reveals The Organization of Lexical Access

Jona Sassenhagen[1], Benjamin Gagl[1,2], Christian J. Fiebach[1,2]; [1]Goethe University Frankfurt, [2]IDeA Center for Indidivudal Development and Adaptive Education, Frankfurt

Many visual word recognition theories propose a more or less parallel sequence of processes mapping from (orthographic, phonological) word form to lexical and semantic representations. For example, Interactive Activation models (e.g. McClelland & Rumelhart, 1981)

propose that individual letters contribute bottom-up activation to corresponding word forms, each activating the corresponding semantic features; for this reason, the word "HOUSE" also activates semantic features like "small", "grey", "likes cheese" because "MOUSE" is a close word-form neighbor, at a Levenshtein Distance/ LD (Yarkoni et al., 2008) of 1. Typically, such models are studied in context/target pair studies (e.g. priming), or by comparing words with rich vs. sparse neighborhoods. We instead directly model such spreading-activation effects to explain the full time course of brain activity elicited by reading individual words. Specifically, we predict brain activity by assuming that words with similar word forms and words with similar meanings elicit similar brain responses, and compare predictions to real EEG data from a large word reading study (Dufau et al., 2015; 960 words, n=75). First, we construct pairwise (word-to-word) distance matrices based on either LD or semantic similarity. Orthographic distance allows us to predict early brain activity (before 200ms; $r > .2$, $p < .01$), but also brain activity in the N400 time window (~350ms; $r > .3$, $p < .01$). Semantic distance allows us to predict only late activity (>300ms; $r > .3$, $p < .01$). Then, we model spreading-activation of semantic features under partial activation by word forms that are orthographically similar to the target word. For this we sum up high-dimensional semantic features (W2V word vectors; Mikolov, 2012) for each word weighted by their respective LD to the actually presented word; that is, we aggregate the semantic features of orthographically similar words. This model predicts brain activity in an intermediate window (150-400ms). Importantly, after ~400ms, this neighborhood-based model does not add to the predictive success of a semantics-only model (built on the meaning of just the target word), indicating only one word remains activated in this time. Thus, with word-to-word distance-based encoding, we directly delineate: (1), an early time window where lexical access is initiated. Here, word forms are (partially) activated by (partial) orthographic matches; these in turn activate semantic features (ca. 250-450ms). (2), a later time window (>400ms) where only one word meaning is represented and lateral-inhibition-like processes have suppressed irrelevant partially-activated concepts. (3) Finally, we found that words with similar word forms elicit similar brain activity well into the N400 time window, indicating that even at latter stages of word reading, spreading activation-like processing occurs in a part of semantic memory organized by both meaning and form. Our findings support parallel-processing models, constraining them in some parameters (e.g. establishing lower bounds on semantic memory processes sensitive to orthographic neighborhood). This opens up new venues for studying the time courses of orthographic processing, semantic/orthographic neighborhood spreading-activation, and exclusive lexical access, while avoiding crucial confounds.

C55 Age-related brain activation changes during rule repetition in word-matching

Ikram Methqal[1], Basile Pinsard[1], Maximiliano A. Wilson[2], Oury Monchi[3], Jean-Sebastien Provost[3], Mahnoush Amiri[1], Yves Joanette[1]; [1]Centre de Recherche de l'Institut Universitaire de Gériatrie de Montréal, Montréal, Québec, Canada, [2]Centre de Recherche de l'Institut Universitaire en Santé Mentale de Québec, QC, Canada, [3]Hotchkiss Brain Institute, University of Calgary, Calgary, Canada

Objective: One of the most used paradigms to explore the ability to apply category-based rules consists in a rule-based category-learning task which requires to make a repeated feedback-driven selection using a given category-based criterion over time. In the area of language, a complex and common rule-based task used has been adapted from the Wisconsin Sorting Card Test. Given the semantic advantage associated with healthy aging, it was expected that the use of such a task in older participants, while acquiring neurofunctional data, would provide some insight into the life-course's adaptive neurofunctional reorganization. The purpose of this study was thus to explore the age-related brain activation changes during a word-matching semantic-category based task. Method: Two groups of healthy adults (20 younger adults and 20 older adults) performed a word-matching task while undergoing a fMRI scan in which they were required to pair a target word with another word amongst three reference cards based on three semantic rules and corresponding to different level of semantic control demands: functional relatedness, moderately typical-relatedness which were considered as low control demands, and atypical-relatedness that was considered as high control demand. The sorting period required a continuous execution of the same sorting rule for a longer period and an inferred trial-by-trial feedback was given. Results: Behavioral performance revealed increases in response times and decreases of correct responses according to the level of semantic control demands (functional vs typical vs atypical) for both age-groups (younger and older) reflecting graded differences in the repetition of the application of a given semantic rule. Neuroimaging findings of significant brain activation showed two principal results: 1) Task-related activation changes in inferior temporal regions bilaterally for the repetition of the application of atypical rule relative to functional and typical. 2) Direct comparisons (older > younger) revealed age-related activation in the left anterior lateral prefrontal cortex for functional and at a greater extent and bilaterally for typical and atypical rule. However, for general semantic processing comparison, only task-related activation changes were found in parieto-temporal regions for functional rule repetition relative to typical and at a greater extent in right frontal and temporal regions for atypical rule repetition relative to typical. Conclusion: These results suggest that successful cognitive aging relies on the adaptive changes of prefrontal

resources involved in the continuous execution of semantic rule according to complexity of the semantic relationship. However, activation changes in semantic networks engaged in general semantic processing appears to be related to a word-matching task than to age per se.

C56 Clustering Abstract Concepts into Distinct Categories *Catherine Walsh[1], Stephen J. Gotts[1], Alex Martin[1]; [1]Laboratory of Brain and Cognition, National Institute of Mental Health*

Object concepts fall naturally into easily identifiable and distinct categories such as animals, tools, furniture, and flowers. In contrast, our large corpus of abstract concepts do not easily fall into distinct categories. In order to make progress on understanding the neural underpinnings of abstract concepts it seems that the first questions that must be addressed concern distinctions among abstract concepts. Do abstract concepts show a categorical structure? Do clear boundaries exist between these different categories? In this study we sought to address these questions using a novel behavioral sorting paradigm and a measure of automatic semantic priming. We completed two experiments. In the first experiment, subjects (n=20) performed a computerized clustering task using 35 words that referred to abstract concepts. All words were rated very low on concreteness and imageability based on standard published norms (Coltheart, 1981; Brysbaert et al., 2014). Participants were presented with the words randomly distributed around a circular array on a computer screen and asked to group them in any way they saw fit. A k-means clustering analysis identified four consistent and robustly separated abstract word clusters, which we called: 1) cognition and thoughts, 2) negative qualities, 3) morality and personality, and 4) aesthetics and morals. When compared to chance (determined through random shuffling of rows/columns for each individual subject in permutation testing, 5000 iterations), within-cluster distances were all significantly smaller than chance (P<.0002, for all) and between-cluster distances were larger than chance (P<.002, for all but cluster 2 with cluster 3, P<.13). These results indicated that abstract concepts can be reliably categorized. We then used these clusters in an automatic semantic priming paradigm with 15 new subjects in order to determine whether these distinctions were processed automatically. Prime words were briefly presented (100 msec), pattern masked (50 msec followed by 100 msec blank screen), with the probe word presented for 250 msec and participants judging whether the probe was a concrete or abstract word. The prime-probe relationship did indeed influence response time, but, surprisingly, not in the expected direction: within-cluster pairs yielded significantly slower, rather than faster responses relative to the across-cluster pairs (paired t-test: t=3.259 (df=14), P<.01). We are currently evaluating this inhibitory priming effect using different priming paradigms (lexical decision; pleasant/unpleasant judgements) and different subsets of abstract words.

C57 The intensity of sensory-perceptual features regulates conceptual processing in the anterior temporal lobe's semantic hub *Jet M. J. Vonk[1,2], H. Isabel Hubbard[2], Maria Luisa Mandelli[2], Roel Jonkers[3], Adam M. Brickman[4], Bruce L. Miller[2], Maria Luisa Gorno-Tempini[2], Loraine K. Obler[1]; [1]The Graduate Center of the City University of New York, [2]Memory and Aging Center, University of California San Francisco, [3]University of Groningen, [4]The Taub Institute for Research on Alzheimer's Disease and the Aging Brain, Columbia University*

The components of semantic representations include sensory-perceptual information. In the hub-and-spoke model these representations emerge from a central trans-modal hub, based in the anterior temporal lobe (ATL), that incorporates input from sensory-perceptual regions (e.g., Patterson et al., 2007). Little is known about the influence of sensory-perceptual features on the intensity of semantic processing in this region. Structural MRI allowed us to investigate whether the involvement of the ATL is dependent on the degree of semantic association with sensory-perceptual information by assessing the relation between regional volume and behavioral lexical-semantic performance in individuals with primary progressive aphasia (PPA). Individuals with the semantic variant (svPPA; atrophy in ATL), generally show a wide-spread semantic deficit, while individuals with the non-fluent variant (nfvPPA; atrophy in premotor cortex) and logopenic variant (lvPPA; atrophy in temporo-parietal cortex) are characterized by intact single-word processing and no semantic impairment. From a set of 350 words—controlled on a broad range of psycholinguistic and semantic variables—the 22 highest and 22 lowest associated words (rated by 242 healthy adults) on each of six noun and six verb sensory-perceptual features were selected. Features for nouns were visual motion, sound, color, manipulation, smell/taste, and shape and those for verbs were mouth use, hand use, leg use, change of state, visual motion and sound. Lexical decision performance and T1-weighted MR images of 37 individuals with nfvPPA (N = 11), lvPPA (N = 13), and svPPA (N = 13), as well as 17 age-matched controls, were analyzed with voxel-based morphometry (VBM) to identify the association between cortical volume and performance on high- and low-association words. Behaviorally, individuals with svPPA showed no differences between high- and low-association items on any of the noun features and performed significantly worse than controls on all high-association noun- and verb-features, demonstrating a general trans-modal semantic impairment. In contrast, those with nfvPPA and lvPPA displayed moderate sensory-perceptual specific impairments, especially for motor-actions and sound words, respectively. Performance on high- and low-association items for eleven of the twelve sensory-perceptual features was associated with lower volume in the left and/or right ATL(s), while there was no other brain region that was similarly consistently involved

across features. For nine of the sensory-perceptual features, the involvement of the ATL remained significant after the VBM statistical map of the high-association words was masked by the VBM statistical map of the low-association words. This masking eliminated effects of equivalent properties of the high- and low-association words, isolating the specific influence of each feature. Hence, the results indicate a stronger correlation of the ATL with impairment on high-association words than low-association words. This study supports the central trans-modal hub role of the ATL, impaired in individuals with svPPA in contrast with the specific sensory-perceptual impairments in individuals with nfvPPA and lvPPA. Results demonstrate that the processing intensity of semantic representations in the ATL is regulated by a concept's degree of association with sensory-perceptual information. This finding expands the idea of the ATL as an active hub that integrates the variable input from sensory-perceptual regions into holistic conceptual representations.

Grammar: Morphology

C58 Tracking the neurophysiological correlates during the computation of agreement dependencies: the access of grammatical feature and associative representations in spoken language

Jane Aristia[1], Angèle Brunellière[1]; [1]University of Lille, CNRS, UMR 9193 - SCALab - Sciences Cognitives et Sciences Affectives, F-59000 Lille, France

Most of event-related potential (ERP) studies (for a review, Molinaro, Barber & Carreiras, 2011) investigating the computation of agreement dependencies revealed three neurophysiological correlates related to grammatical violations: left anterior negativity, N400, and P600. Nonetheless, little is known in terms of how the representations are accessed during the agreement processing. Some prior studies suggested the using of abstract representations in terms of grammatical features to compute agreement dependencies (Harley & Ritter, 2002; Pearlmutter, 2000) between words, whereas others proposed the access to associative lexical representations to code the probability between words (Truswell & Tanenhaus, 1994; Seidenberg & MacDonald, 1999). Moreover, the neurophysiological correlates associated with grammatical violations have been mainly examined in reading task. Therefore, the present study aims to explore on how the representations are accessed during the agreement processing in spoken language. To this end, we conducted an ERP experiment, in French pronominal subject-verb agreement wherein we manipulated the abstract features involved in agreement violations and the associative frequency between the pronominal subject and the verbal inflection. First, four experimental conditions are created as followed (1) congruent, (2) person violation, (3) person & number violation, (4) more number than person violation (i.e., orthographically it is a number violation but in spoken language, it can be recognized as number and person violation) to test the access of abstract features. The incongruent stimuli were twenty percents of the total stimuli and participants were asked to make a response if they hear a nonword. The results based on the neurophysiological correlates associated with the grammatical violations are in line with the previous studies suggesting the access of grammatical features to compute agreement dependencies. More precisely, the person violations elicited a posterior P600 wave at around 800 ms from the onset of verbs in comparison with the congruent conditions whereas the number and person violations triggered an anterior negativity at around 600 ms and a P600 at around 900 ms. Additionally, more number than person violations elicited a late negativity at around 700 ms over the anterior sites. To probe the activation of associative representations, we analyzed separately the pronouns depending on how frequent they are followed by a particular verbal inflection (e.g., nous proceeded by –ons inflection is more frequent than je by –ai). We found that low associative frequency between the pronominal subject and the verbal inflection induced a stronger negative response in comparison with high associative frequency. Altogether, beyond on the access of abstract grammatical features, this study highlights the role of associative representations during the computation of agreement dependencies.

Meaning: Prosody, Social and Emotional Processes

C59 Effects of cortical thickness on pause duration in neurotypical adults' speech: Evidence for the role of the left middle temporal gyrus in lexical retrieval

Georgia Angelopoulou[1], Dimitrios Kasselimis[1,2], Maria Varkanitsa[3,4], Panagiotis Fotiadis[3], Charalambos Themistocleous[5], Dimitrios Tsolakopoulos[1], Christally Grillou[1], Foteini Christidi[1], Efstratios Karavasilis[6], George Argiropoulos[6], George Velonakis[6], Sofia Karanassou[7], Zoi Nikitopoulou[7], Petros Roussos[8], Dionysis Goutsos[8], Nikolaos Kelekis[6], Ioannis Evdokimidis[1], Constantin Potagas[1]; [1]Eginition University Hospital - National and Kapodistrian University of Athens, [2]University of Crete, [3]Massachusetts General Hospital - Harvard Medical School, [4]University College London, [5]University of Gothenburg, [6]Attikon University Hospital - National and Kapodistrian University, Athens, Greece, [7]Panteion University of Athens, [8]National and Kapodistrian University of Athens

The relationships between individual differences in speech production and individual variability in measures of cortical structure in healthy individuals have received relatively little attention. This study aims to reveal the neural correlates of pauses, by investigating possible associations between cortical thickness of specific brain regions and pause duration, a measure thought to reflect speech planning and word retrieval. Twenty five right-handed Greek speaking neurotypical adults (9 males) with

a mean age of 49 years (SD=9.54) and a mean education level of 14.44 years (SD=3.38) participated in the study. Speech samples were derived from participants' narrations about an experience of an illness. All pauses were automatically segmented using a customized Praat script, followed by manual correction. Cortical surfaces from the T1 MR images were reconstructed using the automated pipeline of FreeSurfer 5.3.0 (http://www.surfter.nmr.mgh.harvard.edu/) and cortical thickness was calculated for each participant for specific left-lateralized regions of interest (ROIs). To investigate the relationship between pause duration and cortical thickness we used linear mixed effects models in R. Pause duration was included in the model as the dependent variable, cortical thickness in a set of left hemisphere ROIs and demographics (age, education level, sex) as fixed factors, and subjects as a random factor. ROIs were selected on the basis of previous literature, indicating brain areas related to language functions. Data were transformed to facilitate the analysis. The best model was selected using model comparison. Cortical thickness in the Middle Temporal Gyrus (MTG) was found to have a negative effect on pause duration (intercept: 28.84, estimate coefficient: -2.27, p-value: 0.00310). Our results show a strong negative relationship between the MTG cortical thickness and pause duration, therefore indicating that an increase of the thickness of the middle temporal cortex would result in reduced mean pause length during speech. The contemporary view of the neurobiological substrate of language points to two different streams: a dorsal stream, involved in articulation-to-sound mapping, and a ventral stream, involved in meaning-to-sound mapping. The latter stream includes the MTG. Moreover, it has been argued that selective retrieval may be facilitated by a network supported by pars triangularis interconnected with temporal cortices, including the MTG, with the extreme capsule fasciculus. In line with these findings, our data suggest that the MTG may play a crucial role in lexical retrieval, as revealed by its effect on pause duration, which, in turn, serves as an index of access to lexical representations and the ability to construct hierarchically organized, meaningful clusters of words.

Speech Motor Control and Sensorimotor Integration

C60 Graph Theoretical Approaches Show a Relationship Between Resting State Functional Connectivity in Younger and Older Adults and Phonological Aspects of Language Production

Victoria Gertel[1], Kerem Oktar[2], Michele Diaz[1]; [1]Pennsylvania State University, [2]Pomona College

Older adults often experience difficulties producing fluent speech compared to younger adults, including increased word retrieval failures and slower speech rates (Burke et al., 2008). Resting state fMRI (rsfMRI), a task-free technique that is used to investigate intrinsic network function, was used in this study. While used extensively to examine some networks, and to compare older and younger adults, few studies have used it to investigate the language network. Prior rsfMRI studies have demonstrated that neural networks strongly correlated during task are strongly correlated during rest as well (Greicius et al., 2003; Rosazza & Minati, 2011). Additionally, resting state functional connectivity (RSFC) is predictive of behavior during task and symptom severity in clinical populations (Mennes et al., 2010; Wang et al., 2007). Here we used rsfMRI to investigate how functional connectivity in the language network in older and younger adults predicts behavior. In examining RSFC within the language network, we hypothesize that older adults will exhibit an overall decline in the RSFC in language network regions compared to younger adults and that age and RSFC will significantly predict accuracy and reaction time on categorically related and phonologically related picture word interference task conditions. Twenty younger adults (mean age = 23.70, 10 females) and 19 older adults (mean age = 67.32 14 females) were analyzed. Regions of interests (ROIs) in the left-hemisphere were selected based on prior research and anatomical atlases (Desikan et al., 2006; Hickok & Poeppel, 2007). During a picture word interference task, participants named a target picture that was overlaid with a distractor word. The two task conditions analyzed included those with the target picture and distractor word being categorically or phonologically related. Accuracy and reaction time data during these two conditions were used as the behavioral metric. Independent Samples t tests showed group differences between older and younger adults in overall network connectivity, with older adults having less network connectivity. A graph theoretical approach was used to determine degree and centrality of the language network across older and younger adults. Weighted, binary graphs with a threshold of r = 0.2 were created. Nodes were first described as connected or not connected. Weights were applied to the connected nodes only (Dosenbach et al., 2007). We used MANOVAs to compare two aspects of network dynamics: centrality and degree. There were no significant age differences in centrality, however, there was a marginally significant effect of age for degree ($p = .07$). Several regions contributed to this effect including IFG, aMTG, pMTG, aInsula, STS, and STG. Relating these effects to behavior, we found a significant effect of degree in anterior insula, which predicted RTs during phonological trials ($p < .05$, $r2 = .129$, younger degree = 3.6, older degree = 2.2). Control analyses in the visual cortex revealed no significant age differences. Our results suggest that while the overall structure of the left hemisphere language network is resistant to age-related decline, connectivities between nodes may decrease with age. This decline may be related to phonological aspects of language production.

Multilingualism

C61 Electrophysiological activity in native, dialectal and foreign accented speech processing

Clara Martin[1,2], Alejandro Pérez[1], Sendy Caffarra[1]; [1]BCBL, [2]Ikerbasque

Despite the growing research on accented speech, it is still unclear whether there is a continuum in speech processing from native accented speech to foreign accented speech, with dialectal accented speech falling in between (Perceptual Distance Hypothesis) or whether processing foreign and dialectal accents is qualitatively and functionally different (Different Processes Hypothesis). To address this debate, we explored neural oscillatory activity and event-related potentials (ERPs) during listening to native, dialectal and foreign accented speech. Twenty-six native Spanish speakers from Spain were exposed to continuous speech in Spanish (one 6-minutes conversation per accent type; grammatically and semantically correct) and isolated words (120 words per accent type) during electroencephalogram recording. Conversations and isolated words were uttered by local Spanish speakers (native accent), Spanish speakers with Cuban (dialectal) accent and Italian speakers (foreign accent). Spectral power analyses of speech perception revealed that dialectal and foreign accented speech differed from native accented speech in high frequency (gamma) bands. ERP analyses revealed that isolated word perception differed in dialectal and foreign accented speech relative to native accented speech, in the 250-350 ms time-window (fronto-central Phonological Mapping Negativity; PMN). Importantly, dialectal and foreign accented speech processing did not differ in each of these analyses. Oscillatory activity in the gamma band during speech perception has been proposed to reflect speech processing at the phonemic level. Moreover, several previous studies have shown that the PMN observed during word processing reflects processes of normalization between acoustic-phonetic input and phonological representations. Consequently, our results suggest that speech and word processing of native language differs when uttered in native relative to non-native accent, mostly at the phonemic/phonological level. Dialectal and foreign accented speech processing does not seem to diverge significantly, which is in favor of the Perceptual Distance Hypothesis.

C63 Individual difference in language proficiency shapes the functional plasticity of language control in bilingual word production

Yongben Fu[1], Yanjing Wu[2], Chunming Lu[1], Taomei Guo[1]; [1]Beijing Normal University, [2]Shenzhen University

The present study aimed to investigate the effect of language switching training on the neural correlates of the reactive control and the proactive control in bilingual word production, as well as the modulation of the L2 proficiency on the training effect. During the pre-test, seventeen unbalanced Chinese-English bilinguals performed the cued picture naming task while being scanned with functional magnetic resonance imaging (fMRI). Participants then took an 8-day training on language switching and performed the same task again in the post-test. Behavioral results showed that the switch cost was significantly reduced in the post-test compared to the pre-test, but the mixing cost was not significantly different between the test sessions. In order to investigate the training effect in bilinguals with different L2 proficiency, bilinguals were split into two groups based on the scores in the College English Test. For the switch cost, fMRI results showed that the activation of the left inferior frontal gyrus, the left precuneus and the bilateral caudate nuclei were reduced for all bilinguals. Furthermore, the high L2 proficiency group showed decreased activity in the left cerebellum but the low L2 proficiency group showed increased activity in the left cerebellum. For the mixing cost, fMRI results showed that the high L2 proficiency group showed increased activation in the right middle frontal gyrus and the right supramarginal gyrus, while the low proficiency group only showed reduced activation in the right middle frontal gyrus. These results suggest that bilinguals with high L2 proficiency shifted to the proactive control to switch between two languages after the training. In contrast, the bilinguals with low L2 proficiency still relied on the reactive control to perform the task. The present study provided evidence for the plasticity of the bilingual language control, and highlighted the role of the L2 proficiency in the bilingual language control.

C64 Effects of Frequency and Construction on the Interpretation of Chinese Quadrisyllabic Idiomatic Expressions: An fMRI Study

Te-Hsin Liu[1], I-Wen Su[1], Chia-Ho Lai[1], Shu-Kai Hsieh[1], Chia-Lin Lee[1], Chia-Rung Lu[1], I-Ni Tsai[1], Tai-Li Chou[1]; [1]National Taiwan University

Chinese quadrisyllabic idiomatic expressions (henceforth QIEs) are highly productive in the modern language. They can be used to understand the cognitive processing of structure and meaning during reading comprehension, for example, the patterning of [qian-A-wan-B] "1k-A-10k-B" (e.g., one-thousand army ten-thousand horse). However, little is known about the underlying mechanisms of QIEs during reading comprehension. In the present study, we aimed to study the neural correlates of frequency effect (high, low) on idiomatic constructions and the degree of constructions (idiomatic, quasi-idiomatic, pseudo- idiomatic). Twenty Mandarin native speakers were recruited to participate in an fMRI experiment, where three types of idioms were designed: 48 [qian-A-wan-B] "1k-A-10k-B" idiomatic constructions divided on the basis of 24 high and 24 low frequency OIEs. (2) 16 quasi-idiomatic constructions non-existent in the modern language but obeying the morphological rule of Chinese idioms. (3) 16 pseudo [qian-A-wan-B] "1k-A-10k-B" trials violating the semantic and morphological restriction of the construction. Participants were instructed to make a semantic congruency judgment during the presentation of a QIE. Our behavioral results showed that native

speakers processed low frequency QIEs faster than high frequency ones, implying semantic satiation to impede the interpretation of high frequency idioms. Our fMRI results also demonstrated that the contrast of high versus low frequency QIEs showed greater activation in the anterior cingulate cortex, suggesting inhibitory control to suppress lasting semantic interference with high frequency QIEs. Moreover, the contrast of idiomatic versus pseudo-idiomatic constructions showed greater activation in the left anterior temporal cortex, suggesting the integration of individual syllables to form larger syntactic structures.

C65 Individual differences in age of acquisition predict fine-grained white matter microstructure in bilinguals

Emily Nichols[1], Marc Joanisse[1], Yue Gao[2], Li Liu[2]; [1]University of Western Ontario, [2]Beijing Normal University

There is an emerging consensus that bilingualism influences the structure of the white matter connections in the brain, especially in left- and right-hemisphere tracts commonly associated with language processing. However, there is appreciable variability in both the nature and direction of these differences, with studies variously observing higher or lower indices of connectivity in bilinguals compared to monolinguals, across a number of tracts in either the left or right hemisphere. The lack of clarity in this regard may stem from differences in analytic approach and sample groups. In the present study we compared fractional anisotropy (FA) of language-related white matter tracts in English-Mandarin bilinguals compared to monolingual controls. Individuals were scanned at 3 Tesla using diffusion-tensor imaging at 64 directions (voxel size: 2.083 x 2.083 x 2 mm; matrix: 96 x 96 x 68), aligned to a high resolution T1 MPRAGE scan (voxel size: 1 x 1 x 1 mm; matrix: 256 x 256 x 176). Individuals were also tested for proficiency in English and Mandarin, and completed demographic questionnaires including measures of language history and day-to-day usage. White matter analyses used automatic fiber quantification (AFQ) to identify and quantify subject-wise fiber tracts, including computing FA at multiple points along each tract. Groupwise comparisons showed significantly lower FA in bilinguals along sub-portions of left arcuate fasciculus (AF), left superior longitudinal fasciculus (SLF), left and right inferior fronto-occipital fasciculus (IFOF), and left inferior longitudinal fasciculus (ILF). One concern with these findings however, is that they are being driven by extraneous differences between groups, rather than bilingual status. We addressed this in follow-up analyses, where we examined whether individual differences in bilingual individuals' age of acquisition (AoA) also showed a similar relationship to white matter FA. Concordant with the groupwise analyses, we found that FA increased as a function of AoA in these same white matter tracts, such that tracts of late bilingual tended to more closely resemble those of monolinguals.

C66 Speech processing and plasticity in the right hemisphere predict real-world foreign language learning in adults

Zhenghan Qi[1], Michelle Han[1], Yunxin Wang[1], Carlo de los Angeles[1], Qi Liu[1], Keri Garel[1], Ee San Chen[1], Susan Whitfield-Gabrieli[1], John D. E. Gabrieli[1], Tyler K. Perrachione[2]; [1]Massachusetts Institute of Technology, [2]Boston University

Goals: Foreign language learning in adulthood often takes place in classrooms where learning outcomes vary widely among students, both for initial learning and for long-term retention. Despite the fundamental role of speech perception in first language acquisition, the role of speech perception in real-world foreign language learning outcomes remains unknown. Using both a speech discrimination functional magnetic resonance imaging (fMRI) task and resting-state fMRI before and after an intensive, classroom-based, Mandarin Chinese course, we examined how variations in pre-training organization, as well as pre-to-post reorganization, of brain functions predicted successful holistic language learning in native English-speaking learners. Methods: Twenty-four adult native speakers of English underwent a month-long, classroom-based Mandarin course. Students' holistic Mandarin attainment was assessed immediately after the course and long-term retention of Mandarin skills was assessed 90 days later. Participants took part in two identical MRI scanning sessions in a Siemens Trio 3T scanner before and after the language learning. In the tone-discrimination fMRI task, participants indicated whether the pitch contours of consecutive pairs of sounds were the same or different for real Mandarin words or nonspeech sinusoidal tones. Participants completed two task runs (TR = 2.7 s; TA = 0.5 s; 145 volumes) and one resting-state scan (TR = 2.5 s; 147 volumes) in each session. fMRI Group-level statistics were based on non-parametric permutation and correction for multiple comparisons was accomplished by controlling cluster-level family-wise error at $p < 0.05$. Results: Prior to the course, greater activation in right inferior frontal gyrus (IFG) in response to discriminating Mandarin speech tones (versus nonspeech sinewave tones) was associated with greater future success in Mandarin attainment. After four weeks of class, more successful learners showed greater pre-to-post reduction of right IFG activation and greater pre-to-post enhancement of resting-state connectivity between left and right IFG. On average, learners showed increased post-training activation in left IFG to lexical tones, but variation in neither left IFG activation nor left IFG plasticity was related to learning outcomes. Predictive models using neural features (pre-training activation and pre-to-post activation change in right IFG) predicted long-term retention of holistic Mandarin skills more accurately than models using behavioral features (pre-training Mandarin speech-sound discrimination accuracy and pre-to-post accuracy change). Conclusion: This study provides critical new evidence about the importance of the right hemisphere

in speech perception for successful acquisition of a whole language in adults. Although the left hemisphere was increasingly recruited in most learners after training, individual differences in speech perception, immediate language learning attainment, and long-term retention of high-level foreign language skills were all related to differences in initial right-IFG engagement and subsequent right-IFG disengagement. The right-to-left transition was accompanied by an increase in resting-state functional connectivity between bilateral IFG regions. Taken together, these findings significantly refine the neurobiological model of ecological adult language learning and retention.

C67 Multi-voxel pattern analysis reveals the impact of language learning experience on the brain's intrinsic functional connectivity *Xiaoqian Chai[1], Shanna Kousaie[1,2], Debra Titone[2,3], Shari Baum[2,4], Denise Klein[1,2,5]; [1]Neuropsychology/Cognitive Neuroscience Unit, Montreal Neurological Institute, McGill University, Montreal, QC, Canada, [2]Centre for Research on Brain, Language and Music, McGill University, Montreal, QC, Canada, [3]Department of Psychology, McGill University Montreal, QC, Canada, [4]School of Communication Sciences and Disorders, Faculty of Medicine, McGill University, Montreal, QC, Canada, [5]Department of Neurology and Neurosurgery, Faculty of Medicine, McGill University, Montreal, QC, Canada*

Previous evidence suggests functional and structural brain changes associated with acquiring a second language. Using resting-state fMRI, a few prior studies have shown that the age of L2 acquisition might be linked with different patterns of connectivity in the brain. These studies were based on a seed-driven connectivity approach, which relies on a priori regions of interests (seeds). Choice of the precise location of the seeds is often arbitrary, and slight shift in the seed location could lead to different patterns of connectivity. In the present study, we applied a whole-brain multi-voxel pattern approach to investigate the effect of L2 age of acquisition on whole-brain intrinsic functional connectivity. Twenty-three English monolinguals, 45 simultaneous English/French bilinguals who started learning both languages from birth, and 99 late bilinguals who acquired their L2 after the age of 5 were included in the analysis. All participants were between 18 and 40 years of age. For all voxels in the brain, we computed the pairwise connectivity pattern between each voxel and the rest of the brain (all other voxels) and reduced the dimensionality of this multi-voxel pattern with principal component analysis (PCA) maximizing the explained inter-subject variability in the resulting patterns using a lower number of spatial components; four components were kept. We then performed multivariate analyses looking at differences in connectivity related to L2 age of acquisition. Between the monolinguals and bilinguals, we found two clusters - the left anterior insula (-28, -20, -6), and the right putamen (16, 8, -6), with connectivity patterns which significantly differentiated the groups (cluster-level FDR-corrected $p < .05$; height threshold uncorrected $p < .001$). Post-hoc analyses were performed using these two areas as seeds in standard seed-to-voxel analyses and identified a number of connections between these seeds and other areas/clusters that showed differences between different language groups. Within the late bilingual group. the left anterior insula cluster (-26, 24, 2) connectivity was also associated with L2 age of acquisition. Our results provide further evidence for the important role of the left anterior insula in L2 learning and suggests earlier L2 learning leads to different connectivity patterns between the left IFG and a wide network of regions in the brain.

C68 The language network of polyglots *Olessia Jouravlev[1,2], Zachary Mineroff[1], Evelina Fedorenko[1,3,4]; [1]Massachusetts Institute of Technology, [2]Carleton University, [3]Harvard Medical School, [4]Massachusetts General Hospital*

The neurocognitive mechanisms of impaired language processing have received a lot of attention in the last few decades. Much less is known about individuals with a special talent for language, like those able to master multiple languages (Erard, 2012). We report the first fMRI investigation of seventeen polyglots (M(languages)=11.6; range(languages)=5-55). We asked two questions: (1) Does the language network of polyglots differ from that of non-polyglots?; and (2) How are multiple languages represented in polyglots' brains? Study 1: The language network was identified in each individual with a language localizer that contrasted responses to sentences and nonwords (Fedorenko et al., 2010). The polyglots were compared to carefully pairwise-matched (including on IQ) non-polyglots, and a larger population of non-polyglots (n=217) all of whom had performed the same localizer. The polyglots showed both less extensive activation ($p<0.001$) and a smaller Sentences>Nonwords effect ($p<0.001$). No group differences were observed in two control brain networks (the Multiple Demand network and the Default Mode Network), arguing against ubiquitous differences in information processing between polyglots and non-polyglots. Why might polyglots use smaller patches of cortex to process language? One possibility is that they process language more efficiently from birth, even as they acquire their first language. Another possibility is that language processing becomes more efficient as a result of acquiring multiple languages. Without establishing a genetic basis for polyglotism combined with longitudinal investigations of individuals as they acquire new languages, both possibilities remain viable. Study 2: We examined the polyglots' neural responses to passages in their native language (L1), three non-native languages of high to moderate proficiency (L2-L4), two cognates of languages familiar to the participant (L5-L6), and two completely unfamiliar languages (L7-L8). Each language included a control scrambled-speech condition matched to the critical conditions acoustically but with no discernable linguistic content (Overath et al., 2015). The Intact>Scrambled contrasts for the different languages

activated highly overlapping areas within the language network. The Intact>Scrambled effect was reliable in all languages (ps<0.03), but its size generally scaled with proficiency, decreasing from L2 to L8, except for the response to L1, which was relatively low. Statistical comparisons revealed that a) the response to L1 was marginally lower than to familiar non-native languages (p=0.05); b) the response to both L1 and familiar non-native languages was stronger than to unfamiliar (non-cognate) languages (ps<0.004); c) the response to familiar non-native languages was stronger than to unfamiliar cognate languages (p<0.001); and d) the response to unfamiliar cognate languages was stronger than to unfamiliar non-cognate languages (p=0.05). Thus the ability to extract high-level linguistic information from the speech signal appears to lead to stronger responses in the language regions. Further, the response scaled with proficiency: the Intact>Scrambled effect decreased from L2 to L3 to L4, and could be predicted from self-rated proficiency ratings (p=0.038), in line with the idea that as proficiency increases one is able to extract progressively more meaning from the signal. However, one's native language constituted an exception: the response was lower than to familiar non-native languages, perhaps reflecting greater efficiency.

C69 Bilingual experience shapes language control networks: the role of L2 AoA and social context of language usage

Jason Gullifer[1], Xiaoqian Chai[1], Veronica Whitford[2,3], Irina Pivneva[1], Shari Baum[1], Denise Klein[1], Debra Titone[1]; [1]McGill University, [2]Massachusetts Institute of Technology, [3]Harvard University

Relative to monolinguals, bilinguals rely more on a distributed network of language and cognitive control regions (including prefrontal cortex, anterior cingulate cortex, and basal ganglia). Extant research investigates the impact of static language learning history, such as second language (L2) age of acquisition (AoA), on the functional organization of the neurocognitive control system. However, recent theoretical proposals note the additional importance of environmental and contextual factors in determining the type and extent of cognitive control processes deployed for bilingual language control. Bilinguals who maintain social networks where both languages are highly integrated likely shift attention and negotiate cross-language competition more frequently compared to bilinguals who spend their time using one language in each context. Thus, integrative language contexts are predicted to promote greater neurocognitive changes relative to compartmentalized social contexts (Abutalebi & Green, 2013, 2014, 2016). We report resting-state (RS) functional connectivity data from a sample of L1 French – L2 English bilinguals (N=27). RS analysis assesses correlated activation of brain networks when participants are at rest. We computed RS connectivity as a function of static language learning experience (L2 AoA) and the degree of mixed-language usage over social contexts (home, work, school, and social life). Results showed independent contributions of both experiential factors. Early L2 AoA was related to greater connectivity between left and right prefrontal cortex, replicating previous studies (e.g., Berken et al., 2016). Moreover, bilinguals who used the two languages in a more integrative manner exhibited greater connectivity among several areas of the bilingual control network (e.g., between anterior cingulate cortex and putamen, and left caudate and bilateral superior temporal gyri). Functional connectivity within the bilingual language control network was further related to proactive cognitive control as measured by an AX-Continuous Performance Task administered outside the scanner. Together, these findings support the hypothesis that static learning history and the social context of bilingualism jointly tune brain networks related to the control of the two languages. These analyses are being extended to a sample of older adults to investigate how social context of bilingualism affects neural networks during healthy aging.

Signed Language and Gesture

C70 Picture-Word Interference in Bimodal Bilinguals

Megan Mott[1], Katherine J. Midgley[1], Phillip J. Holcomb[1], Gabriela Meade[1,2], Zed Sevcikova Sehyr[1], Karen Emmorey[1]; [1]San Diego State University, [2]UCSD

A central issue in bilingual language performance concerns how bilinguals manage to select words in a target language while ignoring words in another language. Some models propose that lexical selection occurs via between-language competition (e.g., Green, 1998), others propose only within-language lexical competition for production (e.g., Costa, 2005), and still others suggest that competition does not occur at the lexical level but at a post-lexical, pre-articulatory level (e.g., Mahon et al., 2007). Bimodal bilinguals can uniquely inform these different accounts because their languages (here English and ASL) do not compete for articulation since they engage distinct motor systems. The current study examines cross-language activation in an ASL production task in bimodal bilinguals (individuals who are fluent in both a spoken and signed language) using a picture-word interference (PWI) paradigm. ASL-English bilinguals viewed a series of trials each of which presented a printed English word (200ms) immediately followed by a simple line drawing (2000ms) to be named in ASL. The words and line drawings were either identically related (e.g., the English word DOG followed by a picture of a dog), semantically related (e.g., DOG followed by a picture of a cat), or unrelated (e.g., DOG followed by a picture of a key). Participants were instructed to produce the ASL sign for the picture, regardless of the English word presented before the picture. Artifact-free ERPs were recorded time-locked to the onset of each picture stimulus and continuing for 800 ms. Reaction times (RTs) from picture onset were measured to hand liftoff from a button at the onset of sign production. Results indicate faster RTs to pictures following the English translation (translation priming)

than responses to unrelated pictures. However, RTs to pictures that were semantically related to the English prime word did not differ from unrelated word-picture pairs, replicating Giezen and Emmorey (2016). Importantly, as in previous PWI ERP studies with unimodal bilinguals, there was evidence of an N400 priming effect for both translation and semantic pairs, suggesting that participants were sensitive to the relationship between primes and targets in both conditions. This pattern of results suggests that English words presented before target pictures in the PWI paradigm are processed for meaning by bimodal bilinguals, but the activated English word does not compete for articulation with the target ASL sign, and thus ASL naming latencies are not slowed in the semantic-related condition. The findings are most consistent with a post-lexical (articulatory buffer) account of cross-language interference in the PWI paradigm.

Perception: Speech Perception and Audiovisual Integration

C71 Neural Correlates of Atypical Categorical Perception in Dyslexia

Sara Beach[1,2], Tracy M. Centanni[2], Ola Ozernov-Palchik[2,3], Sidney C. May[2], Dimitrios Pantazis[2], Tyler K. Perrachione[4], John D. E. Gabrieli[2]; [1]Harvard University, [2]Massachusetts Institute of Technology, [3]Tufts University, [4]Boston University

Many studies find that individuals with dyslexia perceive speech sounds less categorically than typically-developing individuals do, which likely impedes mapping speech sounds to print during reading acquisition. This deficit manifests in less consistent labeling of individual sounds, a shallower slope of the identification function over a sound continuum, weaker discrimination of two sounds that lie across a phonemic boundary, and better discrimination of sounds that lie within a phonemic category. The reason for these behavioral phenomena has not been conclusively identified. At least a subset of dyslexics seems to have auditory processing deficits, particularly for rapid spectrotemporal features that cue consonant identity, and there is evidence that neural hyperexcitability contributes to more variable sensory encoding. In parallel, dyslexics fail to benefit from regularities in acoustic signals, leading to a deficit in stimulus-specific adaptation, which may diminish the ability to abstract both short- and long-term representations. In this study, we explored how these brain-based theories account for categorical perception deficits in dyslexia. Our first aim was to determine whether neural mismatch responses pattern categorically, such that between-category mismatches are greater than within-category mismatches, or whether mismatch responses are graded according to the acoustic distance between the deviant and the standard. This would reveal the degree to which subphonemic information is preserved in automatic speech processing, and whether this differs in dyslexia. Our second aim was to spatially and temporally characterize neurophysiological phoneme adaptation by testing whether classifier error is reduced for subsequent stimulus repetitions, and whether this effect differs in dyslexia – exploring for the first time how neural adaptation affects the coherence of neural representations. Adults with and without dyslexia completed two tasks while undergoing magnetoencephalography (MEG). First, participants labeled 40 instances each of ten continuum tokens, in random order, as either 'ba' or 'da'. From their responses, we derived each individual's identification function and selected from it five equidistant tokens representing two endpoints, two within-category tokens, and an ambiguous midpoint. In the second task, participants were exposed to these tokens in a passive roving-oddball paradigm. Trains of four to six token repetitions were presented with a 250-ms interstimulus interval, for a total of 3000 items, while participants watched a silent movie. We conducted univariate analyses of the magnitudes of the neural mismatch response to the deviant syllable and of neural adaptation within a syllable train, as the deviant (the first token) gradually became a standard. We also trained a machine learning classifier to distinguish token identity and tested it on held-out portions of the MEG data. Using exemplars selected to best represent each individual's perceptual space, preliminary data show how categorical representation of speech is encoded in the cortical response patterns of adults with and without dyslexia, and include specific examination of the M100 component, at whose latency the persistence of subphonemic information has been unclear. MEG data reveal neurophysiological adaptation to these repeated exemplars and varied decodability of each exemplar with respect to its position on the continuum and its repetition history.

C72 Brain-behavior relationships in implicit learning of non-native phonetic categories

Sahil Luthra[1], Pamela Fuhrmeister[1], Peter J. Molfese[2], Sara Guediche[3], Sheila E. Blumstein[4], Emily B. Myers[1,5]; [1]University of Connecticut, [2]National Institutes of Health, [3]Basque Center on Cognition, Brain and Language, [4]Brown University, [5]Haskins Laboratories

Learning non-native speech sounds in adulthood is notoriously difficult, and perceptual studies probing non-native phonetic learning in the laboratory have typically employed explicit training paradigms. Functional neuroimaging data from explicit training studies have suggested that learning involves a shift in processing from frontal regions to temporo-parietal ones (Golestani & Zatorre, 2004; Myers & Swan, 2012). However, it is unclear whether these same brain regions are also recruited for non-native phonetic learning in the absence of overt category labels. Of particular interest is whether activation observed in frontal areas in previous phonetic learning studies is a result of using an explicit categorization task. In this study, we examined participants' behavioral sensitivity to a difficult non-native phonetic contrast (the Hindi dental-retroflex contrast) following several

training sessions with an implicit learning paradigm (Vlahou, Protopapas & Seitz, 2012). To investigate potential relationships between brain and behavior, neuroimaging data were collected before and after training. Functional scans employed a short-interval habituation paradigm to test for differences in BOLD signal when phonetic category information was held constant (within-category trials) compared to when phonetic category information varied (between-category trials). As is common in non-native phonetic training studies, some participants appeared to be able to capitalize on the implicit training paradigm, whereas others showed no evidence of learning. In fact, implicitly-trained participants were not significantly better than a group of naïve participants, despite a numerical trend in the expected direction. To examine changes in brain activity as a function of individual differences in learning, we included factors of Session (before and after training) and Token Type (between- vs. within-category trials) and included behavioral post-training discrimination scores as a continuous covariate. Functional neuroimaging data revealed that bilateral middle and inferior frontal gyri were less active after training than before training (effect of Session), and LMFG and LIFG were sensitive to the phonetic category distinction (effect of Token Type). The left supramarginal gyrus was sensitive to the interaction between Session and Token Type, while the right SMG was sensitive to an interaction between Session, Token Type, and participants' behavioral scores on the post-training discrimination assessment. A generalized psychophysiological (gPPI) interaction analysis indicated that the left frontal regions that were sensitive to the phonetic category distinction (LIFG/LMFG) showed increased functional connectivity with temporo-parietal regions (bilateral SMG and angular gyri) as a function of session and of post-training discrimination scores. Taken together, the data suggest that the same frontal areas recruited in explicit learning of non-native phonetic categories are recruited even in the absence of overt category labels. These findings are broadly consistent with non-native phonetic learning frameworks (e.g., Golestani & Zatorre, 2004; Myers & Swan, 2012) in which processing of non-native speech sounds extends beyond frontal areas and engages temporoparietal regions as a result of learning.

C73 Neural entrainment to acoustic edges in speech

Maria Oana Cucu[1], Nina Kazanina[1], Conor Houghton[1]; [1]University of Bristol

Introduction The theta rhythm of neural oscillations was shown to reliably track speech at the level of syllables (Luo & Poeppel, 2007). Syllable onsets may aid neural entrainment by acting as acoustic edges for phase resetting (Doelling et al., 2014). Furthermore, the level of entrainment depends on the intelligibility of the stimulus, with native speech eliciting stronger responses than foreign speech (Perez et al., 2015). Our aim was to investigate whether the acoustic properties in the syllable onsets of natural speech modulate neural entrainment. The effects of syllable onsets on neural entrainment was explored both in the native (English) and foreign (Russian) language. Methods The quality of the acoustic edge provided by the syllable onsets was varied in each language condition by using either 'strong' ('b','d','g','k','p','t') or weak ('f','l','r','s','v','z') consonants. For each language, we used 20 sets of stimuli comprising of a strong, weak and filler sentence. Sentences were between 8-11 syllables long and were all matched for length (in syllables), lexical stress and syntactic structure. Each sentence was repeated four times. Nineteen native speakers of English listened to the stimuli and were required to press 'Space' as soon as they heard a cough (that always occurred within a filler sentence). EEG was recorded using a 32-channel BrainProducts system at 1KHz sampling rate. Analysis For each subject, we computed the cerebro-acoustic coherence between the EEG signal of individual channels in each trial, and the sound envelope of the stimulus. Sharpness values for each stimulus were obtained as the positive derivative of the sound envelope, normalised by the integral of the envelope. Results (preliminary) Sharpness values were significantly greater in the strong versus weak condition across both language, but there was no difference between English and Russian. Coherence values clearly follow different trends in each condition. The present analysis focused on the theta (4-8 Hz) and gamma (25-40 Hz) ranges only. In line with previous findings, coherence was significantly greater in the theta than in the gamma range ($p<.05$). In the theta range, we obtained greater coherence to weak than strong consonants, and this was only significant in the native language condition. In the gamma range, strong English stimuli elicited higher coherence than the other conditions, although not significantly. While we expected more entrainment to strong versus weak stimuli in both the theta and gamma ranges, it is possible that acoustic edges as defined by their phonetic characteristics may only aid neural entrainment in their corresponding frequency domain. Instead, neural entrainment in the theta range may reflect a process of tracking syllable onsets, and therefore temporal properties of speech, rather than acoustic ones. We are currently conducting further analyses to shed light onto this phenomenon.

C74 Tonal triggers to word-level and sentence-level predictions

Pelle Soderstrom[1], Merle Horne[1], Mikael Roll[1]; [1]Lund University

The present contribution describes two studies of anticipatory processing at two different levels of language structure. The investigations take advantage of predictive prosodic cues occurring in Swedish to study the effect of prediction triggered by a tonal cue before the predicted structure has been heard. The neural underpinnings of both word-internal and sentence-level predictions were investigated using concurrent ERP/fMRI paradigms in two separate experiments. We propose that both types of prediction are indexed by an ERP component, the 'pre-

activation negativity' (PrAN), which has previously been linked to predictive certainty (Söderström et al. 2016). In the word-level experiment, participants listened to sentences with critical words in which the tone (low or high) of a word's stem is predictive with regard to suffixes attached to the stem. Critical words were nouns which had either singular or plural endings. Low stem tones cue singular suffixes while high stem tones cue plural suffixes in Central Swedish. The high tone is also a cue for compound word structure. Thus, high stem tones always cue a larger number of possible continuations. This is also the case for high tones at the beginning of clauses, where they can cue different kinds of structures (statements, questions) as opposed to low clause-initial tones which only cue subordinate clause structure. In the second experiment, we therefore took advantage of sentence-level tones that cue either an upcoming main or subordinate clause structure in embedded clauses. ERPs and event-related fMRI were time-locked to both predictive cue onset (i.e. the tone) and onset of the predicted structure. Results show that more predictive cues, both at word level and sentence level, gave rise to a left-lateralised and anterior pre-activation negativity in the ERPs, at around 100 ms after cue onset. At the word level, predictive cues also increased activity in the left inferior parietal lobe and temporal lobe, while the pre-activation negativity for more predictive cues at the sentence level correlated with activity in left inferior frontal gyrus (BA44) and anterior insula. Disconfirmed predictions led to P600 effects in both studies, with an additional N400 found for unexpected suffixes. We suggest that the pre-activation negativity reflects the pre-activation of strongly expected linguistic information at both the word and sentence level.

C75 Early Sensory Changes in Neural Processing Gate Generalized Perceptual Learning

Shannon Heald[1], Sophia Uddin[1], Stephen Van Hedger[1], Joel Snyder[2], Howard Nusbaum[1]; [1]The University of Chicago, [2]University of Nevada, Las Vegas

The ability to generalize beyond a series of experiences is an important aspect of learning. This ability may underlie robust recognition of spoken words despite a wide range of acoustic-pattern variability, noise, and distortion in the listening environment. While there is evidence that generalized learning from training results in changes in central auditory processing, the time course and nature of these changes is unclear. To assess how generalized learning rapidly alters central auditory processing, we measured auditory evoked potentials (AEPs) while listeners engaged in a generalized synthetic speech learning task. Listeners were tested and trained on synthetic speech (Rsynth, a Klatt based synthesizer) generated by rule, containing degraded and sometimes misleading acoustic cues. Training consisted of identification of single spoken words followed by a paired presentation of the spoken word with its printed form. We measured single word AEPs to 100 words at pretest before training and to 100 words at posttest after training with 128 electrodes (EGI system). Testing consisted of word identification without feedback. As a consequence of training, listeners' recognition of hard-to-understand synthetic speech rapidly improved, even though no words repeated across tests or training, indicating successful generalized learning. Analysis of changes in the AEPs from pretest to posttest revealed both short-latency and long-latency changes concomitant with generalized learning. The degree of behavioral improvement was significantly related to long-latency brain electrical responses (~584 ms to 784 ms) in posttest AEPs. However, a multiple mediation analysis revealed that early AEP components (during the N1 and P2 period), that reflect changes in auditory cortex, mediated this association. These results suggest that generalized learning can quickly alter central auditory processing and that such changes, which reflect an adjustment of attention and refinement of auditory representations, appear to mediate changes in later stages of processing.

C76 Cortical entrainment depends on temporal predictability, not periodicity

Geoffrey Brookshire[1], Daniel Casasanto[1,2]; [1]University of Chicago, [2]Cornell University

When people perceive language, low-frequency cortical oscillations (< 8 Hz) entrain to rhythms in the stimulus. Entrainment to language may be a neural strategy to boost perceptual sensitivity to informational peaks in a time-varying signal. What neural processes support cortical entrainment to language? Here we test two possible answers to this question. First, neural entrainment may occur when intrinsic cortical oscillations become synchronized to rhythmic stimuli, analogous to mechanical resonance between coupled oscillators. Second, entrainment may reflect active neural predictions: The brain may form predictions of upcoming events, and adjust the phase of ongoing broadband oscillations to ensure that perceptual systems are maximally sensitive when important information occurs. To test these hypotheses, we recorded electroencephalography (EEG) while participants watched sequences that varied in their temporal predictability and periodicity. If entrainment relies on coupling of intrinsic oscillations, then cerebral cortex should only entrain to periodic stimuli. Alternatively, if entrainment depends on active, flexible temporal predictions, then cerebral cortex should entrain to any stimuli that are temporally predictable. We recorded EEG from human subjects (N=11) while they watched sequences of flashing abstract images. Participants performed a vigilance task in which they pressed a button whenever a specific image appeared. Inter-stimulus intervals (ISIs) comprised 4 approximately logarithmically-spaced values (100, 167, 300, 500 ms) in a similar frequency band as variability in the volume envelope of speech (2–10 Hz). Stimuli appeared in three conditions. In the periodic and predictable (Periodic-Predictable) condition, all stimuli within a block were separated by the same ISI, giving uniform and perfectly predictable timing. In the aperiodic

and unpredictable (Aperiodic-Unpredictable) condition, the ISIs were randomly shuffled. In the final condition, stimulus onsets were not periodic at the frequency of the individual stimuli, but remained perfectly predictable (Aperiodic-Predictable). To construct sequences in this condition, we created a group of the 4 distinct ISIs. This ISI group was then repeated back-to-back (e.g. ABCDABCD…). Because every ISI uniquely predicts the following ISI, this condition is perfectly predictable despite between aperiodic on the level of individual items. We measured entrainment by computing the cross-correlation between stimulus onsets and EEG activity in each electrode. Stimulus onsets were coded as impulse responses and matched with EEG recordings using a photodiode. The magnitude of the cross-correlation at any given time-lag indicates how strongly the EEG signal predicts a stimulus onset. Cross-correlations were stronger for Periodic-Predictable sequences than for Aperiodic-Unpredictable sequences. Furthermore, cross-correlations were stronger for Aperiodic-Predictable sequences than for Aperiodic-Unpredictable sequences. Predictability boosted entrainment at both positive and negative lags, indicating that cortical activity reflects predictable stimuli before they occur. However, item-wise periodicity did not have any effect on entrainment beyond that of temporal predictability; differences between Periodic-Predictable sequences and Aperiodic-Predictable sequences were weak and varied by timing-lag. People entrain more strongly to predictable sequences than to random sequences, both before and after the stimulus appears, even when those sequences are not periodic at the item frequency. We conclude that cortical entrainment does not rely on coupled oscillators. Instead, entrainment reflects active and flexible cortical predictions.

C77 When Do Words Get in the Way? An EEG Investigation of the Interaction between Talker and Linguistic Cues in Speech Processing

Philip Monahan[1], Chandan Narayan[2]; [1]University of Toronto, [2]York University

Talker- and linguistic-specific information have been shown to segregate relatively early in auditory cortical processing (Formisano, De Martino, Bonte, & Goebel, 2008). How and when these two information types interact is largely unknown. Recent behavioral findings suggest that a listener's discrimination of two talkers each speaking a single monosyllabic word of English is affected by the lexical relatedness of the two words (Narayan, Mak, and Bialystok, 2016). Discrimination accuracy was significantly poorer when the same talker produced a sequence of words that were linguistically unrelated (e.g., "tooth"-"bread") compared to when that sequence formed a compound (e.g., "tooth"-"paste"). Similarly, when different talkers produced words forming a compound, listeners' discrimination of their voices was significantly worse compared to unrelated words. We present the results of an EEG study that suggest that listeners expect words spoken by the same talker to be linguistically related. Furthermore, this expectation occurs relatively early in the neurophysiological response during the sequential presentation of two words. Sixteen native speakers of English participated. Stimuli were 90 auditory pairs of words that were either a repetition (e.g., "tooth"-"tooth"), compound or unrelated (see above). Each pair was repeated four times (360 total trials) by two male native speakers of English (e.g., M1-M1, M2-M2, M1-M2, M2-M1). EEG recordings were acquired with a 32-channel system (Brain Products GmbH, Germany). For statistical analyses, the dependent variable was the mean amplitude of ERP waveform in four time-windows: P50 (40-100ms), N1 (100-175ms), P2 (175-250ms) and a late negativity (300-500ms). These values were aggregated over Frontal/Central electrode sites. The data was submitted to a maximal mixed effects model with the fixed effects of Talker (Same, Different) and Condition (Repeated, Compound, Unrelated). ERP results revealed patterns consistent with the behavioral findings in Narayan et al. (2016). Significant Condition by Talker interactions were observed in the N1, P2, and N4 time-windows. Pairwise interaction comparisons were performed to assess the effect of Condition in different Talker contexts. In particular, we found significant differences in the ERP responses in these three time windows between the Compound and Unrelated conditions when talkers were the Same (N1: $X2(1)=8.09, p<0.05$; P2: $X2(1)=9.06, p<0.05$; Late Negativity: $X2(1)=9.66, p<0.01$). In the late negativity time-window, we do not observe a difference between the Repeated and Compound conditions ($X2(1)=0.38, p=0.54$), while the Unrelated condition elicited are larger negativity relative to the Repeated ($X2(1)=8.22, p<0.05$) and Compound conditions ($X2(1)=6.74, p<0.05$). These results suggest that words spoken by the same talker are privileged with an expectancy of linguistic relatedness. Unrelated words spoken by the same talker elicited a significantly larger potential in the three time windows relative to compound words, and in particular, the Unrelated condition elicited a larger negativity in the Late Negativity window compared with the other two conditions. Finally, ERPs reveal that linguistic processing is integrated with the acoustic characteristics of talkers and occurs on a very short time scale, as differences are observed in middle-latency auditory ERP responses, from approximately 100ms post-stimulus onset.

C78 High gamma neural responses dissociate between the acoustic and linguistic analysis of temporal speech structure

Gregory Cogan[1], John Pearson[2], Michael Haglund[1], Saurabh Sinha[1], Tobias Overath[2]; [1]Duke University School of Medicine, [2]Duke University

Speech perception entails the mapping of the acoustic waveform to its linguistic representation. For this mapping to succeed, the speech signal needs to be tracked across a large temporal range at high temporal precision in order to decode linguistic units (e.g. phonemes, syllables, words). Here we test how cortical processing of such temporal

speech structure is modulated by higher-order linguistic analysis. To control the temporal scale of analysis, we used a novel sound-quilting algorithm that controls acoustic structure at different temporal scales; using fMRI, we recently showed that activity in human superior temporal sulcus (STS) increases as a function of temporal scale in an unfamiliar language (Overath et al., 2015). To control the linguistic content, we constructed speech quilts from both familiar and foreign languages. This ensures that any changes at the signal-acoustics level affect both languages identically, while manipulating the linguistic percept differently. Thus, neural responses that vary as a function of segment length but are shared or similar across the two languages suggest analysis at the signal-acoustics level, whereas neural responses that differ based on language familiarity imply the presence of linguistic processing. Here, we recorded electrocorticography (ECoG) from electrodes placed over left temporal or fronto-temporal lobes in three patients who were undergoing pre-surgical monitoring for pharmacologically resistant epilepsy. Patients listened to 6 s long English or Korean speech, quilted with 30 ms or 960 ms segment lengths. Electrodes with significant auditory responses were initially assessed via a permutation test between the 1 s time window following sound onset compared to the pre-stimulus baseline. Neural signals were filtered between 70 and 150 Hz (high gamma) and the results were Bonferroni corrected for multiple comparisons across electrodes. 20/124 electrodes demonstrated a significant auditory response. Within these electrodes, a follow-up analysis showed that sustained high gamma responses throughout the 6 s sounds showed a main effect of segment length (30 vs. 960 ms) in 85% (17/20), a main effect of Language (English, Korean) in 60% (12/20), and an interaction in 50% of auditory electrodes (10/20). Specifically, electrodes that showed an interaction generally displayed a larger increase in high gamma power as a function of segment length in English than in Korean. These results suggest that high gamma neural responses are a potential neural mechanism for tracking speech-specific temporal structure. Ref: Overath T, McDermott JH, Zarate JM, Poeppel D (2015). Nat Neurosci 18:903-911.

C79 Effects of Signal Quality on Audiovisual Integration in Cochlear Implant Users

Hannah Shatzer[1], Mark Pitt[1], Aaron Moberly[1], Jess Kerlin[2], Antoine Shahin[2]; [1]Ohio State University, [2]University of California, Davis

Humans frequently use both auditory and visual signals simultaneously to understand speech when communicating with each other. While individuals with normal hearing typically use auditory speech as the dominant mode of communication, visual speech cues (e.g. mouth shape, tongue and jaw movement) often provide linguistic information and become more valuable for accurate perception when the auditory signal becomes noisy or less reliable, such as in a crowded restaurant. Visual speech cues are even more important for cochlear implant users, whose electroacoustic speech signal is severely impoverished. The Dynamic Reweighting Model (Bhat et al., 2015) posits that if the auditory signal is noisy, a clear visual speech signal will suppress and overwrite early auditory cortex information, causing a reweighting of neural processing in favor of the reliable visual linguistic information. Therefore, cochlear implant users would show a stronger weighting of visual speech information and stronger suppression of early auditory cortex. The current study tested this prediction using postlingually deafened cochlear implant (CI) users and age-matched normal-hearing (NH) controls in an AV identification task. Participants completed an AV task with electroencephalography (EEG) recording in which auditory tokens (/aba/, /aga/, /awa/) were presented at a signal-to-noise ratio (SNR) above or below a predetermined threshold and paired with congruent or incongruent videos of the mouth movements for the tokens. Videos were either clear or highly blurred. Participants identified the consonant they heard, with the addition of a fourth response button for perception of consonants other than /b/, /g/, or /w/ (e.g. the McGurk effect; McGurk & MacDonald, 1976). Behavioral results indicated that while NH controls were always likely to report the consonant presented in the auditory stimulus regardless of SNR or visual clarity, CI users were more prone to reporting the visually presented consonant or a McGurk/fusion percept, particularly when the visual signal was clear and the auditory signal was presented below their SNR threshold. ERP results time-locked to the acoustic onset show P1 suppression for clear visual conditions compared to blurred in both CI and NH participants; however, CI users also show N1 amplitude suppression for blurred conditions that is not present in NH controls. These results together suggest that CI users weight the visual speech signal more heavily in AV integration than NH controls when the visual signal is clear, implying a stronger influence of visual information on early auditory cortex when the acoustic signal is less meaningful. This finding is consistent with the predictions of the Dynamic Reweighting Model: Linguistically salient visual information, as seen in clear as opposed to blurred speech, appears to suppress and overwrite early auditory activity, thus indicating a heavier weighting of visual speech. The effects of visual speech on early auditory cortex are even more pronounced for CI users, who are constantly exposed to an impoverished acoustic speech signal.

Poster Session D

Thursday, November 9, 6:15 – 7:30 pm, Harborview and Loch Raven Ballrooms

Animal Communication

D1 von Economo and fork neurons in vocal forebrain nuclei of vocal learning birds : neural basis of Vocal learning and language

Shubha Srivastava[1]; [1]Kashi Naresh Government Post Graduate College, Gyanpur U P India

Vocal learning, the capability of modifying, memorizing and producing complex auditory and syntactic sounds, or imitating the new sounds, is an indispensable requirement of human spoken language. This capability is considered as a significant innovation for the evolutionary origin of the human verbal communication. Little attempt was made to link neural systems for vocal learning in birds and mammals with that for spoken language in humans because this talent is randomly distributed in both these taxa. To understand how evolution designed brain circuits for acquiring language and speech the avian brain has been used as a model as birds have been shown to be remarkably intelligent in a similar way to mammals such as humans and monkeys. A network organization of the vocal counterparts of the brain of a few Indian vocal learner birds like a Ringneck parrot, exceptional for oratory skill of human language and emotional makeup, budgerigar and songbirds have been investigated by Nissl staining, Golgi, and Neuroimaging methods. Dendritic neuroarchitecture of all the neuronal subtypes and their morphometry has also been examined.Results unveiled that their brain is organized very differently from the laminar cortex of mammals and other birds as well, but neuronal classes are remarkably similar to upper layers of the frontoinsular cortex of human and other vocal learning mammals. The detail anatomical investigation of compact vocal nuclei and their neuroarchitecture revealed the presence of some unusual, rare neuronal types, the von Economo neurons (VENs), fork cells and enveloping neurons with a typical pyramidal neurons in nidopallium caudolaterale, arcopallium and dorsolateral corticoid areas of the bird's pallium; these cells have been noticed to date only in layer V of the frontal insular cortex of humans, a few primates and distantly related groups of mammals especially cetaceans (harbor seals, whale and dolphin) pinnipeds (walrus), pigmy hippopotamus , elephants, ring-tailed lemur, pig , deer, macaque monkey, rock hyrax, and zebra. Most of these vertebrates communicate acoustically, but a few, among them such as humans, dolphins, elephants, whales, and a few primates in which VENs are more abundant, larger and clustered can learn to produce elaborate patterns of vocalizations and to grasp the meaning of sound. While the other VENs containing animals are moderate and limited vocal learner and have numerically less and scattered VENs. These findings challenged the previous opinion that VENs are almost exclusive in hominids and large-brained animals, and appeared only recently during evolution on one hand and on the other hand it provides a new insight in the direction to understand that these neurons might in some way be related to the vocal production learning and language. Morphological alterations in these cells have also been associated with some neuropsychiatry and neurodegenerative disorder which affects language skills like- Dementia, Autism, and Alzheimer' s. This study will also be useful to track that whether von Economo neurons might in some way be related to the disease process itself, and to gain insight for the treatment of language-related disorders.

Grammar: Syntax

D3 Linking white matter integrity to syntactic category processing - an ERP and DTI study

Wan-ting Lin[1], Chen-Hsiang Weng[1], Min-Hsin Chen[1], Wen-Yih Isaac Tseng[1], Joshua Oon Soo Goh[1], Chia-Lin Lee[1]; [1]National Taiwan University

This study investigated the structural basis of syntactic neural networks across the left and right hemispheres (LH, RH). We used event-related potentials (ERP) to assess structural (P600) and lexical-semantic (N400) aspects of syntactic category processing in 16 young right-handers without familial sinistrality during a grammaticality judgment task. Two-word Chinese phrases were presented word by word on a screen. ERPs were time locked to target words presented laterally to either left or right visual fields (LVF, RVF), matching or mismatching the syntactic category expectancy established by a preceding central cue (e.g., Grammatical: li□ng-dòng fáng-zi "two houses"; jí-shí bang-máng "to immediately help". Ungrammatical: jí-shí fáng-zi "immediately house"; li□ng-dòng bang-máng "to two help"). Consistent with English findings, our results showed a left-lateralized P600 grammaticality effect with right VF presentation only and bilateral N400 grammaticality effects with both VF presentations. In the same participants, we used diffusion tensor imaging (DTI) to assess the white-matter fractional anisotropy (FA) reflecting microstructural tissue integrity of the corpus callosum (CC) and tracts found to be relevant for syntactic processing—superior longitudinal fasciculus (SLF), uncinate fasciculus (UF), semantic processing—inferior fronto-occipital fasciculus (IFOF), inferior longitudinal fasciculus (ILF), and tracts relaying dorsal syntactic and ventral semantic streams—perpendicular fasciculus (PF). Lower left-lateralized P600 effects significantly correlated with higher right ILF integrity, which was also marginally associated with higher LVF/RH P600 effects. This finding suggests that LVF/RH P600 is semantically mediated, and, consistent with the literature, that reduced language left-lateralization is due to increased RH instead of reduced LH activation. We also found important associations of the CC with lateralization of syntactic category processing. Higher integrity of anterior CC (precentral gyrus) correlated

with reduced RVF/LH P600 effects, and higher integrity of posterior CC (postcentral gyrus, temporal pole, and inferior parietal lobule) correlated with a left-dominant trend (reduced LVF/RH overall grammaticality effect and larger RVF/LH N400 effect). These results underscore the importance of examining the differential roles of CC connections—excitatory or inhibitory—across callosal sub-regions. Finally, larger RVF/LH N400 grammaticality effects were associated with higher integrities of the left IFOF, supporting the semantic nature of IFOF involvement, and left PF, implicating the cross-talk between syntactic and semantic processes in the presently observed N400 effects. These findings bridge critical knowledge gaps between white-matter microstructure and temporally dynamic neural activities underlying language comprehension.

D4 On the neural dynamics of syntactic prediction *K. Strijkers[1], V. Chanoine[2], D. Munding[3], A.-S. Dubarry[1], A. Trébuchon[4], J.-M. Badier[4], F.-X. Alario[3]; [1]Aix Marseille Univ, CNRS, LPL, Aix-en-Provence, France, [2]Aix-Marseille Univ, Brain and Language Research Institute, Aix-en-Provence, France, [3]Aix Marseille Univ, CNRS, LPC, Marseille, France, [4]Aix Marseille Univ, INSERM, INS, Inst Neurosci Syst, Marseille, France*

The human brain can predict upcoming linguistic information based on prior constraining contexts, an important asset to enhance the speed and efficiency of language processing. However, the scope and nature of the neural dynamics underpinning predictive processes in language remains poorly understood. The current study examined whether the brain utilizes grammatical information to anticipate syntactical structure in a continuous and automatic fashion, and the spatiotemporal dynamics that would drive such syntactical predictions. We conducted an MEG experiment in which we contrasted MRI-constrained sources elicited by nouns and verbs when they were preceded by a predictive context (i.e., possessive pronouns for nouns, and personal pronouns for verbs) versus an unpredictive context (visually matched symbols). The results showed rapid (from ~80 ms onwards) noun-verb differences in the left and right inferior frontal gyri (IFG), but only when those nouns and verbs were preceded by the syntactically predictive context (i.e. their corresponding pronoun). Furthermore, the contrast between possessive and personal pronouns that preceded the rapid noun-verb modulations in the IFG also produced differences in source activation in various regions of the prefrontal cortex (the superior frontal and orbitofrontal cortex), previously associated with top-down processes such as goal-directed behaviour, planning and proactive biasing. Taken together, these data demonstrate that predictive processing constitutes an integral and automatic part of the neural dynamics underlying syntactic parsing. These syntactic predictions may be sustained by the dynamical binding of the IFG with a domain-general, top-down biasing network in prefrontal cortex.

D5 ERP responses to two types of subject island violations and constructions with substantially similar processing dynamics *Jayeon Park[1], Jon Sprouse[1]; [1]University of Connecticut*

The goal of this experiment is to expand the set of ERP responses to complex syntactic phenomena, in order to contribute to the expansion of the empirical base of syntax beyond offline acceptability judgments. To that end, we compared two types of subject island violations to two constructions that share some of the same sentence processing dynamics. Though these results don't militate for or against any specific syntactic or processing theories yet, the results could be leveraged in the future to adjudicate less clear cases in the syntactic literature (e.g, Korean island effects). Our first comparison is between standard subject island violations in (1), and yes-no questions with a missing word in (2). (1) *What did [the article about __] annoy the governor? (2) *Did [the article about __] annoy the governor? Neville et al. 1991 recorded ERPs to (1), and found a more positive P2 peak and a P600/SPS at the verb after the illicit gap. Given that the active filling strategy is suspended within complex subjects (Stowe 1985), it seems plausible that the parser initially interprets the preposition-verb sequence in (1) as representing a missing word rather than a wh-gap. This suggests that a minimal comparison would be with a yes-no question with a missing word as in (2). Any unique effects in (1) versus (2) could represent properties of wh-dependency processing and subject island constraints. Our second comparison was between the non-finite subject island in (3), and a classic filled-gap paradigm as in (4). (3) *What did [the attempt to clean __] immediately shatter the beaker after the experiment? (4) What did the surgeon clean the scalpel carefully and thoroughly with __ at the hospital? The rationale behind this comparison is that the locus of ungrammaticality in (3) is not the gap, because the sentence would be grammatical if there were a gap downstream at the matrix object position; therefore the ungrammaticality arises at the filled-potential-gap after the matrix verb (Endgahl 1983, Phillips 2006). We compared ERP responses (N=24, RSVP, 500ms SOA, 200ms ISI) to (1-4) with matched grammatical controls. For both subject islands and missing words, we found increased P2 responses and late P600/SPSs. We also observed a marginal gradient negativity in the 300-500ms window (missing-word > subject-island > control), and a significant late anterior negativity for the missing word violation. For the classic filled-gap effect, we found a sustained anterior negativity (SAN) that is smaller in the words before the filled-gap location, and increases for the words after the filled-gap location. To our knowledge, this is the first report of an increasing SAN (cf. Phillips et al. 2005), which could be indexing the re-starting of the wh-dependency after the

incorrect gap-filling at the verb. We observed no similar effect for non-finite subject islands. Instead, we observed two phasic posterior negativities after the "filled-gap". Though much work remains in linking these effects to specific processes, these results suggest that ERP responses to island constraints are qualitatively distinct from violations with similar processing profiles.

D6 In search of syntax: The case of English post-nominal modification

Graham Flick[1], Liina Pylkkänen[1,2]; [1]New York University Abu Dhabi, [2]New York University

A principal challenge for the study of the neural underpinnings of syntax is deconfounding it from semantic composition. Consequently, attempts to isolate syntax typically involve stimuli that are either not representative of natural language (e.g., violation or jabberwocky stimuli) or working memory intensive (making it hard to separate syntactic effects from effects of memory). The perfect test of syntax would involve well-formed lexically identical instances of natural language, which nevertheless differ in syntactic complexity, without semantic consequences. While such cases may be impossible to find in pure form, we developed a study around post-nominal modification in English, which allowed us to come close to meeting these requirements. While the canonical position of adjectival modifiers in English is pre-nominal (wide trail), certain classes of "heavy" modifiers are licensed post-nominally (trail wide enough to allow…). Although the semantic impact of pre- vs. post-nominal modification is very similar, post-nominal modification is hypothesized to be more structurally complex (e.g., Sadler & Arnold, 1994). We compared post-nominal modification to string-identical sequences which instead of post-nominal modification, exemplified predication structures as in "this trail is wide". To make the noun and adjective adjacent, a question form of such expressions was used, resulting in the contrast (a) vs. (b): a. Post-nominal: "There are many trails wide enough to allow…" b. Predication: "Are many trails wide enough to allow…". To test whether any observed differences may be due to the declarative vs. interrogative nature of the expressions, a parallel control experiment was run with pre-nominal modification embedded inside similar questions and statements. Finally, to compare effects of syntactic and semantic composition, we also varied the semantic match between the types of the adjectives and nouns, such that in some cases semantic composition required a coercion operation (e.g., interpreting "difficult trail" requires the insertion of some activity as in difficult TO-HIKE trail whereas an event nominal can compose with difficult directly: "difficult trek"). In all, both the post-nominal main experiment and the pre-nominal control experiment fully crossed the factors Syntactic Frame (statement vs. question), Noun Type (entity vs. event) and Adjective type (entity vs. event). The second word of the adjective-noun or noun-adjective sequences was always the target of MEG analysis. Results: Analysis of the post-nominal main experiment revealed a main effect of Syntactic Frame in the posterior superior temporal lobe, between 205 and 225 ms, while no parallel effect was seen in the control experiment, suggesting the effect indeed tracked the presence of post-nominal modification. While we did not identify any correlate of the hypothesized semantic coercion operation, a semantically modulated pattern of activity was identified in the left anterior temporal cortex, with largest amplitudes for the semantically simplest combinations of adjectives and nouns. This conforms to prior findings implicating the LATL in "simple" cases of conceptual combination (Ziegler & Pylkkänen, 2016). In sum, this study isolates activity in the posterior temporal cortex as a potential correlate of syntactic composition, and offers further evidence for the LATL as a locus of "quick and easy" conceptual combination.

D7 The role of structural repair and presentation modality in (dis)agreement processing in Dutch: An ERP study

Srdan Popov[1,2], Roelien Bastiaanse[2]; [1]International Doctorate for Experimental Approaches to Language and Brain (IDEALAB), Universities of Groningen (NL), Newcastle (UK), Potsdam (DE), Trento (IT), Macquarie University (AU), [2]Center for Language and Cognition Groningen (CLCG), University of Groningen, The Netherlands

In this ERP study, conducted in both visual and auditory modality, we compared how DP-internal gender and number disagreement is processed. Theoretically, number and gender disagreement in Dutch differ in three major aspects: 1) number is semantically determined (numerosity), while gender is inherent (lemma); 2) number is morphological (plural suffix) and gender is lexical; 3) number disagreement allows for more repair options. Regarding the last point, number disagreement can be repaired either at the noun (e.g., singular into plural) or the preceding element (e.g., singular article into plural article). In contrast, gender cannot be repaired at the noun, being a lexical feature. Previous studies (e.g., Aleman-Bañón, Fiorentino, & Gabriele, 2012; Barber & Carreiras, 2005) have often reported a biphasic response of LAN and P600 to both kinds of violation. Barber and Carreiras (2005) reported a small increase in the late stage of P600 in gender disagreement compared to number disagreement, demonstrating that the major difference was in the way the violation was repaired. Since Dutch number disagreement is more complex to repair than gender disagreement, the P600 effect was expected to be larger for number. We expected similar results for both visual and auditory presentation modalities (c.f., Hagoort & Brown, 2000). We tested 60 native speakers of Dutch, 30 per modality. Each participant either read or heard 160 experimental sentences, 80 of which contained gender disagreement (e.g., eenSG mooieSG.M/F dorpN – 'a beautiful village') and another 80 contained number disagreement (hetSG mooieSG dorpenPL). There were also 80 filler sentences

with the purpose of preventing a guessing pattern. EEG Data were recorded with a 64-channel EEG system (ANT Neuro) and pre-processed using the Brain Vision Analyzer 2 (Brain Products). Averaged values (in μV) were extracted per participant, per condition, and per region of interest and analyzed with repeated measures ANOVA separately for reading and listening. Analyses were performed on pre-determined time windows usually associated with the LAN and P600. The P600 component was elicited in both modalities. The effect was significantly larger in number than gender disagreement, with an earlier onset as well. Interestingly, the LAN was elicited only for gender disagreement in the auditory modality. The earlier onset time of the P600 for number disagreement compared to gender disagreement probably reflects the ease of access to the number feature. More precisely, number as an inflectionally coded feature is easier to access than a lexical feature such as gender (Barber & Carreiras, 2005). In line with our prediction, the larger P600 effect reflects a more complex repair mechanism of number disagreement compared to gender disagreement. Finally, the remaining issue is the presence of the LAN in gender condition in auditory modality only. The influence of the presentation modality on the LAN has been reported before (c.f., Hagoort & Brown, 2000). At this point we can only speculate that LAN may be sensitive to different rates at which grammatical information is delivered in different presentation modalities.

D8 Incremental commitment and revision in Icelandic compound processing

Kaylin Smith[1], Alicia Parrish[1], Alan Beretta[1]; [1]Michigan State University

Recent studies on compound processing suggest that, while incrementally building syntactic structure, the parser makes temporary commitments and subsequent revisions to mistaken commitments (Staub et al., 2007; Whelpton et al., 2014). In Icelandic, a productive compounding language, there exists a unique compound structure ideally suited for investigating commitment and revision. This compound structure cannot exist in isolation as its construction is dependent on selectional restrictions imposed by a preceding verb. For example, 'milk glasses' can have two syntactic structures—both semantically plausible and grammatical—with the use of different verbs: (a) 'She ingested milk glasses' and (b) 'She scratched milk glasses'. In (b), 'milk glasses' has a canonical compound structure, in which the second noun ('N2') is a semantic head, resulting in the following interpretation: "She scratched glasses used for milk". In (a), 'milk glasses' has a statistically atypical compound structure. In (a), the first noun is the semantic head of the compound, while N2 acts as a classifier, resulting in the following interpretation: "She ingested glasses' worth of milk". Since the standard compound structure in (b) has a semantic head at N2, but (a) does not, (a) should undergo syntactic revision after the arrival of N2. Results of a recent ERP study in Icelandic (Trotter et al., submitted) demonstrated just that. Given the important status of the verb in the construction of the statistically atypical compound structure in (a), we set out to investigate whether using different verbs in (a) and (b) confound the revision which occurs at N2. We investigated this possibility by comparing (a) with a condition which uses the same verb, but reveals a standard compound structure at N2: (c) 'She ingested milk puddings'. Native Icelandic speakers read 40 sentences per condition in a 2x2 design (semantically plausible/implausible at first noun x functional/lexical head at second noun) and completed a yes/no comprehension task while event-related potentials were recorded. Stimuli were presented via Rapid Serial Visual Presentation for 350ms with an ISI of 350ms (SOA 700ms), with compound constituents presented separately. Two ROIs were constructed: Anteriority (2: Anterior, Posterior). Condition (a) was more positive when compared to condition (c) in the posterior electrodes, which we interpret as an effect of syntactic revision upon receiving a classifier, rather than a semantic head, at N2. This result provides further support for an incremental model of compound processing, under which the parser makes temporary commitments to the compound's structure and then revises mistaken commitments. More importantly, this result suggests that, although the verb plays a role in the construction of the atypical compound structure, verb choice does not account for the costly syntactic revision that occurs when encountering a unique, atypical compound.

D9 Investigating task-modulated syntactic prediction with MEG

Phoebe Gaston[1], Chia-Hsuan Liao[1], William Matchin[2], Ellen Lau[1]; [1]University of Maryland, College Park, [2]University of California San Diego

INTRODUCTION: Prior work has argued that sentence processing is predictive, to an extent potentially modulated by demands of the task and context. This may account for variability in reported effects of syntactic structure in regions such as left inferior frontal gyrus (IFG) and posterior superior temporal sulcus (pSTS), if observed activity is in fact reflective of syntactic prediction rather than structure-building. The goal of this study was to directly investigate the relationship between effects of syntactic structure and task demands for prediction, using a novel paradigm explicitly encouraging or discouraging structural prediction while keeping stimuli constant. METHODS: We visually presented determiner phrases (DPs) in sentence contexts (These wolves chase many ducks), in two-phrase list contexts (these wolves many ducks), and in mixed contexts where DPs were equally likely to begin a sentence or a phrase list. Participants were informed of the context before each block began, and tasked with detection of agreement violations. Because linguistic input at the first DP has not yet begun to differ between conditions, effects of syntactic structure should reflect only the cost of syntactic prediction and the extent to which it is encouraged by the context. The sentence trials in mixed vs. sentence blocks also allow comparison of the

neural response throughout the trial to identical stimuli in contexts that had encouraged structural prediction to a greater or lesser extent. Neural data were recorded using MEG (N = 21), and permutation cluster tests were performed on the time-courses of activation in four regions of interest (ROIs): pars triangularis and pars orbitalis in left IFG (IFG-tri, IFG-orb), left pSTS, and left temporal pole. Spatiotemporal cluster tests were then performed in a broader language-related area encompassing left temporal and inferior parietal lobes and left IFG. RESULTS/DISCUSSION: Surprisingly, initial results demonstrated the reverse of the expected pattern for prediction effects, raising the possibility that this version of the paradigm engenders other unintended differences between conditions. 796-980 ms. after the onset of the first DP in the left IFG-orb ROI, we found increased neural activity during phrase blocks, which do not encourage structural prediction, relative to sentence blocks, which do. This apparent facilitation for sentences could be due to shifts of attention in anticipation of upcoming structure, but may also follow from the necessarily higher proportion of within-DP agreement violations in the phrase blocks than in the sentence or mixed blocks. A potentially related effect in left anterior temporal lobe, from 696-888 ms., showed increased activity for the second DP in a phrase list when it occurred during phrase-only relative to mixed blocks. We also found more activity for the second DP in a phrase list than the second DP in a sentence, across the temporal lobe from 636-1000 ms. This is likely due to increased semantic predictability of the second DP in sentences. These results indicate the need for further development of a promising window onto predictive structure-building, encouraging careful accounting of both task demands in neurolinguistic paradigms and the role of probabilistic structural predictions in language comprehension.

D10 A syntax area in the posterior superior temporal sulcus

William Matchin[1], Gregory Hickok[2]; [1]UC San Diego, [2]UC Irvine

Prominent hypotheses about the neural implementation of syntax ascribe a central role for the left inferior frontal gyrus (LIFG), typically the pars opercularis or pars triangularis, in the generation of basic syntactic structure (Hagoort, 2005; Friederici, 2011; Nelson et al., 2017). However, the hypothesis of a central role for the LIFG in syntax is untenable due to the fact that lesions to this region do not impair basic sentence comprehension or production (Mohr et al., 1978) or acceptability judgments (Linebarger et al., 1983), basic expectations for a brain region involved in core structural aspects of language. The prominent alternative hypothesis for the neural locus syntactic structure building is the anterior temporal lobe (ATL), as this region's activity reliably correlates with the presence of linguistic structure (Mazoyer et al., 1993; Rogalsky & Hickok, 2009; Pallier et al., 2011; Brennan & Pylkkanen, 2016). However, the ATL is an equally unlikely candidate for the localization of syntax as damage to this region does not result in syntactic deficits in speech production or comprehension (Garrard & Hodges, 2000) and does not impair sentence comprehension beyond the lexical level (Mesulam, 2015). We present a new framework for understanding the neural basis of syntax by positing that an area in the posterior temporal lobe in the ventral bank of the superior temporal sulcus is the locus of hierarchical syntax. We call this region the pSTS syntax area. Previous research has associated this region with lexical processing rather than combinatorial processing (see Hickok & Poeppel, 2007 and Lau et al., 2008 for reviews). However, most researchers in syntactic theory, psycholinguistics, and computational parsing assume at least some "lexicalized" syntax (e.g. Vosse & Kempen, 2000; Joshi et al., 1975; Lewis & Vasishth, 2005; Demberg & Keller, 2008), i.e. stored structure, suggesting a basic overlap in lexical and syntactic processing. Therefore, we posit that the pSTS syntax area houses lexicalized syntactic representations. We review neuroimaging (fMRI, MEG) and aphasia evidence that converges on the pSTS as a core area for lexical-syntactic processing. The pSTS syntax area shows a neuroimaging profile consistent with activation of syntactic representations used for sentence processing in a predictive fashion (Matchin et al., 2017; Matchin et al., submitted). Damage to this region impairs sentence comprehension above and beyond word comprehension (Pillay et al., 2017; Rogalsky et al., submitted), and impairs syntactic acceptability judgments (Wilson & Saygin, 2004). The pSTS syntax area is localized directly in between brain regions specialized for processing speech, orthography, and visual motion. It is also localized directly in between brain regions that are involved in processing semantic information in the ATL and angular gyrus (Binder et al., 2009). Thus, the pSTS syntax area is ideal for relating language data from the external world to semantic representations, in accordance with the classic view that language is the connection between sound and meaning (de Saussure, 1916; Chomsky, 1965).

D11 EEG correlates of covert dependency formation in Mandarin wh-questions

Chia-Wen Lo[1], Jonathan Brennan[1]; [1]University of Michigan

Event-related potential (ERP) components are sensitive to the processes underlying how questions are understood. For example, English wh-questions elicit an increased negativity over left-anterior sensors ("LAN") between the sentence-initial wh-word and the gap site where it is interpreted (Kluender & Kutas 1993) while a P600 and/or a LAN has been observed at the gap site itself. Kaan et al. (2000) suggest that while the P600 reflects syntactic integration of the sentence-initial wh-word with the rest of the question, the earlier LAN may reflect maintenance of an incomplete wh-dependency in working memory. Work with Japanese extends these efforts to languages with so-called "covert" dependencies where the question word is in situ rather than sentence initial, and is followed by a sentence-final question particle. Ueno and Kluender

(2009) find that, like English, there is an anterior negativity (right lateralized) in Japanese but no P600. These results suggest that memory maintenance demands are similar both for "overt" dependencies, like English, and covert dependencies, like Japanese. Mandarin Chinese also has covert wh-questions, though it lacks a sentence-final question particle. We test the prediction that, despite surface differences, wh-questions in Mandarin will show similar memory maintenance demands as indexed by an anterior negativity. Methods: N=34 native speakers of Mandarin Chinese read Chinese question and declarative sentences word-by-word during EEG recording. Target sentences (100 per condition plus fillers) were (1) direct questions (English approximation: "J thinks M saw which paper" = "Which paper does J think M saw __?", (2) indirect questions ("J wonders M saw which paper" = "J wonders which paper M saw __"), or (3) yes/no questions ("Did J think M saw this paper?"). Only the indirect questions with "wonder"-type verbs provide a cue to form a dependency prior to encountering the question word itself. This condition is where we predict an anterior negativity for memory maintenance. Data were manually cleaned of artifacts, filtered from 0.1-30 Hz, baseline corrected, and conditions were compared across 0-1 s using a non-parametric permutation test. Simulations indicate that N=34 with ~100 trials per condition yields power > 0.9 to detect effects as small as d = 0.1. Results: We find a left-lateralized anterior negativity at the in-situ wh-word for indirect and direct questions as compared to yes/no questions (120-250 ms, $p < 0.05$). This effect is consistent with memory mechanisms engaged when forming a covert long-distance dependency triggered by the wh-word (e.g. Kluender & Kutas 1993), but these data cannot rule out lower-level sensitivity to wh-words versus a deictic pronoun ("these"). Consistent with prior work with Japanese covert dependencies, we do not find a P600 at the gap site, but in contrast we also do not find an anterior negativity between the cue "wonder" verb and the wh-word in indirect questions. The absence of such a negativity may suggest earlier reports reflect storage of the wh-word, specifically, and not more general active maintenance mechanisms.

D12 Decoding the P600: late ERP positivities to syntactic mismatch share neural patterns with nonlinguistic oddballs, but not face or semantic manipulation patterns

Jona Sassenhagen[1], Christian J. Fiebach[1,2]; [1]Goethe University Frankfurt, [2]IDeA Center for Indidivudal Development and Adaptive Education, Frankfurt

The late positive P600 component of the Event-Related Potential/ERP is often interpreted as a correlate of high-level linguistic processing (e.g., syntactic or semantic integration). We aim to test the alternative hypothesis that the P600 is an instance of the low-level, domain-general P3 component. Multivariate Pattern Analysis/ MVPA of EEG data (King & Dehaene, 2014) can be used to probe questions about cognitive and ERP phenomema that cannot be addressed via standard univariate ERP analyses, complimenting previous findings. For example, pattern classifiers can be trained on one experimental contrast and then tested on their performance on a different manipulation. If the pattern classifier performs well on this kind of cross-study task, this indicates the ERPs, neural process, and fundamentally cognitive processes characteristic of the first experimental contrast also govern the second. In a pre-registered analysis (osf.io/7e93a/), we collect EEG data for the same subjects (n=25) for three experiments: a sentence processing experiment with semantic and syntactic (agreement) violations, an auditory Oddball (rare tone) experiment, and a face processing task. Thus, we combine the study protocols typically used to elicit P3 (Oddball), N170 (face), N400 (semantics) and P600 (syntax) components. With MVPA, we investigate to what extent the neural patterns characteristic of syntactic mismatches in our (standard) P600 paradigm overlap with those of processing faces, semantic mismatches or Oddball tones. MVPA decoders from the Oddball experiment (regularized logistic regression, cross-validated, fit for each time sample) successfully classify trials from the syntactic manipulation (ROC AUC ~.65, $p < .01$); they perform about as well as when classifying based on P600 patterns themselves (ROC AUC ~.65), and much better than semantic and face processing-sensitive components (both $p < .01$), whose performance is around chance (ROC AUC ~.5). This pattern is expected if the EEG responses to non-linguistic Oddballs (P3) and to syntactic mismatches (P600) exclusively share a neural substrate (Coulson et al., 1998; Sassenhagen et al., 2014; Sassenhagen & Bornkessel-Schlesewsky, 2015). Consequently, functional interpretations of the P600 should be aligned with models of the P3. We also caution against "reverse inference": observing neural patterns equivalent to those of the P600 does not necessarily entail any specific high-level linguistic process.

D13 Test-retest reliability of language evoked potentials

Matthew Walenski[1], Elena Barbieri[1], Brianne Dougherty[1], Cynthia K. Thompson[1,2,3]; [1]Department of Communication Sciences and Disorders, Northwestern University, Evanston, IL, USA, [2]Cognitive Neurology and Alzheimer's Disease Center, Northwestern University, Evanston, IL, USA, [3]Department of Neurology, Northwestern University, Evanston, IL, USA

Introduction. We examine the test-retest reliability of ERP components elicited in event-related potential (ERP) studies of sentence processing, the: left anterior negativity (LAN), N400 and P600. If these components are to be used as markers of intervention effectiveness – for example, assessing the efficacy of treatment interventions in individuals with language disorders – it is important to measure their stability over time in order to separate intervention effects from day-to-day variation. No prior published studies have reported on the reliability of these

components in sentence comprehension. Method. We recorded scalp EEG from 32 electrodes while participants listened to grammatical passive sentences (The cook was scolded by the waiter on opening night), sentences with a semantic violation expected to elicit an N400 (The cook was printed by the waiter on opening night), and sentences with a syntactic violation expected to elicit LAN/P600 effects (The cook will scolded by the waiter on opening night). Nineteen healthy college-age participants were each tested twice on the same materials, in two sessions roughly one week apart. Data from 4 participants were excluded due to high rates of epochs with artifacts (> 25%) in one or both sessions. Thirty-eight sentences of each type were presented, along with 60 filler sentences (i.e., grammatical future tense sentences, ensuring 'will' did not serve as a cue to grammaticality) and active versions of the same 3 sentence types. Event-related potentials were time-locked to the onset of the verb in all experimental conditions. For each violation, we examined effects relative to the grammatical baseline in two time windows of interest: 450-700 ms for the LAN and N400, and 700 – 950 ms for the P600. To examine test-retest reliability across the 2 test sessions, we computed intra-class correlation (ICC) coefficients for each sentence type (grammatical, semantic violation, syntactic violation) at the electrode with the peak ERP effect for each violation in each time window. These coefficients have a maximum value of 1, with scores above .75 indicative of excellent reliability across sessions. Results. The semantic violations elicited a left-lateralized centro-parietal negativity in the early time window, which was maximal at electrode CP1. ICC scores were fair for the violation (.429), but poor for the grammatical sentence (.327). The syntactic violations elicited a left anterior negativity in the early time window, which was maximal at electrode FC5. This effect showed poor reliability for the violation (.281), but fair for the grammatical baseline (.548). In the late time window a significant positive effect was found, maximal at FC2. For this effect, reliability was excellent for the violation (.812), and fair for the grammatical baseline (.568). Conclusions. Reliability was generally higher for violations than for grammatical sentences, and was strongest for the P600 in the late time window. The results should inform analyses of intervention effects for these components. When ICC values are low, ICC values could be included as a covariate (e.g., ANCOVA), or alternate analyses could be pursued (e.g., structural equation modeling) to control for inter-session variability.

Language Therapy

D14 Aligning sentence structures in a language game: evidence from healthy aging and aphasia

Jiyeon Lee[1], Grace Man[1], Victor Ferreira[2], Nick Gruberg[2]; [1]Purdue University, [2]University of California San Diego

Speakers align syntactic structures with their conversational partners. Gruberg et al. (in prep-a) discovered that this syntactic alignment occurs for associations between event content and sentence structures, also known as syntactic entrainment, beyond the level of sentence constituent orders. These effects are shown in both young adults and children, and are viewed as reflecting ongoing prediction error-based 'tuning' or language learning throughout the lifespan. Crucially, the prediction errors that cause syntactic alignment are experienced during comprehension, rather than production of sentences (Chang et al., 2006; Jaeger & Snider, 2013), predicting that listening to their interlocutor's utterances would suffice for speakers to adapt their production preferences. We test this hypothesis in older and aphasic speakers to better understand the mechanisms of syntactic learning. Experiment 1 examined syntactic entrainment in a comprehension-based picture matching game. In Experiment 2, the game was modified so that the participant repeats their partner's utterances during card matching, obligating prior production of the target structures. For Experiment 1, 20 young, 20 older adults, and 13 adults with aphasia participated in a collaborative language (picture-matching) game. Participants played the 'matcher' and subsequently 'director' roles with the experimenter, who described pictures using either preferred (active, prepositional dative, and on-variant locatives) or non-preferred structures (passive, double-objective dative, and with-variant locative). When playing the matcher role, the participant placed their cards in the correct order after listening to the experimenter's sentences. Then the participant, playing the director role, described pictures for the experimenter to match. We measured whether the participant produced the same structures to refer to specific events in the pictures as the experimenter. Results revealed that young adults were more likely to produce preferred structures upon hearing experimenter's use of preferred vs. non-preferred structures ($p < .001$) – that is, syntactic entrainment. However, no syntactic entrainment effects were shown in older and aphasic participants (Figure 1a). For Experiment 2, we tested 12 older adults and 8 adults with aphasia. Participants were instructed to verbally repeat the experimenter's sentences before they select the matching picture card, thus obligating prior production of target sentences. Remaining procedures were the same as Experiment 1. In contrast to the results of Experiment 1, both older ($p < .001$) and aphasic speakers ($p = .01$) used preferred structures more frequently following experimenter's use of preferred vs. non-preferred structures (Figure 1b). Together, our findings show that comprehension-induced prediction error is not sufficient for successful syntactic entrainment effects in older and aphasic speakers, different from what has been shown in young adults and children (Gruberg et al., in prep a, b). This further suggests that as an effect of aging and aphasia, content-structure mapping becomes stabilized so that active production of target content-structure

associations has most predictive effects in syntactic learning. In sum, the current study illustrates that the mechanisms of syntactic learning change as a function of age and modality, which may need to be considered in the existing models of error-based language learning (Chang et al., 2006; Jaeger & Snider, 2013).

Language Development

D15 Resting-state connectivity during second language learning in deaf individuals

Velia Cardin[1], Elena Kremnova[2], Elina Zmeikina[2], Anna Komarova[3,4], Valeria Vinogradova[1,3], Tatiana Davidenko[3,4], Bencie Woll[5]; [1]University of East Anglia, [2]Moscow Neurological Institute, [3]Sign Language Centre, Moscow, [4]Moscow State Linguistics University, [5]University College London

Studies of neural reorganisation as a consequence of early deafness show that regions in the superior temporal cortex, which are usually considered to be involved in speech processing in hearing individuals, are involved in sign language processing in deaf individuals. Furthermore, we have shown that the posterior portion of the superior temporal cortex is also recruited for visual working memory processing in deaf individuals, independently of the linguistic content of the stimuli, and that there is an increase in resting state connectivity between posterior superior temporal cortex (and frontoparietal regions. These results potentially suggest a general role in pSTC) control for these areas. In this study, we are interested in understanding whether early deafness results in reorganisation of brain networks involved in language learning. Specifically, we want to understand whether there is an increase in resting state connectivity between pSTC and frontoparietal regions during language learning. Neuroimaging studies of language learning typically concentrate on spoken language, usually in artificial lab conditions. Here we studied changes in resting state connectivity in groups of individuals as they learned a sign language as a second language during a 12-week course. There were two groups of participants: Deaf signers of Russian Sign Language and hearing native speakers of Russian who also knew Russian Sign Language. Participants were enrolled in a course equivalent to Level 1 British Sign Language. Resting state fMRI scans were collected before, during and after the BSL course. Preliminary results show significant resting state connectivity between right and left pSTC in both deaf and hearing individuals. In the group of hearing individuals, no differences in resting state connectivity between pSTC and fronto-parietal regions were found after learning BSL. Further analysis will be conducted in the group of deaf individuals to see whether language learning in deaf individuals changes connectivity between pSTC and frontoparietal regions.

D16 Speech sound processing and its association to familial risk of dyslexia and communication skills in six-month-old infants

Linda Lönnqvist[1], Paula Virtala[1], Eino Partanen[1,2], Paavo Leppänen[3], Anja Thiede[1], Teija Kujala[1]; [1]Cognitive Brain Research Unit, Department of Psychology and Logopedics, Faculty of Medicine, University of Helsinki, Finland, [2]Center of Functionally Integrative Neuroscience, Department of Clinical Medicine, Aarhus University, Denmark, [3]Department of Psychology, University of Jyväskylä, Finland

Developmental dyslexia is a difficulty in achieving age-appropriate literacy skills in absence of intellectual disabilities or educational deprivation. This heritable condition is relatively common and it often hampers the academic success, employment opportunities, and everyday life of the affected individual. Today dyslexia is usually diagnosed at the end of first or second grade, even though the mechanisms behind the condition are thought to be present and affecting the individuals' language development from a very early age on. Both structural and functional abnormalities in brain areas associated with processing of sound, speech sounds and language have been found in children who later develop dyslexia. The early stages of the neural development leading to dyslexia and the relation between neural sound processing and early communication skills should be further investigated. If children in need of intervention could be detected and offered support at an early age, problems affecting the individuals' well-being could be alleviated substantially. The aim of this study was to investigate the relations between neural speech sound processing, prelinguistic communication skills and familial risk of dyslexia in infants. The study is a part of a longitudinal research project studying language development in children with or without a familial risk of dyslexia from birth to school age. The current study includes data from approximately 100 participants, measured at six months of age. A smaller sample was used for these preliminary results. The at-risk group and the control group were matched by age and gender. We studied cortical discrimination of frequency, duration, and vowel changes in natural speech sounds by recording event-related potentials (ERPs) in a multifeature paradigm. To assess early communicative skills we used questionnaires filled-in by the parents. We predicted that the brains of children at risk of dyslexia would respond to speech sound changes differently than the brains of children not at risk, as reflected in group differences in event-related potentials (ERPs) and that there would be an association between the neural response (ERPs) to speech sound changes and early communication skills. Preliminary results suggest that infants with familial risk of dyslexia differ from infants without the risk in processing of speech sounds and speech sound changes. For example, neural discrimination of sound frequency changes was altered in at-risk infants. Additionally, the parental questionnaires tentatively suggest lower prelinguistic

communication skills in the at-risk group compared to the control group. Significant correlations between ERPs evoked by speech sound changes and prelinguistic communication skills were found. For example, the size of ERPs evoked by the vowel change showed a positive correlation with prelinguistic skills. To conclude, our results suggest that language development differs between children with vs. without a familial risk of dyslexia both at the neural and the behavioral level, and that speech sound processing is associated with prelinguistic communication skills already at six months of age. The findings may be useful for identifying children in need of language intervention early and for developing the principles of effective interventions aiming to alleviate or even prevent later language and literacy difficulties.

D17 Rhythm sensitivity assists in overcoming acoustic and syntactic challenges during speech listening

Sanghoon Ahn[1], Ian Goldthwaite[1], Kate Corbeil[1], Allison Bryer[1], Korrin Perry[1], Aiesha PolaKampalli[1], Katherine Miller[1], Rachael Holt[1], Yune Lee[1,2]; [1]The Ohio State University, [2]Center for Brain Injury, The Ohio State University

A growing body of evidence has indicated connections between speech, language, and music. In particular, rhythm processing has been implicated as important in studies measuring various aspects of speech and language proficiencies (e.g., reading, speaking, and listening). Here, we investigated how rhythm sensitivity influences spoken sentence recognition under both sensory (e.g., impoverished acoustic quality) and cognitive (e.g., complex syntactic structure) challenges. Seventy-eight children (age range: 7-17 yrs; mean age: 11.4; 39 females) were recruited through The Ohio State University's Language Pod located at the Center of Science and Industry. All children were native English speakers with normally developed speech, hearing and language abilities, per parent report. Children were administered two tests (each took approximately 10 minutes). First, in the speech/language test, children listened to short spoken sentences that simultaneously varied in their acoustic (clear vs. 15-channel vocoded speech) and linguistic (subject- or object-relative embedded clause) structure. For each sentence, children were asked to indicate the gender of the agent performing the action via button-press. For example, children were instructed to press the "male" button for the sentence, "Boys that kiss girls are happy." Second, in the music test, children were presented with a pair of short rhythm sequences consisting of either 6 or 7 intervals and were to determine if they were the same or different. Half of the pairs contained the same rhythmic patterns, and the other half contained different patterns (the number of intervals were matched in each pair). To identify which factors accounted for performance in the speech/language test, we ran a linear mixed effect (LME) regression analysis in which the fixed effects included children's rhythm test score, age, gender, music training period, language environment (e.g., bilingual), parents' education, syntax (subject/object) and acoustic (clear/15ch) and the random effect included subjects. The LME revealed that music test ($p = 0.002103$), age ($p = 3.662e-06$), syntax ($p = 2.2e-16$), and acoustic difference ($p = .000726$) significantly predicted speech/language performance. Together, we found that rhythm sensitivity helps children better cope with sensory and cognitive challenges that are both simultaneously and independently present in spoken sentences. By controlling for potentially confounding variables (e.g., music training background, age, language environment, etc.), we showed that better performance in the speech/language test was independently driven by rhythmic sensitivity. The present behavioral data lay the groundwork for examining genetic and neural connections between speech, language, and music processes.

D18 Early classroom exposure to expository texts predicts developmental trajectory of genre-related neural specialization

Katherine Aboud[1,2], Laurie Cutting[1,2,3,4]; [1]Vanderbilt Brain Institute, [2]Peabody College of Education and Human Development, [3]Vanderbilt Kennedy Center, [4]Vanderbilt University Institute of Imaging Science

Successful language comprehension in elementary school is a key predictor of long-term educational outcomes, and requires adequate skill in both narrative and expository genres (e.g. stories versus science/history material). Historically, expository text has received lower attention in the classroom, resulting in a critical gap between expository and narrative reading performance in grade school. In response, the Common Core State Standards of education now encourage introduction to expository comprehension as early as first grade (5-7 years old). However, very little is known of the neural substrates of genre, or how/whether the development of genre-specific neural networks are influenced by early exposure. Previous neuroimaging work in our own lab has found that expository texts do indeed require different neural resources than stories in young learners. Specifically, appropriate comprehension of expository texts requires recruitment of restricted regions within the left-lateralized default mode network (DMN) as compared to the bilateral DMN in narratives, and this specialization in exposition is facilitated by the frontoparietal control network. While these findings shed critical light on the disparate neural demands of different types of texts, no studies to date have tracked the development of these systems, or how they are influenced by early classroom experiences. In the current study, we used functional magnetic resonance imaging to identify (1.) the developmental trajectories of expository comprehension, and (2.) whether greater exposure to exposition in the first-grade classroom interacts with these neural trajectories. As part of a larger longitudinal study (n = 140), we examined 20 second and third graders (time 1 age = 8.54 +/- .28, time 2 age = 9.52 +/- .31, 10 females) with typical IQ and word reading ability as they listened to scientific texts in the scanner. We found that

during expository comprehension, third graders showed greater recruitment of DMN areas than second graders, potentially suggesting increased engagement in building a situation model of the stimuli with increased age and experience. Interestingly, however, children who had a higher percentage of first grade expository exposure showed significantly decreased reliance on the right angular gyrus in third vs. second grade. Given previous findings that adult patterns of expository comprehension are restricted to left-lateralized DMN, these results indicate that greater early exposure to exposition results in earlier specialization towards ideal expository neural networks in children. These findings have important implications for early classroom practice, and pave the way towards future examinations of how these trends vary among different learner subpopulations.

D19 Prior knowledge influences in learning and consolidating new words

Emma James[1], M. Gareth Gaskell[1], Lisa Henderson[1]; [1]University of York

The complementary learning systems account of memory proposes that a newly encountered word is initially bound and stored as a distinct representation in the hippocampus, but that offline reactivation enables a strengthening and integration of this information with neocortical-based vocabulary (McClelland et al., 1995; Davis & Gaskell, 2009). Extant evidence suggests that this memory consolidation process is facilitated by related prior knowledge and/or by sleep rich in slow oscillations. James et al. (2017) have proposed that these mechanisms might differentially support word learning across development: children benefit from larger amounts of slow-wave sleep that supports ongoing neural maturation, whereas adults experience a greater benefit from their richer knowledge base. We present two behavioural experiments that examine the role of existing knowledge in consolidating new linguistic information in children and adults. The availability of prior knowledge was manipulated experimentally by training novel words with/without close orthographic neighbours in the English lexicon. For example, a single letter swap from ballow can form ballot, wallow, bellow etc., whereas no existing words can be formed from marpan. Participants were children aged 7-9 years (n = 232) in Experiment 1, and adults (n = 79) in Experiment 2. Prior knowledge contributions to word learning was further examined on an individual level by including a standardised measure of existing vocabulary knowledge. In order to test hypotheses regarding prior knowledge contributions at learning and over a period of consolidation, we tested memory for the new words using cued form recall and a recognition task at three time points: the same day, next day, and one week later. Both children and adults showed better cued recall performance for words with neighbours, suggesting that they could access prior knowledge to support learning in this paradigm. However, whilst adult memory performance remained influenced by prior knowledge over the course of the week, the effect of word neighbours was reduced at subsequent test points for children. These contrasting patterns are consistent with a model in which children have superior sleep-associated consolidation processes compared to adults, which can better support novel learning. An additional condition in Experiment 2 showed that a single word neighbour was sufficient to boost learning, and that learning in this condition only was predicted by adults' existing vocabulary knowledge. Our results are consistent with the proposal that children's superior sleep architecture may facilitate learning of more novel stimuli during this period of development, whereas adults are more reliant on prior knowledge during consolidation. A third experiment is underway to re-examine the contributions of vocabulary knowledge in children, by including the single neighbour condition and by removing potentially confounding contributions of orthographic knowledge. We discuss implications for the complementary learning systems account of word learning in light of these developmental differences.

D20 Frontal Shift of the Imageability Effect on N400 in Elders

Chih-Ting Chang[1], Chia-Ju Chou[1], Jie-Li Tsai[2], Chia-Ying Lee[1,2,3,4]; [1]Institute of Neuroscience, National Yang-Ming University, Taipei, Taiwan, [2]Department of Psychology, National Chengchi University, Taiwan, [3]Institute of Linguistics, Academia Sinica, Taipei, Taiwan, [4]Institute of Cognitive Neuroscience, National Central University, Taipei, Taiwan

Aging has been associated with cognitive decline and the aging brain may recruit extra brain regions to cope with the declined neural efficiency and cognitive ability. A well-known phenomenon in the cognitive neuroscience of aging, the Posterior-Anterior Shift in Aging (PASA), is that elders tend to exhibit increased prefrontal lobe activation and decreased activation in visual cortex for tasks involving working memory (WM), visual attention (VA), and episodic retrieval. This phenomenon suggests that older adults compensated for visual processing deficits (occipital decrease) by recruiting higher-order cognitive processes (PFC increase). However, it remains unclear whether the PASA phenomena also exist for visual word recognition. Evidences from event-related potentials (ERPs) studies have suggested that high imagery words may associate with richer semantic features and tend to elicited greater N400 than the low imagery words in the frontal sites. Functional neuroimaging studies of imageability have also showed that the semantic retrieval of words with high versus low imageability might involve different weighting in frontal and temporal regions. This study aims to address this question by examining how aging shapes the familiarity and imageability effect on N400. The imageability (high versus low) and familiarity (high versus low) of the target words were manipulated in a two-by-two factorial design. Two groups of participants were recruited, one group includes 19 younger adults (five males; mean

age 25.32 years, range 21-36), and the other group includes 18 elder adults (five males; mean age 65.06 years, range 56-78). Participants were requested to carry out a button-press if the target word refers to an animal. Results from both groups showed the typical familiarity effect on N400, in which the unfamiliar words elicited a greater N400 than the highly familiar words. The imageability effect that the high imagery words elicited a significantly greater N400 than the low imagery words only observed in highly familiar condition. The absence of the imageability effect for unfamiliar words may due to the resources occupation between reading and imagery process (Unnava, Agarwal, & Haugtvedt, 1996). For those highly familiar words, the younger group showed the imageability effect in the centroposterior regions, while the elder group showed the effect distributed in the fronto-central region. Our findings consistent with the PASA phenomenon and suggest the age-related compensatory mechanism in visual word processing in elders.

D21 Developmental change in cerebellar white matter pathways is associated with reading proficiency in children

Lauren R. Borchers[1], Trang H. Nguyen[1], Lisa Bruckert[1], Katherine E. Travis[1], Michal Ben-Shachar[2], Bruce D. McCandliss[1], Heidi M. Feldman[1]; [1]Stanford University, [2]Bar Ilan University

A distributed network of cortical areas and their white matter connections have been linked to reading proficiency (Price, 2012; Wandell & Yeatman, 2013). A recent cross-sectional study demonstrated that microstructural properties of cerebellar pathways were negatively associated with reading skills in children aged 9y-17y (Travis et al., 2014). Longitudinal studies estimate individual change and therefore allow better understanding of the coupling between developmental processes in the cerebellar white matter and reading. In this study, we examined two longitudinal datasets to determine whether changes in fractional anisotropy (FA) of the cerebellar peduncles were associated with individual differences in reading skills. Sample 1 included 35 children (M age time 1 = 6.21y, 14 males), scanned at age 6y with a two-year follow-up using a dual-spin echo diffusion-weighted sequence (3T, 30 diffusion directions at b=1000 s/mm2, 3 volumes at b=0, voxel size 2 x 2 x 2 mm3). Sample 2 included 28 children (M age at time 1= 7.92y, 13 males) scanned between age 5y-9y with a one-year follow-up (3T, 32 diffusion directions at b=700 s/mm2, 1 volume at b=0, voxel size 2 x 2 x 2 mm3). The Automated Fiber Quantification software package (Yeatman et al., 2012) was employed to segment whole brain deterministic tractograms and calculate mean FA of the inferior (ICP), superior (SCP), and middle cerebellar peduncles (MCP) at both time points in both samples. Developmental change in white matter properties was assessed by subtracting mean FA of a given tract at time 1 from time 2. Reading skills were assessed using the Word Identification (Sample 1 & 2) and Passage Comprehension (Sample 1) subtests of the Woodcock Reading Mastery Tests. Pearson correlations were used to assess the strength of association between mean FA change and standardized reading scores at time 1. FA increased from time 1 to time 2 for all cerebellar peduncles in Sample 1, while only the ICP and SCP increased in Sample 2. Single-word reading was negatively correlated with the change in FA of the left SCP in both samples (Sample 1: r = -0.36, p = .038, n = 34; Sample 2: r = -0.46, p = .015, n = 27). Further analysis of Sample 1 confirmed that these associations extended beyond single-word reading, with reading comprehension being negatively correlated with the left SCP (r = -0.42, p = .014, n = 34) and right ICP (r = -0.37, p = .042, n = 30). These findings suggest that higher reading scores were associated with a decrease in FA over time. The results demonstrate negative correlations between reading skills and change in white matter properties of the cerebellar peduncles in young children. These findings are consistent with cross-sectional results observed in older children (Travis et al., 2014). Our data support the concept that the development of efficient transfer of information between the cortex and cerebellum is an important factor explaining individual differences in reading. On-going studies are exploring the factors associated with efficient transfer in cerebellar pathways, such as crossing fibers or myelin content.

D22 Can microstructural properties of cerebellar pathways improve prediction of reading skills in children?

Lisa Bruckert[1], Katherine E. Travis[1], Michal Ben-Shachar[2], Heidi M. Feldman[1]; [1]Stanford University, [2]Bar Ilan University

Introduction: Cerebellar pathways have been recently associated with reading abilities in typically developing children and adolescents (Travis et al., 2015). Children born preterm (PT) are at-risk for reading impairments and for cerebellar injury (Aarnoudse-Moens et al., 2009; Limperopoulos et al., 2010). Therefore, they represent an interesting group for studying the contribution of the cerebellum to reading. Here, we set to determine whether variation in microstructural properties of the cerebellar peduncles at age 6y improves the prediction of reading proficiency at age 8y, beyond socioeconomic status (SES) and behavioral measures, in PT and full term (FT) children. Methods: Thirty-eight children born FT (mean gestational age (MGA) = 39.6 weeks, 14 male) and 32 born PT (MGA = 29.8 weeks, 21 male) were assessed at age 6y with diffusion MRI (dMRI) and standardized tests of phonological awareness and reading, language, and non-verbal IQ. Fluency, comprehension and oral reading at age 8y were used as outcome measures. In dMRI, we applied a dual-spin echo diffusion-weighted sequence (3T, 30 diffusion weighted directions at b = 1000 s/mm2, 3 volumes at b = 0, voxel size 2 x 2 x 2 mm3). We used the Automated Fiber Quantification package (Yeatman et al., 2012) to segment whole brain deterministic tractograms and calculate the mean fractional anisotropy (FA) of the inferior (ICP), middle (MCP) and superior cerebellar

peduncles (SCP) in each child. Correlations between mean FA and outcome measures were used to select cerebellar pathways included in subsequent analyses. Hierarchical multiple regression models assessed the contribution of SES, behavioral measures and mean FA at age 6y in predicting reading scores at age 8y. Results: Children born FT and PT did not differ significantly in outcome measures assessed at age 8y. Significant but weak associations were found between the mean FA of the left ICP and measures of fluency ($r = 0.27$; $p = .039$, $N = 61$) and oral reading ($r = 0.29$; $p = .020$, $N = 66$) at age 8y. A moderation analysis revealed that birth-group status significantly moderated the relationship between mean FA of the left ICP and the outcome measures. Multiple regression analyses were therefore carried out separately in the FT and PT groups. In children born FT, but not PT, mean FA of the left ICP predicted reading fluency ($\Delta R2 = 0.10$, $F(1,30) = 6.83$, $p = .014$) and oral reading ($\Delta R2 = 0.13$, $F(1,30) = 11.5$, $p = .002$) at age 8y, above and beyond SES, non-verbal IQ, language and phonological awareness. A parallel analysis of the left SCP did not reveal a significant contribution to prediction of reading outcome at age 8y. Conclusion: Microstructural properties of the left ICP (but not SCP) improved the prediction of reading skills at age 8y over known environmental and behavioral contributing factors. This was observed only in FT children, and not in PT children. These results suggest that children born premature may rely on alternative routes to achieve fluent reading.

Signed Language and Gesture

D23 Language pathway development requires childhood language acquisition: Effects of sensorimotor modality and language deprivation on brain connectivity for language

Qi Cheng[1], Eric Halgren[1], Rachel Mayberry[1]; [1]University of California, San Diego

Long-range white matter fiber tracts play an important role in establishing the dynamic and distributed language network. Previous research on spoken languages had identified two information streams that are crucial for language processing, namely the ventral and dorsal pathways. The dorsal pathway consists of the superior longitudinal fasciculus (SLF) - arcuate fasciculus (AF) complex, connecting the inferior frontal gyrus (IFG) with the superior temporal gyrus/sulci (STG/STS) and the inferior parietal lobule (IPL). Ventral pathways include the inferior fronto-occipital fasciculus (IFOF), the inferior longitudinal fasciculus (ILF), and the uncinate fasciculus (UF). American Sign Language (ASL) activates very similar brain regions such as the STG/STS and the IFG, despite differences in sensorimotor modality. No study to date has examined the effect of sensorimotor modality on brain connectivity for language processing. Previous studies on deaf brain connectivity showed inconsistent findings, likely due to the variability of deaf population of their language acquisition and use. Deaf people with hearing parents often experience early language deprivation, which may affect their brain connectivity. The current study investigates the effect of sensorimotor modality and language acquisition history by examining the white matter connectivity of the dorsal and ventral pathways among congenitally deaf people with or without early access to American Sign Language (ASL). Diffusion data were acquired using a GE 1.5 Tesla scanner and preprocessed following standard steps. We identified dorsal pathways AF and posterior SLF (pSLF), and ventral pathways IFOF, ILF, and UF, using an automated tract atlas. Next we calculated the average fractional anisotropy (FA) value of each tract of interest in each hemisphere. For Study 1, we recruited 12 hearing people and 12 deaf native signers to determine if the two groups show similar ventral and dorsal language pathways. In Study 2, we examined the language tracts of three deaf individuals who experienced minimal language until adolescence or adulthood, two adolescents who were at the initial stage of language learning, and one adult who had completed his (limited) language acquisition. The results indicate that individuals born deaf with infant language experience have language tracts that are not different from hearing controls. Both groups show left lateralization and a similar range of FA values. By contrast, all three cases of extremely late L1 exposure demonstrated significantly lower FA values for the left AF tract compared with the deaf native group, but not for other tracts including pSLF, IFOF, ILF and UC, where the FA values were generally within a normal range. These findings indicate that auditory deprivation and the sensorimotor modality of language do not affect the white matter connectivity between language regions. However, childhood language deprivation alters white matter connectivity, especially in the dorsal AF pathway. This is apparent for individual adolescents in the early stages of language acquisition, as well as for the adult with more than 20 years of ASL experience. Our findings indicate that growth of the brain language pathways are not solely driven by biological maturation but require language acquisition during childhood to connect in the expected fashion.

Language Disorders

D24 Same but different: comprehension of spatial terms in highly verbal individuals with autism and typically developing controls

Agata Bochynska[1], Valentin Vulchanov[1], Mila Vulchanova[1]; [1]Norwegian University of Science and Technology, NTNU Trondheim

Spatial abilities of individuals on the autism spectrum vary to a great extent, from superior (performance on the Block Design or embedded figures tasks) to impaired skills (egocentric transformations, memory for item location). Importantly, spatial language (i.e. descriptions of relations between objects) is a language domain that relies on non-linguistic spatial representations (Hayward & Tarr, 1995; Jackendoff, 1996; Landau & Jackendoff, 1993; Munnich, Landau, & Dosher, 2001) and it can be affected

by impairments in the non-verbal domains (e.g Landau & Hoffman, 2005). Despite extensive research on non-verbal visuo-spatial abilities in autism, spatial language use has never been thoroughly investigated in this disorder. Here we are interested in the comprehension of locative spatial terms (e.g. "above", "below", "to the left", "to the right") focusing on the axial reference system in highly verbal individuals with autism compared to typically developing controls. We have adapted the Comprehension Task from the study by Landau & Hoffman (2005), originally based on the paradigm developed by Hayward & Tarr (1995). In the current study, stimuli were presented on a computer screen and answers were collected by mouse clicks to the Areas of Interest (AOIs) that formed a grid surrounding the reference object (the grid was not visible to the participants). Each trial consisted of a fixation cross, followed by a sentence in Norwegian that was describing the location of the circle, e.g. "Sirkelen er ovenfor firkanten" ("The circle is above the square"), followed by a picture of a blue square in the middle of the screen (the reference object). Participant's task was to place the circle in relation to the square as described in the sentence by navigating the mouse cursor and clicking on the chosen location. There were in total 26 trials in the experiment: nine with vertical positive terms (V+), 9 with vertical negative terms (V-), 4 with horizontal terms that specify direction (HD, Left or Right) and 4 horizontal neutral terms (HN). Twenty-two highly verbal individuals with autism (diagnosed with high-functioning autism or Asperger's syndrome) and 22 typically developing controls matched for age and IQ scores participated in the experiment. All participants were native speakers of Norwegian. Results showed that the highest proportions of answers fell into the AOIs along the orthogonal axes of the reference object in both groups. This points to a spared axial reference system in high-functioning autism that supports comprehension of spatial language. However, highly verbal individuals with autism made more errors both in the vertical condition (e.g. by choosing a V- area for the term "way above") and horizontal condition (e.g. by choosing a Left area for the term "on the right side of"). The majority of these errors represented the wrong direction within the correct axis. We conclude that, overall, representation of the spatial terms in the axial reference system did not differ between typically developing controls and highly verbal individuals with autism; nevertheless the latter group was more prone to make directional errors.

D25 Connections between implicit learning and reading fluency: an fMRI investigation

Ola Ozernov-Palchik[1,2], Tracy Centanni[2,4], Sara Beach[2,3], Sidney May[2], Meredith Brown[1], John Gabrieli[1]; [1]Tufts University, [2]Massachusetts Institute of Technology, [3]Harvard University, [4]Texas Christian University

Developmental dyslexia is a prevalent learning disability affecting approximately 10% of all individuals. It is characterized by difficulties with speed and accuracy of word decoding, reading, and spelling. Functional studies of dyslexia have demonstrated altered response in left-hemispheric temporo-parietal, occipito-temporal, and inferior frontal regions during tasks requiring phonological decoding and single word reading. Few studies to date have examined neural activation during a naturalistic reading task and the brain basis of reading fluency in dyslexia is not well understood. Fluent reading relies on perceptual learning of the distributional statistics of phonology and orthography of one's language, and on automatic integration across multiple components of the reading network. Since both perceptual learning and skill automatization operate under implicit learning conditions, fluency deficits in dyslexia have been hypothesized to stem from underlying impairments in implicit learning. No studies to date, however, have examined the association between implicit learning skills and the neural components of reading fluency in dyslexia. The current study investigates the neural underpinnings of reading fluency in adults with and without dyslexia and relates them to out-of-scanner performance on a range of implicit learning tasks. Participants are asked to read seven paragraphs out loud in their normal reading voice and rate in a 3T-scanner. Each paragraph appears on the screen for 16 seconds, followed by a control block with arrows pointing up and down, requiring the participant to describe the orientation of arrows ("up" or "down"). This is followed by fixation. Participants also completed several implicit learning tasks outside the scanner. 1) In rotary pursuit, participants attempt to maintain contact between a hand-held stylus and a light moving rapidly around the circumference of a figure. With practice, participants increase the time per trial that they are able to maintain contact with the light. 2) In mirror tracing, participants trace a figure with a stylus, only seeing their hand, the stylus, and the figure reflected in a mirror. With practice, participants trace the figure more quickly and tend to make fewer departures from the figure. 3) In selective adaptation, participants must identify ambiguous phonemes on a /b/-/d/ continuum, after exposure to several prototypical instances of either of these phonemes. Participants also complete behavioral measures of reading accuracy and fluency. Preliminary results suggest activation in distinct occipito-temporal and inferior frontal regions of the reading network during the in-scanner fluency task ($p<0.05$, uncorrected). The examination of differences in response patterns between typical readers and individuals with dyslexia reveals the neural mechanisms of reading fluency in dyslexia. Relations between implicit learning and reading fluency will be discussed and theories of an implicit learning deficit as an etiological mechanism in dyslexia will be evaluated.

D26 Neural network of verbal, nonverbal and amodal semantic processing deficits in semantic dementia

Yan Chen[1], Keliang Chen[2], Junhua Ding[1], Yumei Zhang[3], Qing

Yang[2], Yingru Lv[2], Qihao Guo[2], Zaizhu Han[1]; [1]Beijing Normal University, [2]Fudan University, [3]Beijing Tiantan Hospital

Semantic memory consists of three interactive principal components: amodal, verbal-specific and nonverbal-specific semantic processing, which are underpinned by separable neural networks. The study of patients with semantic dementia (SD) has emerged as an important lesion model for studying human semantic memory. Although it is well known of the amodal and modality-specific deficits of SD patients, the exact manner in which gray matter (GM) regions and their structural and functional connections are related to the deficits are not fully elucidated. The aim of this study was to map the neural network supporting the three semantic components in 33 SD patients. We acquired T1-weighted images, diffusion-weighted images, resting-state functional resonance images (rs-fMRI) and behavior data on word and picture semantic processing tasks. We found that the gray matter volume (GMV) of the left inferior temporal gyrus and the superior/middle temporal gyrus was highly correlated with verbal semantic processing, GMV of the right anterior middle temporal gyrus was associated with nonverbal semantic processing, while the GMV of the left anterior fusiform gyrus predicted amodal semantic processing. All six node pairs were found to be directly connected by WM tracts and the integrity of these six WM tracts was decreased in SD patients. We further found the integrity of different WM tracts was related with distinct semantic component. Rs-fMRI revealed the left anterior fusiform was functionally connected with the other three verbal and nonverbal nodes in healthy subjects. However, in SD patients, only one node pair (anterior fusiform-left superior/middle temporal gyrus) remained marginally significantly connected. No correlations were found between the strength of functional connections with distinct semantic components. Furthermore, the effects of regions and tracts remained significant even when we controlled for a wide range of potential confounding variables including overall cognitive state, whole brain gray matter volume and non-semantic control tasks (oral repetition and number calculation tasks). These results therefore address an important topic concerning the semantic deficits in SD, with implication for the neural network underlying different components of semantic knowledge in the human brain.

D27 How does iReadMore therapy change the reading network connectivity in patients with central alexia?

Sheila Kerry[1], Zoe Woodhead[2,3], Oscar Aguilar[1,4,5], Jenny Crinion[1], Will Penny[4], Yean-Ong Hoon[4], Alex Leff[1,3,4]; [1]Institute of Cognitive Neuroscience, University College London, 17 Queen Square, London, WC1N 3AR, UK, [2]Department of Experimental Psychology, University of Oxford, UK, [3]Department of Brain Repair and Rehabilitation, Institute of Neurology, University College London, UK, [4]Wellcome Trust Centre for Neuroimaging, University College London, 12 Queen Square, London, WC1N 3BG, UK, [5]Facultad de Psicología, Pontificia Universidad Javeriana, Bogotá, Carrera 7, No. 40 – 62, Colombia.

Introduction: Central alexia is an acquired reading disorder co-occurring with a generalised language deficit (aphasia). We investigated the effects of a reading training App, called iReadMore, designed to improve word reading accuracy on the reading network of patients with Central Alexia. Methods: 23 patients with central alexia in the chronic post-stroke phase participated in the study. Participants completed a four-week therapy block in which they attended three 40 minute face-to-face sessions per week and completed a total of 35 hours of training at home. Before and after therapy, word reading accuracy for trained words and a matched list of untrained words was assessed and an MEG scan was conducted. During each MEG scan participants were presented with trained and untrained words. Variational Bayes Equivalent Current Dipole 1 source localisation identified subject specific dipoles in the following locations: left and right occipital regions (OCC), ventral occipitotemporal regions (vOT) and inferior frontal gyrus (IFG). DCM 2 modelled the modulation in effective connectivity for reading trained items after therapy compared to before therapy, in the first 300ms of word processing. A random effects Bayesian Model Averaging analysis was conducted to identify significantly modulated connection strengths. The relationship between reading network modulation and percentage change in word reading accuracy was investigated using Automatic Linear Modelling. Results Participants reading accuracy improved by on average 9.2%, Cohen's d =1.29 (large). The following were stronger for trained words following therapy: i) left and right IFG self-connections ii) left and right OCC self-connections ii) from left OCC to left vOT iv) from left OCC to left IFG v) from left OCC to right OCC and vi) left to right IFG. The ALM identified a significant positive correlation between improvement in reading accuracy and modulation of the right OCC self-connection ($p<0.05$) and the connection from the right OCC to left OCC ($p<0.05$). The modulation of the backwards connection from left vOT to left OCC and from right IFG to right vOT was significantly negatively correlating with improvements in word reading accuracy for trained items. Conclusion Overall, a strengthening of left hemisphere, feed forward connections were observed for trained words. This is interpreted as the representations of these words being updated in the left IFG. Larger therapy gains were associated with greater strengthening of the right OCC self-connection and the lateral connection from right OCC to left OCC, suggesting that patients who processed the left-side (prefix) of words well and integrated this information across hemispheres did better than those who did not.

D28 Sentence Repetition Impairment in Primary Progressive Aphasia: A Voxel-Based Morphometry (VBM) study

Sladjana Lukic[1], Maria Luisa Mandelli[1], Ariane

Welch[1], Yann Cobigo[1], H. Isabel Hubbard[1], Maria Luisa Gorno-Tempini[1]; [1]Memory and Aging Center, Department of Neurology, University of California San Francisco

Introduction: During repetition tasks, humans engage their speech production system, retaining phonemes, syntax and semantics in short-term memory. Previous studies indicate that repetition is affected in patients with primary progressive aphasia (PPA), particularly in the logopenic variant PPA, and it is associated with atrophy in the left posterior temporal and parietal regions [1-3]. However, repetition deficits may result from breakdown at any level of processing, and have not yet been thoroughly investigated. The purpose of this study was to examine how gray matter (GM) atrophy contributes to sentence repetition performance in PPAs with non-fluent (nfvPPA), logopenic (lvPPA) and semantic variant (svPPA). Of particular interest was evaluating how processing long or short and meaningful or non-meaningful phrases, contribute to repetition performance in PPAs. Method: 86 PPAs (25 nfvPPA, 42 lvPPA, and 19 svPPA; Age range = 51 – 84, mean = 64.9; 52 females) were classified into three subtypes based on published criteria [4]. All performed the repetition task comprised of 20 phrases that varied in length and meaning (a shorter version of Bayles test [5]). The patients' T1 images were pre-processed using a standard VBM procedure: segmentation (gray and white matter), normalization, modulation, and 8mm Gaussian kernel smoothing. Using regression models, we tested: (1) the effects of length and meaning on repetition performance in PPA variants, (2) the relation between GM volume and repetition performances across PPA variants, and (3) group differences in GM volume in regions-of-interest (ROIs) where PPAs showed a significant relation between GM volume and repetition performances. Age, total intracranial volume, and sex were included as covariates in the model. Significance was set at $p < 0.05$ corrected for multiple comparisons. Results: The regression analyses revealed: (1) poorer performance for longer and non-meaningful phrases across PPA variants. LvPPA performed worst across all phrases, svPPA in long phrases, and nfvPPA did not show any repetition deficits. (2) Decreased performance on long meaningful phrases was associated with atrophy in the bilateral planum temporale (PT), superior and middle temporal gyri (STG, MTG). Left-lateralized PT, MTG, STG, and thalamus atrophy were associated with poor performance on non-meaningful phrases, short or long. No areas were associated with performance on short meaningful phrases. (3) Finally, ROI analysis showed decreased GM volume in the bilateral PT and STG for lvPPA when compared to nfvPPA or svPPA variants. Also, lvPPA showed decreased GM volume in the bilateral MTG and the right thalamus when compared to nfvPPA and svPPA, respectively. No differences in GM volume were found between the latter two. Conclusions: The data showed that longer and non-meaningful phrases were the hardest across PPAs. Decreased GM volume within the bilateral temporal regions contributed to impairment on repetition tasks in lvPPA, providing direct evidence that these regions are implicated in the phonological anatomical network. This study showed that specific neuroanatomical and linguistic features of repetition tasks could inform the diagnosis of logopenic and semantic variant PPA. Eventually, these findings may provide some insights to distinguish the different processes, such as semantics or phonology that underlie repetition.

D29 Implicit verbal structure learning in Developmental Verbal/Orofacial Dyspraxia due to FOXP2 mutation: An fMRI study

Georgios P.D. Argyropoulos[1], Mortimer Mishkin[2], Faraneh Vargha-Khadem[1,3]; [1]UCL Great Ormond Street Institute of Child Health, London, UK, [2]National Institutes of Health, Bethesda, Maryland, USA, [3]Great Ormond Street Hospital for Children National Health Foundation Trust, London, UK

Introduction: A dominantly inherited speech and language disorder in half the members of the multi-generational 'KE family' (Hurst et al., 1990; Vargha-Khadem et al., 1995) is linked to a mutation in the FOXP2 gene (Lai et al., 2001). The neural phenotype of this mutation is primarily characterized by a pronounced volume reduction in the caudate nucleus bilaterally (Vargha-Khadem et al., 1998). Since both speech and grammar involve the implicit acquisition of structured sequences, the developmental verbal/orofacial dyspraxia in the affected KE (aKE) members may extend to impaired grammar learning (Vargha-Khadem et al., 2005). An ideal paradigm to study the implicit acquisition of combinatorial rules is provided by artificial grammar learning (AGL; Reber, 1967). After implicit training with outputs of a grammar, neurotypical adults (CTRs) accurately classify novel outputs according to their well-formedness (viz Grammaticality), without awareness of rule structure. This is consistent with fMRI studies associating Grammaticality with caudate activation (Lieberman et al., 2004). To determine whether the structurally abnormal cortico-striatal circuitry of aKE members is associated with deficits in implicit acquisition of abstract combinatorial rules, we conducted an fMRI study of AGL. We predicted that aKE members would show behavioural/hemodynamic abnormalities related to judgements of Grammaticality. Methods: 20 CTRs and 4 aKE members were implicitly trained on an auditory-verbal version of a finite-state grammar (Lieberman et al., 2004), and made grammatical classifications on new words during (rapid event-related) fMRI. Grammaticality of words and their Similarity to exemplars of the training phase were manipulated in an orthogonal fashion. Results: Behaviour: CTRs performed above chance (t=3.79, p=.001), endorsing grammatical more frequently than ungrammatical words (t=3.65, p=.002), and low-similarity items more frequently than high-similarity ones (t=3.03, p=.007); aKE members performed at chance-level (t=-

.9), worse than CTRs (t=2.20, p=.039), showing reduced Grammaticality (Grammaticality*Group: F=4.62, p=.043) but not Similarity (Similarity*Group: F<1) effects on endorsement rates. fMRI: For CTRs, Grammaticality-related activations were found in superior occipital gyri and dorsal striatum; Similarity-related activations were seen in the right supramarginal gyrus and left posterior HVIIa Crus I/II; aKE members showed hypoactivations for Grammaticality-related effects in right superior temporal gyrus, left supplementary motor area, bilateral central operculum/anterior insula, left paravermal HVI/HVIIa Crus I and HVIII; no functional abnormalities were observed for Similarity effects. Activation clusters survived whole-brain FWE-correction ($p < .05$) at cluster size / voxel peak level over individual voxel threshold of $p < .001$. Conclusion: aKE members show compromised implicit AGL and associated hypoactivation in structures fundamental to speech processing. Our results support the proposal that the cortico-striatal structural/functional abnormalities of the aKE members give rise to a series of impairments that stem from, but go beyond the acquisition of articulate speech and impede the implicit acquisition of verbal structure (Vargha-Khadem et al., 2005). The combined behavioural-neural phenotype of aKE members is consistent with deficits in the cortico-striatal habit system (Mishkin & Petri, 1984).

D30 Semantic Comprehension Errors in Pure Word Deafness *L. Robert Slevc[1], Ryan A. Simmons[2], Randi C. Martin[3]; [1]University of Maryland, [2]Duke University, [3]Rice University*

Individuals with acquired pure word deafness (PWD) show selective deficits in speech perception despite preserved hearing, preserved abilities in other aspects of language (semantic knowledge, reading, and production), and often preserved perception of non-speech auditory stimuli (environmental sounds and music). PWD typically results from bilateral temporal damage and is often assumed to reflect underlying deficits in rapid temporal processing that disproportionately impact speech perception (e.g., Poeppel, 2001). However speech perception deficits in some cases of PWD, especially cases resulting from unilateral left-hemisphere damage, do not always appear to reflect a deficit in rapid temporal processing (e.g., Slevc et al., 2011), and these cases can show a counterintuitive tendency to make semantically related errors in speech comprehension (e.g., Metz-Lutz & Dahl, 1984). Speech comprehension deficits in individuals with PWD who show semantically related comprehension errors (e.g., repeating "salt" as "pepper") seem unlikely to simply reflect auditory processing deficits. However, there has not yet been a careful investigation of semantic comprehension errors in a PWD patient. Here, we present one such investigation of patient NL, who shows dramatically impaired performance on standardized tasks of speech perception but performs largely within the normal range on non-speech auditory perception, written comprehension, and speech production (Slevc et al., 2011). To determine whether NL makes semantic comprehension errors (e.g., repeating "diamond" as "ring") more often than would be expected by chance, we administered two word repetition tasks and used Latent Semantic Analysis (LSA; Landauer & Dumais, 1997) to quantify the semantic similarity between the target (to-be-repeated) words and the words NL actually said. We then compared the semantic distances for NL's repetitions to chance estimates of semantic overlap calculated via Monte Carlo simulations. NL's productions were much more closely related to target words (mean LSA distance = 0.252; 95% CI: 0.173, 0.331) than were chance estimates (mean LSA distance = 0.078; 95% CI: 0.076, 0.079), showing that he does indeed often make semantic comprehension errors despite impaired perception of speech. We also investigated whether NL's impaired speech perception would be influenced by semantic variables. In both a repetition task and an auditory lexical decision task, NL was more accurate on high compared to low imageability words (e.g., "building" vs. "thing") – a semantic property – but his accuracy was unrelated to the lexical property of word frequency. NL's perception also was impacted by semantic priming: his repetitions were more closely related to the target words (higher LSA values) after hearing related compared to unrelated words in an auditory semantic priming task. Because NL's speech perception deficit is accompanied by semantic comprehension errors and is influenced by semantic factors, his deficit seems unlikely to result from perceptual problems alone. Instead, NL's speech processing might reflect rapid decay of phonological representations, leading to relatively greater influence of weakly-activated semantic representations (cf. some accounts of deep dysphasia; Martin & Saffran, 1992). Alternatively, his speech processing might reflect an overreliance on relatively coarse right hemispheric semantic representations (cf. the right-hemisphere reading account of deep dyslexia; Coltheart, 2000).

D31 What Matters about White Matter *Argye Hillis[1], Amy Wright[1], Sadhvi Saxena[1], Bonnie Breining[1], Rajani Sebastian[1], Donna Tippett[1]; [1]Johns Hopkins University School of Medicine*

Introduction Although numerous studies have shown that damage to particular white matter tracts disrupt specific language tasks, few studies have examined the role of leukoaraiosis (diffuse white matter disease) in both hemispheres on recovery of language after stroke. Based on the premise that the health of non-infarcted regions is critical to recovery from aphasia, we hypothesized that moderate to severe leukoaraiosis is associated with poor recovery of language after stroke, independently of the volume of infarct and time post onset. We focused on naming because naming deficits (measured with object naming and word fluency such as rapid animal naming) are the most common residual deficits in chronic aphasia. Methods We studied 42 adults, mean 39 ± SD 36 (range

3-157) months post stroke, with the Western Aphasia Battery (WAB) and brain MRI. Participants were mean age of 56.1 years ± SD 15.1 years, and had mean 14.8 ± 3.1 years of education. Scans were rated for the severity of leukoaraiosis by a neurologist and a technician masked to the language scores, using the Cardiovascular Health Study (CHS) rating scale (ranging from 0 to 9, with 9 being 'most extensive'). There was excellent interrater agreement in rating leukoaraiosis (kappa = 0.93). We tested the relationships between severity of leukoaraiosis and language scores (WAB Aphasia Quotient, object naming, word fluency) using Pearson correlations. Ten patients did not complete the entire WAB, so they had only naming and fluency scores. We tested the association between "good outcome" (highest quartile of each language score) and moderate to severe leukoaraiosis (≥5 on 0-9 scale) using chi square tests. We also used linear regression, with language scores as the dependent variable, and leukoaraiosis, lesion volume, and time post-onset as independent variables, to evaluate the contributions of each to recovery of language. Results Severity of leukoaraiosis negatively correlated with WAB AQ (r= -0.43; p=0.016), object naming (r=-0.47; p=0.0017), and word fluency (r=-0.36; p=0.019). Moderate to severe leukoaraiosis (CHS score ≥5) was negatively associated with highest quartile of object naming (chi squared = 4.7; p=.031) and word fluency (chi squared = 5.3; p=0.022). In multivariate analysis, severity of leukoaraiosis, lesion volume, and months post-onset together predicted recovery of object naming (p=0.036), but only the severity of leukoaraiosis was independently associated with recovery of object naming (p=0.01; CI -7.07 to -.85). Severity of leukoaraiosis was also the only independent (negative) predictor of recovery of word fluency (p=0.041) and WAB AQ (p=0.011) when we included infarct volume and months post-onset in the regression. Conclusions These results indicate that moderate to severe leukoaraiosis is associated with poorer recovery of naming and other language skills, independently of infarct volume and months post-onset of stroke. Results may help with prognosis. Further studies are needed to determine if leukoaraiosis can prospectively predict language recovery or response to treatment in larger, independent samples.

D32 Using background connectivity to index recovery of function in acquired language impairments

Yuan Tao[1], Brenda Rapp[1]; [1]Johns Hopkins University

It is both theoretically and clinically important to understand the neural changes that take place in the course of recovery of function in the adult lesioned brain. From a theoretical perspective, this is part of the larger enterprise of understanding the possibilities and constraints of neuroplasticity. From a clinical perspective, this understanding contributes to our ability to optimize neural interventions for recovery of function following brain lesions. Recovery of function, as a form of (re) learning, can be expected to result in local neural changes as well as changes in the interactions between more distant brain regions (Buchel & Friston, 1999). In this research, we examine changes in the neural interactions that accompany recovery of function subsequent to rehabilitation for stroke-induced written language deficits. Background connectivity, as developed by Norman-Haignere et al. (2011), provides a measure of the interaction between brain areas in a way that removes the contribution of stimulus-locked activation fluctuations. We used classification-based analysis approaches to detect rehabilitation-related changes in background connectivity patterns. Eleven right-handed (5 females) individuals with acquired dysgraphia subsequent to a single left-hemisphere stroke (14-103 months post-stroke) underwent biweekly behavioral rehabilitation for approximately 12 weeks. All individuals exhibited significant improvement in spelling accuracy and fMRI data were collected during performance of a spelling task both before and after treatment. After standard pre-processing, we estimated background connectivity using GLM residuals. The GLMs included task events, 6 motion regressors, and averaged sub-cortical time-series to remove physiological artefacts. For 264 5mm-radius spheres (locations from Power et al., 2011), we calculated the absolute values of all pairwise Pearson correlations (Fisher z-transformed). Lesioned voxels were assigned a zero value, indicating no information. We applied Linear Discriminate Analysis (LDA) to classify each individual's pre vs. post-training correlation matrices using a leave-one-subject-out cross-validation procedure. Prior to each cross-validation iteration, feature selection was carried out to identify the most informative connections. Pre- vs. post-training correlation matrices were most reliably distinguished with 200 connections (accuracy=0.73, permutation test p=0.01) and 51 of these were identified in all cross-validation iterations. Thirty-seven exhibited a correlation decrease from pre- to post-training and only 12 showed an increase (two-tailed $p<0.05$). Among the connections with decreased correlations, more than 87% were either within the left hemisphere (40%) or between hemispheres, while only 13% were within the right hemisphere. Although informative connections were widely distributed, nodes involved in connectivity decreases were concentrated in bilateral motor cortex and the anterior cingulate/paracingulate cortex, while connectivity increases were concentrated in the right anterior insular, contralateral to the most heavily lesioned area. In conclusion, the connectivity-based approach revealed systematic neural changes from pre to post treatment for acquired language deficits in both the directionality of the interaction (increase or decrease connectivity) and the hemispheric lateralization. The finding of widespread functional connectivity decreases is consistent with previous findings of abnormally high levels of post-stroke resting state connectivity (Carter et al., 2012; Park et al., 2011) in certain brain areas. Furthermore, the results suggest that rehabilitation may support normalization of left hemisphere connectivity.

Meaning: Combinatorial Semantics

D34 Verb constraint and semantic integration

Ben Rickles[1,3], Gwen A. Frishkoff[2]; [1]Georgia State University, [2]University of Oregon, [3]University of Maryland

Despite a long history of experimentation using behavioral and brain imaging methods, questions remain about the processes readers use to first access and then combine or, integrate, single word meanings to form higher-level semantic structures. Using event-related potential technique, we showed participants a series of four words, asking them whether the words combined to form a possible event. We maintained the order of the thematic roles (Agent, Action, Patient, Goal), while manipulating both the semantic congruity between the verb and final noun (Congruity), and local association between nouns (Relatedness) in an attempt to separate processes of structure building from retrieval-based processing. A frontal negativity peaking roughly 450 milliseconds (ms) after the Goal was modulated by Congruity, while contrary to our expectations, a posterior positivity, peaking between 500-600 ms, was seen to increase only when final words were both congruent and related. In a further examination of differences between verbs, the frontal effect was stronger for Goal words following the verb "gave" , while the posterior effect was stronger for Goal words following the verb "put". We explain the effects in terms of how the verb constrains the processes involved in semantic structure building during reading.

D35 Effects of Aging on Semantic-Syntactic Integration in Chinese Classifier-noun Agreement

Chia-Ju Chou[1], Chih-Ting Chang[1], Jie-Li Tsai[2], Chia-Ying Lee[1,3]; [1]National Yang-Ming University, [2]National Cheng-Chi University, [3]Academia Sinica

Language comprehension involves various processes operating in parallel. Although most language comprehension abilities remain relatively stable in old age, age-related cognitive declines may change the pattern of language process. Semantic and syntax are core components for language comprehension. According to the constraint-satisfaction model which claims that both syntactic and semantic processes work together to determine the meaning of a sentence. This Event-Related potential (ERP) study examines whether aging affects these two key processes by investigating how the semantic constraint of classifiers modulates the semantic and syntactic violation in normal aging. In this study, semantic constraint strength of classifiers (strongly and weakly) and three types of completions (expected noun, implausible noun, implausible verb) were manipulated. 18 young adult subjects, ranging from age 20–30 years (mean = 24; 9 males), and 22 older adult subjects between the ages of 56–78 years (mean = 65.0; 7 males) participated. Cognitive performance was assessed in elders using the Mini-Mental State Examination (MMSE, mean = 28.35, SD = 1.5). Participants were asked to read a classifier which followed by a pairing completion on the center of the screen for the acceptability judgment task. ERPs elicited by the completions showed that, for young adults, implausible noun and implausible verb elicited significant larger N400s than expected noun did, under both the strongly and weakly constrained condition. Importantly, the syntactic violation effect on the P600 was only found under the strongly constrained condition. It suggests that the syntactic appropriateness would only be evaluated when the context is semantically and syntactically highly predictive. The semantic influence on syntactic processes supports the constraint-satisfaction model. Data from older adults revealed the semantic and syntactic violation effects on N400, although the effects were reduced and delayed when compared with those in young adults. In addition, the semantic and syntactic violation effects on N400 was larger and broadly distributed under the strongly constrained condition than those under the weakly constrained condition. Critically, no syntactic violation could be found in elder's data, even under the strongly constrained condition. It suggests that elders tend to allocate most of the cognitive efforts in resources for resolving the semantic plausibility for reading comprehension. Moreover, the implausible verb elicited a frontal distributed P600 under the weakly constrained condition, suggesting that elders may utilize a compensatory neural system for the syntactic-semantic integration.

D36 Predicting the negative: investigating the comprehension of negated sentences in an event-related potential study

Viviana Haase[1], Markus Werning[1]; [1]Institute for Philosophy II, Ruhr University Bochum, Germany

It is widely agreed that prediction is a key feature of language comprehension (e.g. De Long et al., 2005; Pickering and Garrod, 2007) leading to the question of what we predict once we encounter a negation in a sentence. Negative sentences have been claimed to be harder to process due to (i) their higher (morpho-) syntactical complexity and (ii) the need to suppress positive information and to eventually represent the negated state of affairs (i.e. the affirmative counterpart) on a first step before representing the actual state of affairs (e.g. Just & Carpenter, 1971; Kaup et al, 2006). Accordingly, negative sentences have been shown to elicit different behavioral and neurocognitive responses than their affirmative counterparts, such as for example higher error rates, longer response times (e.g. Just & Carpenter, 1971), but also different ERP (e.g. Fischler et al, 1983; Lüdtke et al, 2008) and fMRI patterns (e.g. Bahlmann et al, 2011). Measuring ERPs, we addressed the questions (i) how prediction influences the comprehension of negated sentences, (ii) whether negation can be processed incrementally or whether a multistep process is necessary and (iii) whether processing differences between negative

and affirmative sentences are correlated with individual personality or cognitive traits. Therefore, we used a 2x2 design with the factors sentence polarity (affirmative vs. negative) and truth (true vs. false). Other than Fischler et al. (1984) we did not ask for explicit truth-value judgement. Furthermore, we controlled for the lexico-semantic relationship between the two nouns occurring in a sentence, as indicated by Latent Semantic Analysis (Landauer, Foltz & Laham, 1998). Additionally, we tested our participants for their working memory capacities by employing the Digit Span and Reading Span test. Based on findings by Nieuwland et al (2010), all subjects were screened with the Autism Spectrum Quotient Questionnaire in order to examine whether differences in the results are triggered by differences in their AQ scores. We observe a clear centroposterior N400 effect for true vs false negatives, indicating that the integration of the negative marker indeed seems to be time-consuming. Other than Fischler et al. (1984) and Lüdtke et al. (2008) we argue that this result does not necessarily reflect different representational steps but rather a difficulty in the prediction process, as prediction involves computations that may require different amounts of time (e.g. Chow et al 2016). Furthermore, our results show that this N400 effect is stronger for subjects with high working memory capacities indicating that they seem to predict a higher number of possible scenarios, possibly in a graded or probabilistic way. Finally, it is argued that we should take into account language-specific differences, as different languages vary with regard to their (default) relative weighting of top-down and bottom-up information sources (e.g. MacWhinney et al 1984, Tune et al 2014). For example, preverbal and postverbal negation affect prediction to different degrees, as the latter renders a reanalysis (from an "affirmative first" reading to a sentence of negative polarity) more likely than the former.

D37 The P600 - not the N400 - indexes semantic integration

Francesca Delogu[1], Harm Brouwer[1], Matthew Crocker[1]; [1]Saarland University

The N400 and P600 are the two most salient language-sensitive components of the Event-Related Potential (ERP) signal. Yet, their functional interpretation is still a matter of debate. Traditionally, the N400 is taken to reflect processes of semantic integration while the P600 is linked to structural reanalysis [1,2]. These views have, however, been challenged by so-called Semantic Illusions (SIs), where semantically anomalous target words produce P600- rather than N400-effects (e.g., "For breakfast the eggs/boys would eat", [3]). To account for these findings, complex multi-stream models of language processing have been proposed in an attempt to maintain the traditional views on the N400 and the P600 (see [4] for a review). However, these models fail to account for SIs in wider discourse [5] and/or in absence of semantic violations [6]. In contrast, the Retrieval-Integration (RI) account [4] puts forward an explanation for elicitation pattern of the N400 and the P600 by rethinking their functional interpretations. According to the RI account, N400 amplitude reflects retrieval of lexical-semantic information form long-term memory, and is therefore sensitive to priming (in line with [7,8]), while processes of semantic integration are indexed by the P600. To provide decisive evidence for the P600/Integration hypothesis, we conducted an ERP study in which twenty-one participants read short discourses in which a non-anomalous target word ("menu") was easy (a. John entered the restaurant. Before long he opened the menu and [...]) vs. difficult (b. John left the restaurant. Before long he opened the menu and [...]) to integrate into the unfolding discourse representation, but, crucially, was equally primed by the two contexts (through the word "restaurant"). The reduced plausibility of (b) compared to (a) was confirmed by offline plausibility ratings. Here, traditional accounts predict that difficulty in integrating the target word in (b) should elicit an N400-effect, and no P600-effect. By contrast, the RI account predicts no N400-effect (due to similar priming), but a P600-effect indexing semantic integration difficulty. As predicted by RI, we observed a larger P600 for (b) relative to (a), and no difference in N400 amplitude. Importantly, an N400-effect was observed for a further control condition in which the target word "menu" was not primed by the context (e.g., "John entered the apartment"), which elicited an increased N400 amplitude relative to (a) and (b). Taken together, our results provide clear evidence for the RI account: semantic integration is indexed by the P600 component, while the N400 is predominantly driven by priming. Our findings highlight the importance of establishing specific linking hypotheses to the N400 and P600 components in order to properly interpret ERP results for the development of more informed neurobiological models of language. [1] Brown & Hagoort (1993), JCN; [2] Osterhout & Holcomb (1992), JML; [3] Kuperberg et al. (2003), Brain Res Cogn Brain Res.; [4] Brouwer et al. (2012), Brain Res.; [5] Nieuwland & Van Berkum (2005), Cogn. Brain Res.; [6] Chow & Phillips (2013), Brain Res.; [7] Kutas & Federmeier (2000), TiCS; [8] Lau et al. (2008), Nat. Rev. Neurosci.

D38 Quick and easy composition of event concepts in the left (but not the right) anterior temporal lobe

Songhee Kim[1], Liina Pylkkänen[1,2]; [1]New York University, [2]NYU Abu Dhabi Institute

While more and more evidence suggests that the neural representation of semantics is broadly distributed, involving many areas of at least the temporal, parietal, and frontal lobes (e.g. [1]), characterizing the precise computations carried out by this network remains a central challenge. One of the better understood nodes within this system is the left anterior temporal lobe (LATL), an integrative hub implicated for certain types of combinatory conceptual operations. Specifically, the LATL shows an early (200–250ms) amplitude increase for words in combinatory contexts if the semantic composition between the current word and its context is in some ways

"simple," involving no reference to a broader context [e.g., 2, 3]. In other words, the LATL appears to compute some type of "first-pass" conceptual combination, limited to simple, straightforwardly composable concepts. However, this type of effect has so far only been demonstrated for the composition of nouns and their modifiers. Here we asked whether a similar pattern is elicited for complex event concepts, as denoted by combinations of verbs and adverbs. Method: We measured participants' (N = 21) MEG responses to adverb-verb combinations, in which the semantic type of the adverb varied. In the simplest case, so-called eventive adverbs, the adverb named a property of the event described by the verb: slowly paints describes a painting event that is slow. But in the other two cases, the adverb described a property of one of the arguments of the verb, which were not named in our two-word stimuli. So-called resultative adverbs described a resultant state of the object – vividly paints describes a painting event that results in a vivid picture – whereas agentive adverbs describe a property of the agent of the event, as in reluctantly paints (the painter is reluctant). A non-combinatory baseline was created by replacing the adverbs with a consonant string. If the LATL's role is limited to simple, directly composable concepts in the verbal domain as well, only the eventive adverbs should elicit an LATL increase as compared to non-combinatory controls. Results: A cluster based permutation test (Maris & Oostenveld, 2007) on the time courses of the left BA 20, 21, and 38 revealed a reliable effect of adverb type in BA 38 at 278-291ms after the onset of the verb, driven by significantly increased activity in the eventive condition. Given prior evidence that the activity patterns of the right anterior temporal lobe may in fact positively correlate with complexity [2], we also tested the right homologues of these regions, finding increased activity for the agentive condition in right BA 21 and 38 at ~250-300ms. Conclusion: Our findings show clear evidence for "quick and easy" composition of verb phrases in the LATL and a sharply distinct effect in similarly timed right-lateral activity, suggesting a right hemisphere focus for more complex cases of conceptual combination. References: [1] Binder, J.R. Psychon Bull Rev (2016) 23: 1096. [2] Poortman, E.B., & Pylkkänen, L. Brain and language (2016) 160: 50-60. [3] Ziegler, J., & Pylkkänen, L. Neuropsychologia (2016) 89: 161-171.

D39 A distributed and dynamic architecture underlies the retrieval of social concepts

Ingrid Olson[1], Yin Wang[1], Jessica A. Collins[1], Jessica Koski[1], Tehila Nugiel[1], Ahtanasia Metoki[1]; [1]Temple University

INTRODUCTION As social creatures, it is essential that we develop a rich storehouse of knowledge about other members of our social network, such as who they are, how they look and sound, where they live, and what they do for a living. Yet little is known about how and where such person knowledge is represented, stored, and retrieved in the brain. This inquiry is challenging because person knowledge is highly multimodal and multifaceted, being linked to both abstract features such as personality and social status as well as more concrete features such as eye color. The neural circuit for person knowledge must therefore have the ability to combine multiple sources of information into an abstract representation accessible from multiplicative cues. The 'hub-and-spoke' theory of semantic knowledge proposes that different features of a concept (such as its color or taste) are distributed throughout the brain and that a centralized 'hub' integrates these features into a coherent, modality-invariant concept (Patterson, Nestor, Rogers 2007). Here we asked whether portions of the anterior temporal lobe (ATL) serve as a hub for a distributed neural circuit of person knowledge. METHODS Fifty neurologically normal young adults were tested across two studies in which they learned biographical information about fictitious people over two days of training. On Day 3, they retrieved this biographical information while undergoing an fMRI scan. In Study 1, we used stimuli from different categories commonly associated with familiar people (e.g. faces, names, homes, and objects) to cue memories for specific individuals. We compared the similarity of response patterns elicited by stimuli from different categories but associated with the same individual to test the abstract person representation properties of the ATL. In Study 2, we asked participants to recollect specific content of fictitious people's biographies and examined whether the ATL coordinates the retrieval of different aspects of person knowledge by recruiting the activation of different brain regions depending on task requirements. RESULTS AND CONCLUSIONS In Study 1, findings from a series of MVPA tests consistently showed that the ATL represents person knowledge in an abstract form that is divorced from a person's face or name. In Study 2, we found that the ATL person identity node is embedded in a neural circuit that is consistently engaged during person memory tasks. Multivariate analyses suggested that different content areas of person knowledge – social status, personality traits, and identity - were represented in discrete nodes within this distributed person-identification circuit. Connectivity analyses (PPI and DCM) further revealed that the ATL may serve as a 'neural switchboard', and is capable of coordinating the flow of person-specific information between sensory brain regions that encode incoming cues and other nodes of this circuit that are engaged when retrieving specific person knowledge content. These results suggest that the ATL is a central hub for representing and retrieving semantic knowledge about people.

Meaning: Discourse and Pragmatics

D40 Semantic activity differs during comprehension and production of sentences

Clara Scholl[1], Alice Jackson[1], Michael Wolmetz[1]; [1]Johns Hopkins University Applied Physics Laboratory

Research on the characteristics and organization of the cortical semantic network has largely focused on semantics during recognition and comprehension. Experimental paradigms and deficit patterns associated with retrieving semantic information to understand pictures and words have yielded increasingly sharp descriptions of the cortical semantic network, but how these descriptions relate to semantic processing for production and communication is not well understood. To begin to address this gap, we used functional Magnetic Resonance Imaging (fMRI) to compare patterns of semantic activity during sentence production and sentence comprehension. After training to type in the scanner, participants (N = 21, mean age = 28) typed sentences about cued topics (e.g. castles) over the course of three functional runs using an MR-safe keyboard, and then participants read short passages on the same topics over the course of three functional runs. The same twelve topics appeared in each run, in a randomized order. Semantic responses during production were compared with semantic responses during comprehension using Representational Similarity Analysis (RSA). Dissimilarity Matrices (DSMs) were calculated at searchlight locations throughout the brain for data collected during the production condition, and separately for the comprehension condition. These DSMs were directly compared to one another, but also compared to a model of the semantic relatedness between stimulus topics based on behavioral ratings collected on Amazon Mechanical Turk. Using these techniques, we observed semantic neural activity patterns associated with the comprehension condition that was consistent with related studies. Many regions, including bilateral superior temporal gyri, bilateral precentral gyri, left middle temporal gyrus, left inferior frontal gyrus, and left cingulate gyrus, had response patterns that significantly correlated with behavior-based semantic relatedness. Semantic neural activity patterns associated with the production data was substantially more variable across subjects, due in part to variability in behavioral responses. There are many challenges in adapting the methods and analysis techniques built for studying cued recognition and language comprehension to questions about language production and communication. This work represents a first step toward studying more naturalistic modes of communication, and extending models of the cortical semantic network to language production.

D41 Neural measures of sensitivity to the acquisition of space-time mappings in an artificial semiotic system

Tania Delgado[1], Tessa Verhoef[1], Esther Walker[1], Seana Coulson[1]; [1]UC San Diego

In languages across the world, a common strategy for expressing the meaning of temporal concepts is to recycle the language of space. The present study tested whether some time-space mappings are easier to learn by recording EEG as participants learned an artificial language derived from a social communication game. In this prior study, we equipped people with a novel communication device (a vertical bar with a knob on it) and asked them to use the bar to convey temporal concepts to each other, such as 'past,' 'future,' 'today,' and 'tomorrow'. In the behavioral study, dyads consistently adopted a duration-mapping strategy early in the interaction, using larger portions of the bar to refer to temporal intervals that were longer. For example, 'day' took up half the bar, while 'year' took up the whole bar. Duration mappings were hypothesized to result from a cognitive bias. By contrast, an order-mapping strategy, using either the top or the bottom of the bar to refer to concepts in the future were more variable across dyads and were hypothesized to rely more on social interaction for their establishment. Here we asked whether the way signals emerge in these social communication games has implications for the difficulty that new individuals experience when they learn them. Accordingly, EEG was recorded as 16 healthy adults learned 'words' in a miniature artificial language derived from the output of one of our most successful dyads in the behavioral study. The mini-language included 16 discrete 1.5-second movements of a round knob along a vertical bar, each corresponding to a particular temporal concept (e.g., day, second, year). Participants viewed each 1.5-second signal followed by a potential English translation of the signal (e.g. yesterday), and then pushed a button to indicate whether or not the translation was correct. Participants' response triggered a feedback tone that enabled learning. In one 'round', a participant saw each of the signals in the language, once paired with the matching translation, and once with a mismatching one. Each 'block' was comprised of three rounds, and each participant underwent two blocks of training. ERPs were time-locked to the onset of English translations. The mean amplitude of ERPs was measured 300-500ms post-stimulus onset to index N400, and 500-800ms post-stimulus to index P600. Analysis of duration mappings contrasted ERPs to matching versus mismatching translations recorded in the first and second blocks, respectively. Repeated measures ANOVA with factors Validity (match/mismatch), Block (first/second), and ROI (six regions of four electrodes each) revealed an interaction of Validity, Block, and ROI. Consistent with our hypothesis that participants have a cognitive bias that supports duration mappings, the duration violations elicited enhanced N400 in the first block, and an N400/P600 complex in the second block. Similar analysis of order mappings revealed no reliable ERP effects in the first block, and significantly larger amplitude N400 for order violations in the second block. Results support the hypothesis that participants in our subject pool have a cognitive bias that supports more rapid learning of duration than order mappings.

D42 Functional connectivity between cognitive control and episodic memory systems in event comprehension

Zachary Ekves[1,2], Pedro Paz-Alonso[3], Nicholas Hindy[4], Sarah Solomon[5], Gerry Altmann[1,2]; [1]University of Connecticut, [2]The Connecticut Institute for the

Brain and Cognitive Sciences, [3]Basque Center on Cognition, Brain and Language, [4]University of Kentucky, [5]University of Pennsylvania

Language comprehension often involves tracking an object undergoing a change in state across time: to understand the event "he chopped the onion" one needs to know the typical semantic qualities of the type "onion" and attribute episodically bound characteristics to a particular object-token (e.g. this particular onion is now in a chopped state). Recent work [1,2] has shown that when language refers to objects that have previously undergone substantial changes in state (e.g. "he chopped the onion, then smelled the onion"), portions of the left ventrolateral prefrontal cortex (VLPFC; an area generally implicated in cognitive control [3]) show greater activation compared to later reference to objects that have not changed substantially (e.g. "he weighed the onion, then smelled the onion"). This increased activation for reference to substantially changed objects is token specific, as later reference to a different token of the same type shows no degree of change effect ("She chopped the onion and then smelled ANOTHER ONION."). The authors suggest that this is indicative of a need to select between competing states of the same object token (does "the onion" refer to the newly chopped state or the previously intact state?), and lends support for a theory of event representation in which object token-states are representational primitives. To examine the relationship between the cognitive control and memory systems underlying language processing in this framework, we examined functional neural connectivity during reading in a reanalysis of fMRI experiments [1,2] that manipulated both the degree of state change that the critical objects underwent and whether reference was made to previous vs novel tokens ("She will WEIGH/CHOP the onion and then she will smell THE ONION/ANOTHER ONION."). Here the focus is on the relationship between cognitive control regions and subsegments of the hippocampus, a region implicated in episodic memory function [4] which is not typically a focus in work on language processing. We found increased connectivity between left pars triangularis (in VLPFC) and left hippocampal body for sentences referring to novel tokens compared to those referring to the same, but substantially changed, object ("chop the onion… smell THE ONION/ANOTHER ONION"). No difference in connectivity between these regions is observed in a comparison between sentences referring to novel tokens vs the same token when the objects have only minimally been changed however ("WEIGH the onion… smell the onion/another onion"). We take our findings to be suggestive of cognitive control regions playing a role in modulating the features being attributed to objects in hippocampal, episodic memory systems during reference in language processing. Connectivity between occipital gyrus, angular gyrus, and the hippocampus will also be discussed.

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D43 Individual Competence in Reading Comprehension and Fluid Intelligence Modulates Right DLPFC Activity when Reading Scientific Texts

Chun-Ting Hsu[1], Benjamin Schloss[1], Ping Li[1]; [1]Pennsylvania State University

Reading is one of the most prominent methods to learn abstract scientific concepts in education. Reading comprehension involves a sequence of cognitive processes, including word recognition, semantic and syntactic processing, world knowledge integration and situation model updating, leading to coherence building. Although linguistically defined, these processes also heavily depend on other cognitive abilities like working memory, executive function, and attention. The competence of reading comprehension would affect the ability to acquire scientific concepts, which is also reflected in the individual measurement of fluid intelligence. Using a design enabled by naturalistic self-paced reading, this study investigated neural correlates of reading comprehension of scientific texts at the level of sentential processing, and the neural correlates reflecting individual differences in the reading comprehension competence and fluid intelligence while reading. Fifty participants read five scientific texts (math, mars exploration, electric circuit, ship building and safety, and GPS) sentence by sentence in a self-paced method inside the scanner while eye-tracking data and multiband EPI of TR = 400 ms were acquired. Participants' reading comprehension ability (measured by the Gray Silent Reading Test; Wiederholt & Blalock, 2000) and non-verbal fluid intelligence (measured by the Raven's Progressive Matrices; Raven et al. , 1988) were collected in their second visit. In the GLM analysis of the fMRI data, using the timing of first fixations on content words as onsets, we modeled the parametric effect of the word position index in a sentence (e.g., coding 3 indicated the third word in a sentence) of content words. We found regions involved in visual feature processing to be more active at the beginning of the sentence, which included bilateral visual cortex and left fusiform gyrus, as well as left dorsolateral prefrontal cortex (dlPFC, MNI: -48 -1 42). By contrast, the regions that were more active toward the end of the sentence included bilateral regions associated with syntactic processing (insula), modality specific semantic processing (pre- and postcentral gyri), semantic retrieval (dorsomedial prefrontal cortex, dmPFC, and supplementary motor area), coherence building (temporoparietal junction, TPJ, and dorsomedial prefrontal cortex), attention and working memory (dlPFC, MNI: -24 14 58 & 48 29 34, and TPJ). More specifically, one peak in the right dlPFC (MNI: 27 14 38) became more activated towards the end of the sentence in participants who had

higher scores in reading comprehension, and another peak in the right dlPFC (MNI: 18 23 42) became more activated towards the end of the sentence in participants with higher non-verbal fluid intelligence. Our results suggest a possible early focus on surface form analysis and later focus on semantic analysis and integration during reading. DLPFC has been associated with executive function, attention, and working memory, and our finding showed right dlPFC activity towards the end of the sentence to be correlated with reading comprehension ability and fluid intelligence. They further suggested the role of dlPFC in the learning of abstract scientific concepts. Causal relationships between executive functions and reading comprehension at the behavioral and neural level should be further investigated.

Meaning: Prosody, Social and Emotional Processes

D44 Neural Mechanisms Underlying Social Criticism and Praise

Shan Gao[1,2], Ting Gou[1]; [1]School of Foreign Languages, University of Electronic Science and Technology of China, Chengdu, China, [2]Key Laboratory for NeuroInformation of Ministry of Education, University of Electronic Science and Technology of China, Chengdu, China

Semantic orientation is the evaluative character of language expressions. Verbal communication with different semantic orientation has a considerable impact on the extent to which social relations are facilitated or undermined. Semantic orientation varies in valence (positive or negative), leading to praise and criticism in social interaction and corresponding emotional reactions. Here using functional magnetic resonance imaging, we investigated how the brain acts in response to social praise and criticism. We engaged men and women in associating male and female neutral faces with descriptives of praising or criticizing behaviours targeting others or objects. The whole brain analysis revealed that while both praise and criticism significantly activated the medial prefrontal cortex (mPFC) and bilateral amygdala the activation in the left mPFC was stronger in response to criticism as compared to praise, which was driven by activation differences in this region between criticism and praise targeting others but not objects. Comments on others relative to objects enhanced the activity in the left mPFC and left posterior cingulate cortex (PCC) such that both praise and criticism of others produced stronger activation in the left PCC than their objects-targeted counterparts whereas the left mPFC showed greater activity only in the contrast of criticism targeting others vs. objects. These main and interactive effects of valence (praise or criticism) and target (others or objects) subsequently led to altered likeability for the faces. And they were not modulated by subject or face sex. Taken together, our findings suggest the fundamental roles of the mPFC and PCC in processing social praise and criticism, verbal cues with different semantic orientation, which may trigger avoidance or approach in social interaction.

Meaning: Lexical Semantics

D45 Effect of methylphenidate on semantic unification: Evidence from an EEG study in the healthy population

Yingying Tan[1], Peter Hagoort[1]; [1]Max Planck Institute for Psycholinguistics

Methylphenidate is the most frequently prescribed medication for people with ADHD. Nowadays, there is an increasing use of methylphenidate in the healthy population, because many studies showed that methylphenidate could enhance cognitive functions in both ADHD and healthy populations, such as working memory (WM) and response inhibition. However, the cognitive-enhancing effect of methylphenidate is under debate and some recent studies suggested that the effect of methylphenidate depends on specific tasks demands and individual differences [1, 2]. So far, there is no empirical study examining the effect of methylphenidate in sentence processing in the healthy population. Given the long-studied link between WM and language processing and the important role of dopamine in language processing [3], we aimed to investigate the effect of methylphenidate on semantic unification during sentence comprehension. This study used a within-subject double-blind randomized placebo-controlled design. 48 healthy native Dutch speakers were recruited and each subject was tested in two sessions. There are three within-subject experimental manipulations: drug (methylphenidate vs. placebo), sentences' semantic congruence, and task type. Half of the subjects received an oral capsule of 20 mg methylphenidate in session 1 while the other half subjects received a placebo, and each subject received the other kind of capsule in session 2. During each session, subjects were instructed to read 180 sentences followed by question. The sentences were either semantically congruent or incongruent, e.g., "Dutch trains are yellow/*sour." For the following questions, subjects have to judge whether the sentence is semantically congruent in one block and whether a probe word presented after the sentence is of the same font size as the sentence word in another block. Subjects' brain responses were recorded from 32 active EEG electrodes. We examined the methylphenidate effect on semantic unification as indexed by change on the N400 component [4]. The behavioral results showed that after taking methylphenidate, subjects are more sensitive to semantic violation and font size changes in both tasks as indexed by a significantly higher d'. The preliminary EEG data showed that there is an interaction of methylphenidate and task type on the N400 component. After taking methylphenidate, subjects showed a comparable N400 component in both tasks. However, in the placebo condition, the scalp distribution of the N400 component differed between the two tasks. The current results suggested that methylphenidate affects semantic unification during sentence comprehension. We are further examining the EEG data and check whether

the methylphenidate effect is related to subjects' WM or baseline dopamine level. References [1] Fallon, S. J., & Cools, R. (2014). Reward acts on the pFC to enhance distractor resistance of working memory representations, JoCN, 26, 2812 - 2826. [2] Cools, R., & D'Esposito, M. (2011). Inverted-U-shaped dopamine actions on human working memory and cognitive control. Biological Psychiatry, 69, e113-125. [3] Grossman, M., et al., (2001). Dopamine supports sentence comprehension in Parkinson's Disease, JoNS, 184, 123-130. [4] Kutas, M., & Federmeier, K. D. (2011). Thirty years and counting: finding meaning in the N400 component of the event-related brain potential (ERP). Annual review of psy, 62, 621-647.

D46 Brain oscillation signatures of learning new meanings for known words and novel words

Xiaoping Fang[1,2], Charles Perfetti[1,2]; [1]Learning Research and Development Center, University of Pittsburgh, [2]Center for the Neural Basis of Cognition

In addition to learning new words, people refine and add new meanings to words they already know. For example, one might learn that "skate" is a kind of fish long after knowing its most common meaning. This type of learning involves strong interactions between new information and prior knowledge and is relatively less studied, compared to the learning of novel words. The current study tracked the two types of learning by recording EEGs throughout the learning phase. Twenty-one native English speakers learned new meanings for known words (e.g., "plenty" means "causing fever") and novel words (e.g., "tasdite" means "having a tight schedule") in an associative learning paradigm in which a word and its meaning were presented consecutively. Each word was presented once in each of six learning blocks. Following the first block of study trials, blocks two through six were test-study trials, requiring participants to attempt to recall the new meanings before viewing them and assessing their recall success. To observe oscillation indicators of learning, we compared early-phase learning trials (the second and third learning blocks) with late-phase learning trials (the last two learning blocks). Self-assessed recall increased from early to late phases, and in both phases the performance for known words was better than for novel words, a pattern also found in a post-learning multiple-choice test. Brain oscillations on the trained words showed different patterns for the two types of learning. In late learning, novel words showed decreased synchronization at alpha band (9-12 HZ) but not at other frequency bands. In contrast, known words showed decreased synchronization in alpha, upper beta (21-29 HZ), and lower gamma (30-59 HZ) bands from early to late learning phases. We interpret the decreased beta synchronization observed in the frontal regions to reflect the suppression of original meanings that comes as a new meaning is learned well enough to evoke competition from a word's original meaning. Theta synchronization did not change over learning phases on either known or novel words, suggesting that neural communications between the hippocampus and neocortex during the retrieval of new meanings were maintained during the 90-120 minutes of learning within the session. This interpretation is consistent with the assumption that episodic learning continues across trials within a single session for both novel and real worlds, with the main difference being the need for suppression of original meanings in the case of real words.

D47 A study, the study: Using indefinite and definite articles to examine the nature of structure building

Regina Calloway[1,2], Charles Perfetti[1,2]; [1]Learning Research and Development Center, [2]University of Pittsburgh Psychology

During text comprehension, readers create a mental structure of the text. When reading sentence beginnings within a text, readers can integrate the new sentence with the previous text or shift to a new mental structure. When possible, readers can also establish co-reference across a sentence boundary (i.e., linking a referent at the beginning of a sentence to an antecedent in the previous sentence). The present study examined whether the default mechanism for processing sentence beginnings is to shift or integrate by using definite (e.g., the) and indefinite (e.g., a/an) articles as sentence beginnings. Definite articles are cues that upcoming information should be old or related to previous information; indefinite articles are cues that upcoming information should be new. We hypothesized that readers should expect to integrate after encountering a definite article and shift to a new mental structure after encountering an indefinite article. Therefore, when nouns are explicitly repeated across a sentence boundary, definite articles should be a cue to establish co-reference, whereas indefinite articles should be a cue that an entity is new. When nouns are not explicit repetitions across a sentence boundary, readers should shift to a new mental structure following an indefinite article; and attempt to integrate following a definite article. A failure to integrate following a definite article should cause increased processing difficulty. In a 2 (explicit antecedent vs. no antecedent) x 2 (definite vs. indefinite article) factorial design we measured event-related potentials on nouns that followed definite and indefinite articles in two-sentence texts. Antecedents occurred at the end of the first sentence and the critical nouns were the second word of the second sentence (e.g., sweater. The sweater). During early processing at occipital sites, nouns that followed definite articles had reduced N170s compared to nouns that followed indefinite articles. At frontal sites, nouns that followed indefinite articles had greater P200s than nouns that followed definite articles. These findings indicate that article definiteness can influence subsequent processing on nouns, allowing nouns that followed indefinite articles to have increased orthographic recognition. At the level of semantic processing, nouns with an antecedent in the previous sentence had reduced N400s compared to nouns that had no antecedent in the previous sentence at right lateralized centro-parietal sites. There was no difference between

nouns with an explicit antecedent that followed definite or indefinite articles in the N400 time window. These findings suggest that the N400 reduction for explicit antecedent nouns was due to easier lexical access from word repetition rather than establishing co-reference. Non-antecedent nouns that followed definite and indefinite articles had similar N400 mean amplitudes, suggesting that 1) when no antecedent is present, being unable to integrate and shifting to a new structure produce similar N400 effects or, more likely 2) when no antecedent is present readers shift to a new mental structure at the beginning of a sentence regardless of whether words were preceded by a definite or indefinite article.

D48 Verb Deficits in Alzheimer's Disease and Aphasia: Argument-Structure and Thematic-Hierarchy Effects

Caitlyn Antal[1], Julie Turbide[1], Roberto G. de Almeida[1]; [1]Concordia University

Verb knowledge deficits have been reported in individuals with probable Alzheimer's disease (pAD) and those with aphasia (PWA), in studies manipulating diverse methods and linguistic materials (e.g., Breedin et al., 1998; Grossman et al., 1996; Kemmerer, 2000; Kim & Thompson, 2003, 2004; Manouilidou, et al., 2009). Nevertheless, the underlying nature of verb deficits remains inconclusive. For some, verb deficits have been operationalized in terms of semantic template complexity, with verbs containing hypothetically more internal predicates being more preserved (heavy verbs; e.g., run) than those with less predicates (light verbs; e.g., go) (Breeding et al., 1998). For others, verb deficits arise as a function of argument structure complexity, with verbs requiring a greater number of arguments being more difficult to produce (Thompson, 2003; Bastiaanse & Platonov, 2015). Research on this argument-complexity hypothesis have yielded inconsistent effects. Thompson et al. (2012) reported PWA showing greater production accuracy for one-argument verbs (die) compared to two (destroy) and three (sell) argument verbs, but less difficulty producing three-argument verbs compared to two-argument verbs, an effect which previously found amongst pAD patients (Kim & Thompson, 2004). While some studies have not classified verbs according to semantic or syntactic classes (e.g., Kemmerer & Tranel, 2000), others have relied on classifications that escape linguistic properties. For example, Grossman et al. (1996) classified a verb such as listen as both motion and perception-cognition. In the present study, we employed short movies depicting events and states to probe for three verb classes with different syntactic and semantic properties: perception verbs, lexical causative verbs, and movement verbs. These classes differ in terms of their number of arguments, thematic roles, and hypothetical internal predicates. Lexical causative verbs (peel) were hypothesized to be semantically and syntactically complex, as they project two arguments and may encode multiple internal predicates (x CAUSE y BECOME <peeled>). Perception verbs were hypothesized to be structurally complex but semantically simplex, as they also project two arguments, but encode one predicate (x PERCEIVE y). And movement verbs were hypothesized to be both, semantically and syntactically simplex, with one argument and one predicate (x MOVE). These verbs also differ with regards to thematic-role hierarchy, whereby causative and movement verbs assign the most prominent Agent role to the subject position, and perception verbs assign a less canonical Experiencer role in the subject position. pAD (N = 13), PWA (N = 7), and healthy controls (N = 18) named events and states depicted in short videos clips. Preliminary results revealed that both pAD and PWA show verb deficits in terms of argument structure complexity and thematic role hierarchy. PWA show greater impairments for perception verbs, which are arguably the most difficult for their complex argument structures and non-canonical thematic structures. Similarly, pAD patients showed greater impairments for verbs with both, complex argument structures and thematic roles, namely perception and lexical causative verbs, in comparison to movement verbs. These preliminary results suggest that the underlying principles for the representation of verbs in the brain are argument structures and thematic roles, not internal predicate complexity.

D49 The fate of the unexpected: Downstream repetition effects for prediction violations

Melinh K. Lai[1], Kara D. Federmeier[1]; [1]University of Illinois, Champaign, United States

Amid increasing interest in the nature and role of prediction in language comprehension, there remains a gap in our understanding of what happens when predictions are disconfirmed. Recent findings have shown that, even when disconfirmed, predictions still linger in memory (Joost & Federmeier, in prep), raising questions about what the impact of these lingering predictions might be for the processing of the unexpected word that was actually encountered. One possibility is these lingering representations interfere with those of the unexpected words. Alternatively, it is also possible that violating predictions strengthens the representations of unexpected words – e.g., by drawing attention and/or making them more distinctive. Here, we explore the consequences of prediction violations using the ERP repetition effect. If violating a prediction results in impaired processing of the unexpected word, then this should decrease repetition effects on the N400 and subsequent late positive complex (LPC); in contrast, enhanced processing should increase repetition effects. Thirty participants read 282 sentences for comprehension. The experimental sentences were weakly constraining ("Yesterday evening I saw the SMOKE", cloze probability 0.01). In the Seen in Strong Constraint condition, the critical word had previously been presented in a sentence that strongly constrained for a different word ("The ship disappeared into the thick SMOKE", cloze 0.01; expected word FOG, cloze 0.85). In the Seen in Weak Constraint condition, the critical word had previously been presented in a weakly constraining sentence ("Rachel was

uncomfortable with all the SMOKE", cloze 0.01). In the Not Previously Seen condition the critical word had not previously been presented. The lag between initial and repeated presentation was three sentences. Fillers ensured that 70% of the final words did not constitute a repetition. Repeated words elicited a reduced (more positive) N400 and enhanced (more positive) LPC. N400 reductions for repeated words have been associated with a superficial sense of familiarity, while LPC enhancements have been related to episodic retrieval of previously seen words. Critically, there was no effect of initial sentence constraint on the size of the repetition effect in either time window. Thus, words that were initially encountered as prediction violations seemed to be processed similarly to words that were simply repeated. Our results suggest that prediction violations are not particularly disruptive to word encoding, even in the face of lingering activation for the predicted word. At the same time, contrary to accounts that posit a role for prediction violations in learning, we also did not observe a memory benefit for prediction violations, at least when those words were encountered again after a short delay. Thus, prediction violations may be neither as costly – nor as critical – for language comprehension as has sometimes been assumed.

D50 Grammatical gender in the aging brain: an ERP study of prediction and integration in a sentence context

Matthew Wood[1], Virdiana Estrada[2], Alondra Chaire[3], Nicole Y.Y. Wicha[1,4]; [1]University of Texas at San Antonio, [2]The University of Texas Medical Branch, [3]Otto-von-Guericke-Universität Magdeburg Magdeburg, Germany, [4]UTSA Neurosciences Institute

Building evidence indicates that older adults do not benefit as much from contextual constraint to facilitate the predictive processes commonly observed during sentence comprehension in younger adults. Instead, older adults engage in processes that facilitate integration of a target word, in addition to typical responses to semantic and grammatical violations. However, the vast majority of this research has been conducted in languages with poor morphosyntactic structure, such as English. The goal of this study was to investigate prediction and integration processes during written sentence comprehension in an older adult Spanish-speaking population. We recorded event related potentials (ERPs) to critical article/noun pairs as dominant Spanish speakers (mean age = 63, range: 55 to 83) read sentences, one word at a time. Each sentence built context leading up to a noun of high cloze probability (cloze range 0.65 to 1.0; mean = 0.8). The noun was either semantically congruent or not within the context. In addition, the preceding gender-marked article was manipulated to either agree or disagree in gender with the upcoming expected noun. Previous work with young adult Spanish speakers has shown typical N400 and P600 effects to semantic and gender-agreement violations, respectively, at the noun. Combined violations of both meaning and gender at the noun led to the largest N400 modulation, indicating that grammatical gender agreement can additionally modulate meaning level processes. In addition, analysis at the preceding article showed evidence of prediction based on the upcoming nouns' expected gender, resulting in a P600 effect when the article violated the gender of the expected, but yet unseen, noun. Critically, this predictive ability seems to diminish with age in equivalent English-language studies manipulating the phonological agreement between article-noun pairs. In the current study, we tested whether the grammatical markings used on Spanish articles and nouns could provide a more reliable cue to enable older adults to show similar effects of prediction as their younger counterparts. ERP analysis time-locked to the critical noun revealed a typical N400 effect followed by a late positive component in response to semantic violations. Gender violations elicited the expected P600 modulation, but unlike younger adults this was preceded by an N400-like negativity. The largest N400 modulation was observed for double violations of meaning and gender, indicating that older adults show strong sensitivity to grammatical gender agreement during sentence comprehension, with this information affecting meaning level processes. When time-locking the ERPs to the prenominal article, a small P600 effect was observed in response to articles that violated the gender of the upcoming expected noun. This suggests that grammatical gender information might be a sufficient cue to reveal predictive effects in older adults. Thus, although the aging brain adopts new strategies to facilitate sentence comprehension with less reliance on predictive processes, the obligatory gender agreement information on words in languages with rich morphosyntactic structure may provide a reliable enough cue to facilitate some forms of predictive processing. Further analysis of individual differences can elucidate which factors contribute most to this predictive ability.

D51 Regions that preferentially respond to verbs or nouns are more sensitive to semantic differences among words in their preferred grammatical class: An MVPA fMRI study.

Giulia V. Elli[1], Connor Lane[1], Marina Bedny[1]; [1]Johns Hopkins University

Numerous neuropsychological and neuroimaging studies have identified cortical areas that are preferentially involved in processing verbs and nouns (Martin et al., 1995; Shapiro et al., 2000). The left middle temporal gyrus (LMTG) and the left inferior frontal gyrus (IFG) respond preferentially to verbs, whereas the left inferior parietal lobule (LIP) and the left inferior temporal cortex (LIT) are more engaged during noun processing (Shapiro & Caramazza, 2003; Bedny et al., 2008). Does this activation reflect preferential involvement in representing verbs and nouns? Or is it related to greater processing demands for one category (e.g. morphological complexity of verbs)? If these regions represent verbs and nouns, we might expect them to be more sensitive to semantic distinctions among words from their preferred class. However, the mean level

of activity in a region is not sensitive to such fine-grained lexical information. We used multivoxel pattern analysis (MVPA) to investigate whether verb- and noun-preferring regions are more sensitive to distinctions among words in their preferred class. We hypothesized that LMTG and LIFG would be more sensitive to differences among verbs, whereas LIP and LIT would be more sensitive to differences among nouns. Participants (N=13, Mage=34, STDage=10) judged the semantic relatedness of pairs of words from 8 semantic categories – 4 verb categories: sound emission ("to boom"), light emission ("to sparkle"), mouth action ("to bite"), hands action ("to caress"); 4 noun categories: birds ("the crow"), mammals ("the lion"), natural places ("the marsh"), manmade places ("the shed"). We identified subject-specific regions of interest (ROIs) in the LMTG and LIFG (verbs>nouns), and in the LIP and LIT (nouns>verbs). Within each ROI, a linear support vector machine (SVM) classifier was trained on half of the data (e.g. even runs), and tested on the other half (e.g. odd runs) to decode among verbs and among nouns. We also inspected the group confusion matrices to better characterize the semantic categories' discriminability profiles. There was a double-dissociation, as the classifier was significantly more accurate for verbs than nouns in LMTG ($t(12)=2.11$, $p=.05$), and for nouns than verbs in LIP ($t(12)=2.67$, $p<.05$) and LIT ($t(12)=3.51$, $p<.01$). There was no difference in classification accuracy between verbs and nouns in LIFG ($t(12)=1.12$, $p=.29$). However, classification performance for both verbs and nouns was significantly above chance (25%) in all ROIs (Ps<.01). In the LMTG, LIP and LIT the classifier distinguished not only the categories with the grossest differences (emission vs. action verbs, animals vs. places), but also some of the fine-grained distinctions (LMTG hand vs. mouth actions P<.05, light emission vs. sound emission P=.06; LIP and LIT manmade vs. natural places P<.05). These findings suggest that the LMTG and LIP/LIT are preferentially involved in representing verbs and nouns lexical-semantic information, respectively. By contrast, the LIFG appears to be equally involved in representing verbs and nouns and activation differences may reflect greater processing demands associated with verbs. Notably, all the studied regions are sensitive to semantic distinctions among both verbs and nouns, suggesting that selectivity within the lexical system is not all or none.

Meaning: Prosody, Social and Emotional Processes

D52 Neural processing of emotional words in post-institutionalized adults: an ERP study using Emotional Stroop task

Marina Zhukova[1], Irina Ovchinnikova[1], Sergey Kornilov[1,2,3,4], Elena Grigorenko[1,2,3,4,5]; [1]Saint-Petersburg State University, Saint-Petersburg, Russia, [2]University of Houston, Houston, TX, USA, [3]Baylor College of Medicine, Houston, TX, USA, [4]Haskins Laboratories, New Haven, CT, USA, [5]Yale University, New Haven, CT, USA

In countries where the foster family system is not widespread, children left without parental care are raised in institutional settings (IC) characterized by impoverished early care environments. Children raised in IC show cognitive, linguistic, and socio-emotional deficits. However, little is known about a) the interplay between cognitive, linguistic, and emotional processing in this subpopulation, b) the extent to which they continue into adulthood. The present study examined processing of neutral and emotional words using the Emotional Stroop (ES) paradigm in a sample of young IC adults, compared to their typically developing peers raised in biological families (BF). ES is a modification of the Stroop paradigm, which uses emotionally charged stimuli as a source of interference (Williams et al., 1996), and has been used with vulnerable subpopulations, including war veterans (Ashley et al., 2013) and abuse victims (Bremner et al., 2004). The goals of our study were two-fold: we investigated whether IC adults demonstrate atypical processing of emotionally-salient words in general, and whether they exhibit selective processing bias towards family-related words. We recruited 28 young adults with IC history (20 males; Mage=21.6, SD=6.2; duration of institutionalization Myears=10, SD=5.1) and 31 BF controls (18 males M=22, SD=5) matched on SES and level of education. Participants viewed words and were asked to press a button corresponding to the color of the word, disregarding the meaning of the word. Target stimuli consisted of 50 nouns (25 positive, 25 negative in valence) semantically associated with the concept of "family" and 50 unrelated nouns matched on the level of abstractness, length, and frequency. Control stimuli included traditional Stroop "color match" and "color mismatch" words. EEG was recorded at the scalp using 64 active Ag/AgCl with the actiCHamp EEG amplifier system. Statistical analyses revealed a complex pattern of results. First, we did not find group differences in the amplitudes of the N2 and P3 components in response to family-associated emotionally-charged words vs. non-associated emotionally charged words ($p > .05$), suggesting that institutionalization does not leave a semantic "traumatic" footprint. Second, adults with a history of IC showed a markedly delayed right-lateralized parietal P3b in the traditional color mismatch Stroop condition, compared to BF (353ms vs. 309ms, p=.006), indicating the presence of overall processing deficit. Finally, we found that while positive-valence words (across conditions) elicited a more pronounced N2 (compared to the neutral color words) in the BF group, the size of this effect tended to be smaller in the IC group (p=.059). Crucially, the size of this difference within the IC group correlated with their emotional well-being as measured by the WHO Quality of Life questionnaire ($r = .42$, $p = .04$). Thus, the results suggest that 1) institutional care is associated with general

cognitive and emotional processing deficits in adulthood in the verbal domain, and that 2) neural sensitivity to positive emotional valence in this subpopulation is associated with levels of their psychological well-being. The reported study was funded by RFBR, according to the research project No. 16-36-60046 mol_a_dk.

Computational Approaches

D53 Bayesian surprise during incremental anticipatory processing: a re-analysis of Nieuwland et al. (2017), based on DeLong et al. (2005)

Shaorong Yan[1], Gina R. Kuperberg[2,3], T. Florian Jaeger[1,4,5]; [1]Department of Brain and Cognitive Sciences, University of Rochester, [2]Department of Psychology, Tufts University, [3]Department of Psychiatry and the Athinoula A. Martinos Center for Biomedical Imaging, Massachusetts General Hospital, Harvard Medical School, [4]Department of Computer Science, University of Rochester, [5]Department of Linguistics, University of Rochester

The extent to which language processing involves prediction of upcoming inputs remains a question of ongoing debate. One important data point comes from DeLong et al. (2005) who reported that an N400-like event-related potential (ERP) correlated with the cloze probabilities of articles whose form depended on an upcoming noun. This result is often cited as evidence for gradient probabilistic prediction of the semantics of the noun (mediated through prediction of its form), prior to its bottom-up input becoming available. However, a recent 9-lab study reports a failure to replicate this effect (Nieuwland et al., 2017). We spell out the computational nature of predictive processes that one might expect to correlate with ERPs evoked by a functional element whose form is dependent on an upcoming predicted word. From this we derive, both conceptually and formally, a principled measure of anticipatory processing of the noun's semantics upon encountering the article: Bayesian surprise, i.e., the relative entropy or change in semantic expectations. We argue that this is a more appropriate measure of gradient semantic prediction than the cloze probability of the article. We then formally show that this measure of Bayesian surprise closely approximates the article's surprisal (i.e., its log-transformed inverted probability). We present a large-scale corpus analysis investigating the relationship between the article's surprisal and the Bayesian surprise over noun semantics. Across several corpora of written and spoken American and British English, we find that the two measures are strongly correlated (rs range from .95 to .98). (This correlation is considerably higher than the correlation between the article's raw probability and Bayesian surprise, which ranged from -.65 to -.75 across the same corpora.) Finally, we re-analyze the ERP data from Nieuwland and colleagues using the article's cloze surprisal, rather than its raw cloze probability, as an index of prediction. We find that surprisal is gradiently correlated with the amplitude of the N400 evoked by the article ($p < 0.05$). Our results suggest that it is premature to conclude that Nieuwland et al.'s dataset provides no evidence for probabilistic anticipatory processing. Rather, in Nieuwland et al.'s data, we find that a measure that closely approximates a principled index of probabilistic semantic prediction—the Bayesian surprise over the noun semantics incurred while processing the article—is correlated with the neural index of semantic prediction: the N400. Our approach does, however, emphasize the need for future studies to further clarify the nature and degree of prediction at the level of both semantics and form, as well as its neural signatures, during language comprehension. REFERENCES: 1. DeLong et al. (2005). Probabilistic word pre-activation during language comprehension inferred from electrical brain activity. Nature Neuroscience. 2. Nieuwland et al. (2017). Limits on prediction in language comprehension: A multi-lab failure to replicate evidence for probabilistic pre-activation of phonology. bioRxiv.

Speech Motor Control and Sensorimotor Integration

D54 White Matter Integrity and Language Production in Aging

Sara Winter[1], Avery Rizio[1], Jack Dempsey[1], Kerem Oktar[2], Michele Diaz[1]; [1]Pennsylvania State University, [2]Pomona College

According to the Transmission Deficit Hypothesis, language production difficulties, which are known to increase in aging (Salthouse, 2010), result from signal transmission failures within the language network (McKay & Burke, 1990). One potential mechanism underlying such transmission failures may be declines in white matter integrity, which, according to Head and colleagues (2004), are associated with normal aging. In order to explore the possibility that white matter decline is related to language decline, this study leveraged the dual stream model of language, which implicates dorsal streams in language production and ventral streams in language comprehension (Hickok & Poeppel, 2007). We hypothesized that better dorsal tract integrity, but not ventral tract integrity, would be associated with better performance on a language production task. Further, we predicted that this effect would be larger in older relative to younger adults. To test this hypothesis, 20 younger (18-31) and 20 older (60-79) adults completed a picture word interference task during a functional MRI scan. Participants were asked to name a picture while ignoring either a phonologically-related word, a semantically-related word, an unrelated word, or a non-word. Diffusion MR images were also obtained from participants. Using probabilistic tractography, we modeled two ventral white matter tracts—the Middle Longitudinal Fasiculus and Inferior Longitudinal Fasiculus—and two dorsal white matter tracts—the Superior Longitudinal Fasiculus-III and Frontal Aslant Tract. The average Fractional Anisotropy (FA) along

each tract was then calculated for the left hemisphere and squared to meet the assumption of homoscedasticity. Using Pearson's correlation tests and multiple regression models predicting accuracy from mean FA and age, we analyzed the relationships between FA, age, and accuracy. Dorsal FA was significantly correlated with overall accuracy ($r = .40$, $p < .01$) while ventral FA was not significantly correlated with accuracy ($r = .15$, $p = .38$). The difference between these correlations was not significant when tested with a Fisher r-to-z transformation ($z = 1.18$, $p = .24$). Age was also significantly negatively correlated with accuracy ($r = -.56$, $p < .001$) as well as with both ventral ($r = -.54$, $p < .001$) and dorsal ($r = -.75$, $p < .001$) FA values. In a regression model with age and dorsal FA, dorsal FA was not a significant predictor of accuracy ($p = .91$) but age was a significant predictor of accuracy ($p = .01$). Similarly, when predicting accuracy from age and ventral FA, ventral FA was not a significant predictor ($p = .17$) while age did predict accuracy ($p < .001$). When including the interaction between age and FA in these models, all predictors were insignificant. These results replicate previous literature showing that white matter integrity and language production ability both decline with age. However, white matter tract integrity did not account for significant variation in language production ability when controlling for age. Further, there was no significant interaction between age and white matter integrity. Together, these results suggest that age may be a proxy variable for a third variable, which influences both white matter integrity and language ability.

Perception: Speech Perception and Audiovisual Integration

D55 Declarative and procedural memory substrates of the categorical perception of speech

F. Sayako Earle[1], Emily B. Myers[2], Jarrad A.G. Lum[3], Michael T. Ullman[4]; [1]University of Delaware, [2]University of Connecticut, [3]Deakin University, [4]Georgetown University

Background. For speech sounds to be considered 'categorically' perceived, two behavioral phenomena have traditionally been required: (1) categorical (rather than linear) identification (e.g. "/ka/ or /ga/?") of sounds that vary across an acoustic-phonetic continuum, and (2) greater accuracy at discriminating sounds that fall across vs. within a category boundary. It is often assumed that performance on these two tasks indexes a common underlying representation. A growing literature challenges this view, suggesting instead that the two tasks may reflect qualitatively different types of speech knowledge (Schouten, Gerrits, & van Hessen, 2003; Antoniou, Best, & Tyler, 2013; Earle & Myers, 2015). However, the precise nature of such potential differences remains unclear. Hypothesis. We propose that learning speech sounds relies on two general-purpose learning and memory systems in the brain, declarative and procedural memory. Under this view, observed dissociations between identification and discrimination (and other) tasks may in part be due to task-specific preferential recruitment of declarative or procedural knowledge (Earle & Myers, 2014). In particular, we suggest that categorical identification, which requires the explicit recall of a category label, generally recruits phonetic features learned by declarative memory, whereas discrimination may be a skill-based task that is learned mainly in procedural memory. Methods. To test this hypothesis, adult participants (18-24) completed a two-session experiment designed to assess the learning (day 1) and retention (day 2) of (i) a set of (non-native) speech sounds and (ii) knowledge in both declarative and procedural memory. To control for circadian effects on learning, and to limit the amount of between-session linguistic exposure, all participants completed the training/assessment session at 7PM, and returned on the next day at 8AM for re-assessment. Speech-sound learning and retention was measured by identification and discrimination tasks on a Hindi dental-retroflex contrast. Learning and retention in declarative memory were measured in a non-verbal recognition memory task (incidental encoding, with a real/novel object decision task). Learning and retention in procedural memory were measured with a serial reaction time task. Between-session sleep was tracked via wrist actigraphy. Results. Regression models on the 18 participants tested thus far revealed that the overnight changes in declarative knowledge (=.604, t=3.686, p=.002), but not procedural knowledge (=-.132, t=-.871, p=.398), significantly predicted overnight gains in speech-sound identification. In contrast, the overnight changes in procedural knowledge (=.303, t=3.043, p=.008) but not declarative knowledge (=.116, t=1.081, p=.297) significantly predicted changes in speech-sound discrimination. These relationships were maintained even after controlling for sleep duration and sleep efficiency. Conclusion. Thus, it appears that the overnight memory processes that act upon declarative memory also act on speech-sound identification. In contrast, the memory processes that act on procedural memory also act on speech-sound discrimination. These findings support the interpretation that, at least in nonnative contrast learning, the identification of speech sounds relies heavily on declarative memory, whereas the discrimination of speech sounds depends importantly on procedural memory. In sum, speech-perceptual task performance may rely on knowledge acquired by two general-purpose learning systems, and moreover, different aspects of speech processing may depend on different types of memory.

D56 Reducing playback rate of audiovisual speech leads to a surprising decrease in the McGurk effect

John Magnotti[1], Debshila Basu Mallick[2], Michael Beauchamp[1]; [1]Baylor College of Medicine, [2]Rice University

We report the unexpected finding that slowing video playback decreases perception of the McGurk effect. This reduction is counter-intuitive because the illusion depends

on visual speech influencing the perception of auditory speech, and slowing speech should increase the amount of visual information available to observers. We recorded perceptual data from 110 subjects viewing audiovisual syllables (either McGurk or congruent control stimuli) played back at one of three rates: the rate used by the talker during recording (the natural rate), a slow rate (50% of natural), or a fast rate (200% of natural). We replicated previous studies showing dramatic variability in McGurk susceptibility at the natural rate, ranging from 0-100% across subjects and from 26-76% across the eight McGurk stimuli tested. Relative to the natural rate, slowed playback reduced the frequency of McGurk responses by 11% (79% of subjects showed a reduction) and reduced congruent accuracy by 3% (25% of subjects showed a reduction). Fast playback rate had little effect on McGurk responses or congruent accuracy. To determine whether are results are consistent with Bayesian integration, we constructed a Bayes-optimal model that incorporated two assumptions: individuals combine auditory and visual information according to their reliability, and changing playback rate affects sensory reliability. The model reproduced both our findings of large individual differences and the playback rate effect. This work illustrates that surprises remain in the McGurk effect and that Bayesian integration provides a useful framework for understanding audiovisual speech perception.

D57 The influence of speaker gaze on situated comprehension: Evidence from an ERP study

Torsten Jachmann[1,2], Heiner Drenhaus[1,2], Maria Staudte[1,2], Matthew Crocker[1,2]; [1]Department of Language Science and Technology, Saarland University, Germany, [2]Cluster of Excellence MMCI, Saarland University, Germany

We present findings from an ERP study (30 German right-handed participants, age: 19–33) investigating the influence of speaker gaze on listeners' understanding of referential expressions in a shared visual scene. In our experiment, we utilized a stylized face performing gaze cues time-aligned to an auditory sentence. We manipulated the gaze cue preceding the second noun in the sentence by 800ms (Griffin & Bock, 2000) to investigate the neurophysiological responses to varying gaze congruency. Our data provides evidence that speaker gaze is used by listeners to make precise predictions about the unfolding sentence (N2) and also affect retrieval (N4) as well as integration (P6) cost, consistent with the retrieval-integration-model (Brouwer et al., 2012). Each experimental item consisted of a visual scene containing three objects that either differed in size (small, medium, large) or brightness (bright, medium, dark) (fully counterbalanced). After three seconds, a stylized face was displayed in the middle of these objects, so that the objects were situated diagonally around the face. Gaze cues were aligned to a spoken comparison of two of the objects of the form "Verglichen mit dem Auto, ist das Haus verhältnismäßig klein, denke ich" ("Compared to the car, the house is proportionally small, I think"). The gaze cue preceding the mentioning of the second noun ("house") was manipulated (fully counterbalanced) to be: a. congruent (toward the named object); b. incongruent (toward the object unnamed in the sentence) c. neutral (straight toward the listener). Our analysis of the ERPs for the three experimental conditions (Congruent, Incongruent and Neutral) on the start of the second noun revealed a globally distributed significantly larger negativity for the incongruent and neutral conditions (b&c) compared to the Congruent condition (a) between 150-300ms (N2). We interpret this early effect as a mismatch between the expected word form given a context and the actual word candidates that are consistent with the speech signal listeners perceive (Hagoort and Brown, 2000). Additionally, an analysis of the time-window from 300-450ms (N4) revealed a central-parietally distributed significantly larger negativity of only the incongruent condition (b) compared to the other two conditions (a&c). We interpret this effect as a predictability-driven N400. In all conditions, predictions about the upcoming words can be made. In both the Congruent and Incongruent condition (a&b), the gazed at object may be predicted to be the upcoming word. In the Neutral condition, both so far unnamed objects are equally likely to be mentioned. Upon hearing the second noun, these predictions are either confirmed (a&c) or violated (b). The latter hinders word retrieval, which in turn leads to a stronger modulation of the N400. Finally, analysis of the time-window from 500-1000ms revealed a significantly larger positivity for only the incongruent condition (b) compared to conditions (a&c), reflecting the additional cost of integrating the noun into the unfolding mental model (Burkhardt, 2007) in those cases where processing was misled by the preceding gaze cue.

D58 Effect of Native Language on L2 Processing of Acoustic and Phonological Information in Mandarin Lexical Tones

Keke Yu[1], Li Li[1], Yuan Chen[1], Yacong Zhou[1], Ruiming Wang[1], Yang Zhang[2], Ping Li[3]; [1]South China Normal University, [2]University of Minnesota, [3]Pennsylvania State University

Previous studies of native speakers of tonal language have indicated the effects of two important types of information for lexical tone perception. One is acoustic information, which refers to the auditory physical features of lexical tones, such as fundamental frequency (F0). The other is phonological information, which can signify distinct word meanings with different tonal categories. For example, in Mandarin Chinese, syllable /ba/ means pulling out when it is pronounced with Mandarin tone-2, while means father when it is pronounced with Mandarin tone-4. But it remains unclear how second language (L2) learners would process these two types of information differently depending on whether their first language (L1) is a tonal language. The present study used event-related potentials (ERPs) to investigate this issue with a multi-feature oddball paradigm. As in previous work, the tonal stimuli included manipulations of phonological information (within- vs.

across- category) and acoustic information (small vs. large differences in F0). A total of 36 adult L2 learners of Mandarin Chinese participated in the study; half of the participants' L1 was a tonal language and the other half's L1 was a non-tonal language. Mismatch negativity (MMN) responses showed distinct patterns for the two groups of L2 learners. For learners with tonal L1, acoustic information in lexical tones affected MMN amplitude whereas phonological information affected both MMN amplitude and peak latency. For learners with non-tonal L1, acoustic information did not affect MMN amplitude or peak latency whereas phonological information affected MMN peak latency. Between-group comparisons also confirmed significant differences in the MMN responses. Compared with learners with non-tonal L1, learners with tonal L1 showed earlier MMN peak latency in within-category tonal stimuli with large or small F0 difference, and smaller MMN amplitude in within-category tonal stimuli with small F0 difference. In a previous study with native L1 Mandarin speakers, we showed that acoustic information only affect MNN amplitude whereas phonological information affected both MMN amplitude and peak latency (Yu et al., 2014). These results indicate the effects of different representations of acoustic and phonological information on L2 processing of lexical tones, which is modulated by experience with the native language features. Learners with tonal L1 seem to perform more native-like in processing these two types of information in L2 lexical tones, which suggests that tonal L1 would promote learners to learn L2 lexical tones. In addition, these results also implied a potential dynamic process for L2 lexical tone learning.

D59 Mice can learn phonetic categories. *Michael Wehr[1], Jonny Saunders[1]; [1]University of Oregon*

How does the auditory system produce invariant perception of a phoneme despite highly variable acoustic information? Because phonemes cannot be identified by any invariant acoustic features, the brain must make use of multiple imperfect cues. Competing auditory speech perception theories for how this problem might be solved remain largely unconstrained by neurobiological data. One reason for this is that most current methods for measuring human brain activity lack the necessary spatiotemporal resolution: speech is too fast and the neural circuitry involved is too small. A growing array of genetic tools for probing neural circuit function are available in the mouse. Although early speech theorists proposed that "speech is special," today many argue that early stages of speech processing in the human brain are likely implemented by evolutionarily-conserved auditory processing mechanisms found in any mammalian auditory system. Here we demonstrate that mice are capable of learning generalizable phonetic categories, and are thus capable of serving as a model system for phonetic perception. A mouse model for phoneme categorization has the potential to powerfully augment the understanding already gained from non-human animal models of speech perception. Here we focus on an important test case, the categorization of consonants in different vowel contexts. We trained mice to discriminate between consonant-vowel pairs beginning with either /g/ or /b/. Mice performed a 2-alternative choice task for a water reward, progressing through the introduction of additional talkers (1 male, 1 female), 2 tokens, and 3 vowel contexts. In a final generalization stage, they were challenged on 20% of trials with 3 novel talkers, 2 novel tokens, and 3 novel vowels. Mice (n=17) progressed to the generalization phase in an average of 15.6 weeks. Mice demonstrated the ability to generalize consonant identity across novel vowel contexts and talkers, consistent with true category learning. Categorization accuracy for all generalization types was significantly greater than chance, indicating that mice learned to discriminate between the initial consonants themselves rather than memorizing the individual training tokens. Different training sets of consonant-vowel tokens from different talkers induced divergent but consistent patterns of novel token categorization, suggesting that the mice learned distinct phonetic 'templates' or discrimination boundaries depending on their precise history of language exposure. These results suggest that mice are a suitable model for studying the neural mechanisms of phonetic categorization.

D60 Somatosensory information affects word segmentation and perception of lexical information *Rintaro Ogane[1,2], Jean-Luc Schwartz[1,2], Takayuki Ito[1,2,3]; [1]GIPSA-lab, CNRS, 11 rue des Mathématiques, Grenoble Campus, BP46, F-38402 Saint Martin D'Hères Cedex, France, [2]Univ. Grenoble-Alpes, 621 avenue Centrale, 38400 Saint Martin D'Hères, France, [3]Haskins Laboratories, 300 George Street, New Haven, CT 06511 USA*

In the framework of perceptuo-motor theories of speech perception, it has been argued that speech articulation could play a role in speech perception. Indeed, recent finding demonstrates that somatosensory inputs associated with speaking motion changes the perception of speech sounds. However, it is still unknown whether somatosensory effects could go up to the level of lexical access in speech comprehension. Access to lexical information depends on a complex word segmentation process. This study aims to examine whether segmentation and lexical information processing could be changed by somatosensory inputs associated with facial skin deformation. We here focus on "liaisons" between definite article and noun in French (e.g. "l'affiche" [the poster] or "la fiche" [the form]), which have the same pronunciation, but can be differentiated by hyper-articulation for the production of the first vowel in each word. If somatosensory information plays a role in lexical information processing, we reasoned that the perception of such sequences could be changed if somatosensory

stimulation was applied in an appropriate timing associated to the corresponding speech gesture. To test this, we applied somatosensory perturbation associated with facial skin deformation at different timings along the presentation of the auditory stimulation. We tested native speakers of French who performed a two-alternative forced choice task between the two percepts associated to a single speech sequence. The stimulation sound was presented through headphones within the carrier phrase "C'est ___ (This is ___)". Participants identified which word was presented (i.e. "affiche" vs. "fiche") by pressing the left or right arrow button on the keyboard as quickly as possible. We used 17 different ambiguous speech sentences recorded by a native French speaker. Utterances were pronounced neutrally without adding hyper-articulation in any single vowel, that is, removing as much as possible acoustic information for decision. For each audio sentence, we applied a somatosensory stimulation consisting in facial skin stretch perturbation, generated by a robotic device. We varied the time of presentation of this facial skin stretch perturbation, with 8 different temporal positions within an acoustic sentence. These temporal positions were set relative to the timing of the first vowel peak amplitude (i.e. "a" in the previous example), separated by 100 ms intervals from -400 ms (around the vowel in "c'est") to 300 ms (around the second vowel, i.e. "i" in the previous example). In each combination of audio and somatosensory stimulation, four subject's responses were recorded, with a total of 544 stimuli (17 sentences * 8 timing conditions * 4 repetitions) presented in a random order. The judgement probability (i.e. percentage of "la fiche" responses) was calculated for each subject and each timing condition. It appears that the percentage of judgement probability was reduced when somatosensory stimulation was ahead of the first vowel (more "l'affiche" responses), and increased when somatosensory stimulation was delayed between the first and second vowel (more "la fiche" responses). This suggests that somatosensory information intervenes in the processing of lexical information, which corresponds to a relatively higher level of processing of speech perception.

D61 Cross-linguistic differences in MMN asymmetry: Voicing underspecification in Japanese

Yasuaki Shinohara[1], Arild Hestvik[2], Rinus Verdonschot[1], Karthik Durvasula[3], Hiromu Sakai[1]; [1]Waseda University, [2]University of Delaware, [3]Michigan State University

Underspecification has been argued to lead to asymmetric Mismatch Negativity (MMN) [1]. In English, a larger MMN is observed when a deviant /d/ is perceived in the context of standard /t/ with varying voice onset time (VOT), compared to when a deviant /t/ is perceived in the context of /d/ with varying VOT [2]. Assuming English to have laryngeal specification for voiceless stops but not for voiced stops, the acoustic /d/-series have no distinctive phonological feature in the memory trace, and therefore cause no conflict with a phonetic deviant /t/, eliciting reduced or no MMN. If this asymmetry arises from language-specific underspecification, then an opposite featural specification is predicted to exhibit the opposite MMN asymmetry. This would be predicted for Japanese, where voiced stops are argued to be laryngeally specified, with voiceless stops unspecified [3]. Recently, an alternative explanation of universal marking of the [SPREAD GLOTTIS] feature has been suggested [4], which predicts that Japanese should exhibit the same asymmetry as English. In the present study, we examined which of these two predictions was correct. Forty-four monolingual Japanese speakers aged 18-24 years participated in a behavioral experiment followed by an ERP experiment. In the behavioral experiment, subjects identified the same stimuli used in [2], continuously varying in VOT as being either /dæ/ or /tæ/, and exhibited a categorical /d/-/t/ phoneme boundary around 35ms. Consequently, four /dæ/ (VOT 10, 15, 20, 25ms) and four /tæ/ (VOT 45, 50, 55, 60ms) tokens were selected. In the ERP experiment, these four VOT variations for each phoneme were presented so that subjects formed their phonemic memory trace for the standard stimuli and used phonetic memory trace for the deviant stimuli. Subjects were randomly assigned to one of two block-order groups (in one order, /tæ/ was the deviant in the first half of the experiment; in the other, /dæ/ was the first deviant stimulus). The results demonstrated that there was a significant MMN effect; deviant tokens had lower amplitude than standards. In addition, Japanese speakers' MMN for /t/ was significantly larger than that for /d/, when /t/ was presented as deviant in the first half of the ERP experiment. This effect was not observed when /d/ was presented as deviant in the first half. This means that underspecification in Japanese elicits an asymmetric MMN in the opposite direction from English. This indicates that Hestvik and Durvasula's result is not due to universal markedness, contrary to [4]. The MMN asymmetry thus provides neurobiological evidence for language specific pattern of underspecification. References [1] Eulitz, C., and Lahiri, A. (2004). Neurobiological Evidence for Abstract Phonological Representations in the Mental Lexicon during Speech Recognition. Journal of Cognitive Neuroscience. [2] Hestvik, A., and Durvasula, K. (2016). Neurobiological evidence for voicing underspecification in English. Brain and Language. [3] Mester, A., and Ito, J. (1989). Feature Predictability and Underspecification: Palatal Prosody in Japanese Mimetics. Language. [4] Schluter, K. T. et al., (2017). Laryngeal Features Are Phonetically Abstract: Mismatch Negativity Evidence from Arabic, English, and Russian. Frontiers in Psychology.

D62 Tracking phoneme processing during continuous speech perception with MEG

Christian Brodbeck[1], Jonathan Z. Simon[1]; [1]University of Maryland, College Park

During speech comprehension, phonemes incrementally provide information about the words making up the linguistic message. Phonemes can thus be analyzed in terms of the information they convey, with measures like

phoneme surprisal and entropy. Previous research with single word stimuli has used these measures to study speech processing. However, behavioral measures are limited by requiring behavioral responses, which interrupt continuous processing; and electrophysiological measures are so far limited by analysis techniques restricted to single word stimuli. This limits the naturalness of the experimental paradigms, and hence the potential generality of the results. We demonstrate a new technique that allows estimating responses to phonemes in continuous speech from source localized magnetoencephalography (MEG) data. We estimated subject-specific linear kernels to predict MEG responses from multiple concurrent predictor variables. This allowed us to utilize the high temporal resolution of MEG to track brain responses to phonemes in continuous speech. Each predictor variable was evaluated by whether it significantly improved the model fit compared to a permuted version, while controlling for contributions from other variables. Model improvements, as well as the response functions, were tested for significant regions in anatomical space and response time while controlling for multiple comparisons with permutation tests. We analyzed MEG data from 17 participants listening to 3 repetitions of 2 one-minute long audiobook segments. We created continuous predictor variables for acoustic power and phoneme information content based on a full listing model. Phoneme entropy is highly correlated with the current size of the cohort; to account for this, we also computed covariates reflecting the current size of the cohort, as well as the number of competitors that the current phoneme removes from the cohort. Results for a model containing only phoneme surprisal and entropy indicated significant contributions by both variables in addition to acoustic power. However, if the cohort size covariates were included, cohort reduction emerged as the most relevant variable: the contribution of cohort reduction was significant after controlling for cohort size as well as entropy, neither of which was significant when controlling for cohort reduction. The effect of phoneme surprisal remained significant. All responses were centered on the superior temporal gyrus, suggesting sources in or close to auditory cortex. The time course of the estimated kernels can inform models of speech perception: While cohort reduction was associated with an early effect, around 70 ms after phoneme onset, a robust response to phoneme surprisal started around 200 ms. This could suggest that upon perception of new information the cohort is updated quickly, while updating of probabilistic expectations is a slower process. Our results demonstrate the feasibility of analyzing brain responses related to the information content of individual phonemes in continuous speech. This opens the possibility for contrasting predictions from different models of speech perception in a more natural setting than was hitherto possible. Crucially, the method we demonstrate allows taking full advantage of the online nature of MEG measurements, which can record brain responses to continuous speech without interrupting the comprehension process by requiring behavioral responses.

D63 Individual Differences in Subphonemic Sensitivity and Reading Ability

Monica Li[1,2], David Braze[1,2], Anuenue Kukona[2,3], Donald P. Shankweiler[1,2], Whitney A. Tabor[1,2], Julie Van Dyke[2], W. Einar Mencl[2], Clinton L. Johns[2], Kenneth R. Pugh[1,2], James S. Magnuson[1,2]; [1]University of Connecticut, Storrs, Connecticut, USA, [2]Haskins Laboratories, New Haven, Connecticut, USA, [3]De Montfort University, The Gateway, Leicester, UK

Introduction: The link between phonological abilities and the development of skilled reading is well-established in both typical and atypical language development. However, the nature of phonological deficits in low ability readers remains a debated topic. One hypothesis is that poor readers have underspecified (or "fuzzy") phonological representations (Tallal et al., 1998) that highly overlap with each other due to lack of detail in phonetic encoding. An alternative hypothesis is that reading difficulty derives from overspecified phonological representations, with perceptual categories of speech sounds as allophones instead of phonemes, resulting in mismatch between written symbols and spoken sound categories (Serniclaes, 2006). Methods: To examine hypotheses of under- vs. over-specified representations, we used a visual world eye tracking paradigm closely modeled after one used by Dahan et al. (2001) to investigate individual differences in sensitivity to subphonemic information in young adults with a wide range of reading ability. We recruited a community based sample of 67 college-aged native English speakers. They were enrolled in GED programs or community college, or not in school at all when they participated. In order to examine individual differences in our sample, we administered a comprehensive set of standardized measures with known connections to reading ability, such as listening comprehension, vocabulary, decoding skills, and phonological skills. During the experimental eye-tracking task, participants saw pictures of four objects (including a target, a competitor, and two unrelated distractors) on a computer screen, while following auditory instructions to click on the target picture. The auditory stimulus for each target word was cross-spliced with either another recording of the target word (W1, e.g., 'cat'), a competitor (W2; e.g., 'cab'), or a nonword (N3; e.g., 'cag'), such that there were three versions of each target word with varying coarticulatory information: consistent coarticulation (W1W1; e.g., 'catt'), misleading competitor coarticulation (W2W1; e.g., 'cabt'), and misleading nonword coarticulation (N3W1; e.g., 'cagt'). We expected that differences in eye-tracking trajectories across the three conditions would relate to individuals' sensitivity to subphonemic information. Results: Consistent with Dahan et al.'s findings, our overall results showed that individuals were sensitive to

subphonemic coarticulatory information: participants' target fixations in the W1W1 condition were greater and faster than in N3W1, followed by W2W1. In addition, individuals' phonological skills (as a proxy for reading ability) were negatively correlated with their subphonemic sensitivity (measured by target fixation differences between conditions), indicating that less skilled readers had higher subphonemic sensitivity. Conclusion: Our measures of the fine-grained time course of lexical activation during spoken word recognition in response to misleading coarticulation suggest that poorer reading abilities are associated with higher sensitivity to subcategorical phonetic detail, consistent with the overspecification hypothesis in developmental reading impairment proposed by Serniclaes (2006). Individual differences in reading ability and phonological representations implicated in the current study may guide future computational modeling and neurobiological work, deepening our knowledge for the underlying mechanisms and factors that contribute to the dynamic between phonological processing and reading skills.

Animal Communication

D64 Auditory and visual sequence learning in humans and monkeys

Alice Milne[1], Chris Petkov[1], Ben Wilson[1]; [1]Institute of Neuroscience, Newcastle University, United Kingdom

Language flexibly supports the human ability to communicate using different sensory modalities. Moreover, syntactic operations engage certain overlapping regions in the human brain during reading in the visual modality and listening to language in the auditory domain. Although it has been argued that nonhuman primate communication is inherently multisensory, there are few direct comparisons of human and nonhuman primate abilities across sensory modalities. Artificial Grammar Learning (AGL) tasks can emulate ordering relationships between words in a sentence, however comparative AGL work has primarily investigated sequence learning in a single modality. We used an AGL paradigm to evaluate how humans and macaque monkeys respond to identically structured sequences of non-linguistic auditory or visual stimuli. In both modalities, the two species gave remarkably similar response patterns in the visual and auditory domains, indicating that the sequences are processed comparably across the sensory modalities. We next conducted an fMRI experiment using the same auditory and visual sequences in humans, and an equivalent macaque fMRI experiment is underway. Multi-voxel pattern analysis of the human fMRI data using Representational Similarity Analyses (RSA) investigated brain responses in sensory cortices and perisylvian regions. The results show that, primary visual and auditory cortices respond to sequencing relationships within their respective sensory modalities. However, Brodmann areas 44/45 and the frontal operculum in frontal cortex respond to aspects of the sequence ordering relationships in both modalities. These observations identify the domain-specific sequencing operations in the respective sensory processing streams, and they highlight inferior frontal cortex as a domain-general substrate for sequence processing. The results also provide initial evidence that human sequence learning abilities stem from an evolutionarily conserved capacity for multisensory sequence processing.

Perception: Auditory

D65 Processing of English focal stress by L1-English and L1-Mandarin/L2-English speakers: An auditory ERP study

Ellen Guigelaar[1,2], John Drury[1]; [1]Stony Brook University, [2]East Tennessee State University

[INTRODUCTION] The present auditory ERP study addresses two issues facing the literature on the neural basis of prosody: (i) previous work on question-induced focus and prosodic marking of accent in question/answer pairs has yielded inconsistent findings, and (ii) the nature of the neural basis of non-native (L2) prosodic processing has been under-investigated (though see Nickels & Steinhauer 2016). Concerning (i): Part of the source of the inconsistency of previous work is methodological, as argued in Dimitrova et al. (2012). To that list of concerns we add an additional worry: several previous studies appear likely to have serious baseline confounds, in particular concerning ERP effect estimates for the second of two target time-locking points in auditorily presented sentences. Here we take steps to avoid these problems, and also begin closing the research gap in the ERP literature concerning non-native/L2 prosodic processing. [PRESENT STUDY/METHODS] Target sentences involved prosodic accent marked on either the first or second object of distransitives (e.g., "Steve only gave [BORIS] [the bulldog] last week" / "Steve only gave [Boris] [the BULLDOG] last week"). In addition to these double object constructions, dative constructions were also employed, so that the direct/indirect object NPs occurred equally often in both the first and second positions in the verb phrase (e.g., "Steve only gave [the BULLDOG] to [Boris] last week" / "Steve only gave [the bulldog] to [BORIS] last week). Collapsing over the construction types, here we examine the contrast between prosodic Accent on first object (OBJ1) versus the second (OBJ2). Accent was crossed in a 2x2 design with expected semantic Focus on OBJ1 versus OBJ2, determined by lead-in questions rendering the answer felicitous (e.g., Q: "Who did Steve give the bulldog to last week?" A: "Steve only gave [BORIS] [the bulldog] last week"), or not (e.g., Q: "What did Steve give to Boris last week?" A: "Steve only gave [#BORIS] [the bulldog] last week"). Native English speaker participants (N=16) and native Mandarin (English-L2) participants (N=27) listened to these question/answer pairs and performed match/mismatch judgments. Potential baseline confounds which we argue have affected previous studies were avoided in analyses of OBJ2 effects by time-locking to the onset

of OBJ2 and using a distant (-900 to -700 ms) baseline. [RESULTS & DISCUSSION] Both native and L2 groups demonstrated robust main effects of Focus (N400 effects for new>old/repeated information) and Accent (larger P200 for Accented>Unaccented) for both OBJ1/OBJ2 positions. Both groups showed an N400-like effect for missing accent on focused OBJ1, with no comparable effect on OBJ2. However, only native speakers demonstrated Focus x Accent interactions tied to an early positivity preceding the Accent P200 effect where the marking of Accent was superfluous, and this pattern manifested for both OBJ1 and OBJ2. However, closer investigation of the L2 group demonstrates that native-like Focus x Accent early interaction for superfluous accent did manifest in earlier, but not in later learners. We relate these patterns to earlier behavioral findings by Akker & Cutler (2003) where similar presence/absence of Focus x Accent interactions were reported for L1/L2 processing.

D66 Prosodic lengthening and boundary prediction in nominal compounds: An ERP study

Alicia Parrish[1], Patrick Kelley[1], Kaylin Smith[1], Yan Cong[1], Alan Beretta[1]; [1]Michigan State University

Recent studies suggest prosody plays an important role in auditory processing of compound nouns (CNs) (Koester, 2004; 2014). Good (2008) reports a reliable difference in the length of nouns, whereby a noun is shorter when used as the first constituent in a compound (N1) rather than as a single noun (SN). This lengthening may be due to a SN's likelihood of occurring at a phrase boundary rather than a word boundary, as with an N1 (Turk & Shattuck-Hufnagel, 2007). Here, we test whether this lengthening of SNs is a sufficient cue for structural prediction. Stimuli varying in prosody (SN-prosody vs. CN-prosody) and phrase type (SN vs. CN) were constructed. For all compounds, both N1 and the second compound constituent (N2) were disyllabic nouns with word-initial stress (e.g. desert [N1] island [N2]). These compounds were situated within sentence frames where either the whole compound or just N1 was present (e.g. Cooper travelled to the [desert] / [desert island] in search of solitude). Splicing was completed to replace each N1 with an N1 that had CN- or SN-prosody. Thus, the sentence frames contained spliced nouns with prosody that was either congruent or incongruent with the frame. Our stimuli reliably differed in duration such that the average length of CNs (first syllable 178ms; second syllable 168ms) was significantly shorter than SNs (first syllable 200ms; second syllable 194ms), both ps<0.01. Twenty-five right-handed native English speakers participated in an auditory ERP study in which each participant heard 100 experimental sentences with 100 fillers in pseudorandomized order. Signals were recorded with a 32-channel cap, average referenced, and analyzed using two ROIs (Inferior & Superior) following Hestvik (2013). 200-700ms post N1, CN phrase types showed a significant interaction of ROI x prosody, p=0.017; SN phrase types were nonsignificant, p=0.459. Pairwise comparisons indicate a positivity of the incongruent SN-prosody within CN phrase types within the Superior region, p<0.01; while the Inferior region was nonsignificant, p=0.12. A Holm-corrected pairwise t-test within the Superior region revealed a difference of CN- vs. SN-prosody in the CN phrase type, p=0.02, but not the SN phrase type, p=0.97. This difference suggests SN-prosody is predictive, but CN prosody is not. As SNs exhibit lengthening, this feature's presence cues the parser to predict a phrase boundary, whereas an absence provides no cue. With CN frames, when SN-prosody is heard, a boundary is predicted, requiring reanalysis when N2 (e.g., "island") appears. When CN-prosody is heard, no prosody-based prediction is made, thus there is no need to reanalyze. In SN frames, SN-prosody elicits a prediction that there is a boundary, which is borne out, so no reanalysis occurs; while CN-prosody, again, elicits no prediction. In line with Kotzor et al. (2017) and Chladkova et al. (2015), we conclude that this asymmetry in processing supports the view of an underspecification of lengthening in its mental representation as a prosodic feature, extending their perception findings into the realm of syntactic predictions.

D67 Accented speech attenuates code-switching costs in bilingual listeners: An auditory electrophysiological study

Carla Fernandez[1], Janet van Hell[1]; [1]Pennsylvania State University

Code-switching, defined as the interchangeable use of two languages within a sentence, is considered one of the hallmarks of bilingualism. Recently there has been growing interest in the neurocognitive mechanisms that drive the comprehension of code-switched sentences. Studies that used the Event-Related Potentials (ERP) technique have typically found that comprehending code-switched sentences entails a cost in terms of lexical-semantic-integration (as represented by the N400 effect) or sentence level restructuring and reanalysis (as represented by the LPC). These previous neurocognitive studies on intra-sentential code-switching presented sentences visual, even though code-switching occurs more frequently in spoken discourse than in writing. Moreover, in natural code-switched discourse, bilingual interlocutors often have an accent in one of their languages, which may affect the comprehension of code-switched speech. Taking this into account, in an ERP study, we analyzed code-switching in the auditory modality and examined the effects of accented speech on listeners' comprehension of code-switched sentences. In this study, 31 highly-proficient Spanish-English bilinguals who identified as Hispanic listened to code-switched sentences (that switched from English to Spanish, or vice-versa) or non-switched sentences produced by a Spanish-accented speaker of English or a non-accented speaker in both Spanish and English (10 Spanish-English bilinguals had rated, and agreed on, the speakers' accentedness in the two languages). We hypothesized that Spanish-accented English would alleviate processing costs in the comprehension of

sentences that switch from English to Spanish, as the Spanish-accented English in the first part of the sentence would facilitate the comprehension of the upcoming switch into Spanish. On the other hand, if the same sentence begins with non-accented Spanish and then switches to Spanish-accented English, the non-accented speech at the beginning of the sentence would not (strongly) co-activate two languages, and a subsequent switch to Spanish would induce switch-related processing processing cost. This pattern was indeed observed: in sentences that switched from English to Spanish, the switch-related N400 effect was smaller when the first part of the sentence was produced in Spanish-accented English relative to non-accented English. Furthermore, for sentences that switched from Spanish to English, no difference in switching costs were expected for the Spanish-accented and non-accented speaker, as both sentences start in Spanish. Indeed, a switch-related LPC effect was observed in both speaker conditions, and the magnitude of the LPC did not differ in the two speaker conditions. These results demonstrate that accented speech can attenuate processing costs associated with the comprehension of code-switched sentences. More specifically, accented speech can facilitate the comprehension of upcoming code-switches into the language compatible with the accent, and serve as a cue to modulate code-switching costs when produced by speakers that have a similar language background as the listeners's background.

D68 Cortical responses to linguistic features in natural story comprehension

Katerina Danae Kandylaki[1], Hugo Weissbart[1], Tobias Reichenbach[1]; [1]Imperial College London

Previous research has reported neural tracking of linguistic features such as phrase structure in spoken language (Ding et al., 2016). However, the employed stimuli had an artificially-imposed periodic timing of words. It thus remained unclear how the obtained results generalise to natural language, in which the timing of syllables and words is irregular. Here we aimed to quantify neural response to linguistic features in natural spoken language comprehension. Previous research on neurological diseases and experiments on aphasia patients points to separate neurocognitive mechanisms for agrammatism and anomia. We therefore tested the hypothesis that neural responses to function words differ from those to content words. Moreover, previous findings on evoked response potentials (ERPs) highlight a different neural response to the word categories of noun/verb (Federmeier et al., 2000), so we tested the hypothesis that cortical responses are sensitive to this grammatical and semantic feature. We used short stories as stimuli; the stories were written in English and spoken out by volunteer speakers (see librivox, public domain). We then recorded cortical responses from 11 participants (5 female) while participants listened to the stories using electroengephalography (EEG). The EEG recordings were then correlated to linguistic features of the spoken language stimuli. First, we applied tools from computational linguistics to tag the texts according to the word category: a. function/content words, b. noun/verb. We then used forced alignment to align the features to the acoustic signal. The EEG responses were filtered between 0.1 and 4 Hz since these low frequencies, mostly in the delta band, match the rhythm of word-based linguistic features. Finally, we used the MNE python toolbox to model the relation between the EEG responses and the linguistic features. Using linear regression, we modelled the word categories as continuous factors and included word onset as a control factor. We also included the word frequency as additional control factor since word frequency can affect ERPs. Word frequency metrics were extracted from Google Ngrams. A cortical response to word onset was found at frontal electrodes bilaterally at a latency of around 400 ms after stimulus onset. A neural response to word frequency emerged around 100 ms after word onset; the response was left lateralised on frontal electrodes. The grammatical distinction of function/content words elicited a sustained cortical response that was mainly frontally and bilaterally distributed. The noun/verb distinction elicited a bilateral response on mainly temporal and occipital channels about 300 ms after word onset; this response was left lateralised at 400ms post stimulus onset. In summary, we found significant cortical responses in the delta frequency band for the linguistic features word frequency and grammatical category. Neural responses to linguistic features of natural spoken language, with an irregular timing of words, can hence be successfully recorded with EEG. The findings point towards a role of the delta frequency band in the predictive coding of spoken language.

Phonology and Phonological Working Memory

D69 Using phonemic, rapid naming and orthographic measures to predict volume of the posterior cingulate

Hannah Travis[1], Jennifer Schlak[1], Ruchi Brahmachari[1], Andrew Molnar[1], George Hynd[2], Michelle Kibby[1]; [1]Southern Illinois University-Carbondale, [2]Oakland University

Introduction: The cingulate gyrus is not as commonly associated with dyslexia as other brain structures, but neurobiological evidence has shown that the posterior cingulate is an important region for reading (Graves et al., 2010; Hosseini et al., 2013). However, there may be differences in which hemisphere is more dominant, and for which skill, of reading. Thus, we examined the relationship of bilateral posterior cingulate volume with component skills for reading. We hypothesized that left hemisphere volume would be correlated with phonological processing/short-term memory, rapid automatic naming and orthographic processing, showing a differential hemispheric relationship. Methods: Participants included 42 children between the ages of 8-12 years who

had reading disability, ADHD, both disorders or were typically developing. The sample was predominantly Caucasian (84%) and male (67 %). Data was collected as part of a larger study focused on dyslexia (NIH/NICHD R01 HD26890). Brain tracing was supported through a separate grant (NIH/NICHD R03 HD048752). Phonological repetition/short-term memory was measured with Nonword Repetition (NWR), and rapid naming was measured with Rapid Letter Naming (RLN), both from the CTOPP. Orthographic processing (OP) was measured with a composite score based off two experimental measures: correct spelling and homophone identification. The Vocabulary subtest from the Weschler Abbreviated Scale of Intelligence (WASI) was used as a covariate to control for verbal intelligence. A 1.5T GE Sigma scanner was used to obtain a 3-D, T1 weighted image. In terms of measurement, first, the cingulate was traced on every slice in the sagittal plane using guidelines from Crespo-Facorro et al. (1999). Next, the cingulate was divided into three regions, and the posterior region ran from the central sulcus to its posterior conclusion. Inter-rater reliability was > 0.90. Results: For both analyses, multiple hierarchal regression was used to examine the relationship between the orthographic processing composite, Nonword Repetition and Rapid Letter Naming (Block 2) and posterior cingulate volume (for both the left and right hemispheres), controlling for Vocabulary (Block 1). We found that RLN predicted left posterior cingulate volume (Delta R^2 =.234, p=.018; Beta=.568, p=.006). We also found that Nonword Repetition (Beta=.527, p=.001) and the orthographic composite (Beta=-.597, p<.001) predicted right hemispheric volume (Delta R^2=.456, p<.001). Conclusion: RLN was the only significant predictor of left posterior cingulate volume, while NWR and OP were significant predictors of right volume. Previous evidence supports a relationship between phonological processing and the posterior cingulate (Bolger et al., 2008). The relationship between right volume and these measures may be due to the visual component in orthography (Mesman and Kibby, 2011) and use of visualization in the STM task. It also could be due to the nature of our sample, as approximately half of our participants had some form of reading disability. There is evidence to suggest that increased activation in the right posterior hemisphere is related to worse spelling abilities (Gebauer et al., 2012), so it is possible that the children with RD are compensating for left dysfunction by relying on their right hemisphere more.

D70 Perceptual sensitivity to non-native sounds: ERP evidence of neuroplasticity in the phonological system related to second language learning

Karin Heidlmayr[1,2], Emmanuel Ferragne[2], Frédéric Isel[3]; [1]Max-Planck Institute for Psycholinguistics, Nijmegen, The Netherlands, [2]Laboratory CLILLAC-ARP – EA3967, Paris Diderot – Sorbonne Paris Cité University, Paris, France, [3]Laboratory MoDyCo-CNRS University Paris Nanterre – Paris Lumières, France

Second language (L2) learners quite persistently encounter difficulties in perceiving specific non-native sound contrasts (e.g., Flege & MacKay, 2004; Dupoux et al., 2008; Sebastián-Gallés et al., 2005), i.e. a phenomenon called phonological deafness (Troubetzkoi, 1939). If, however, neuroplastic changes do take place in the cerebral network underlying phonological processing, sustained L2 experience should lead to adaptive processes and eventually to a certain capacity to discriminate non-native phonemic contrasts even in late L2 learners (Best & Strange, 1992; Flege et al., 1997; Iverson et al., 2012). Here, we aimed to examine the extent to which neuroplastic changes take place in the phonological system as a function of L2 experience. We designed an ERP experiment in which the capacity of listeners to discriminate L2 phonemic contrasts mediated lexical access. A semantic violation paradigm was used in which the difference between semantically congruent and incongruent items was implemented by a phonemic contrast that is unique to the L2, English (e.g., /ɪ/ - /i/: ship – sheep), but does not exist in the L1, French. Nineteen young adult native speakers of French with intermediate proficiency in English listened to sentences that contained either a semantically congruent item (e.g., The anchor of the ship was let down) or an incongruent one (e.g., *The anchor of the sheep was let down) while EEG was continuously recorded. They performed an acceptability judgement. The ERP data revealed a fronto-central incongruency effect, i.e. a larger negativity for incongruent than congruent words between 180-220 ms post-stimulus onset. Importantly, this early effect was larger in more proficient L2 learners. Moreover, a centro-parietal N400 incongruency effect was found, i.e., a larger negativity for incongruent than congruent words between 350-650 ms. The effect peaked earlier in more proficient L2 learners. Taken together, our findings indicate that L2 learners were sensitive to semantic incongruencies mediated by non-native phonemic contrasts. However, the proficiency-related variations of ERP effects suggest that perceptual sensitivity to non-native sounds depends on the amount and type of sustained L2 experience. However, the capacity to acquire non-native phonology has previously been found to show considerable inter-individual variability (Pruitt et al., 2006; Golestani & Zatorre, 2009). Future studies should try to identify which factors play a facilitating or limiting role for neuroplastic changes in the phonological system and investigate the role of targeted training on the sensitivity to second language phonemic contrasts.

D71 The Neural Basis of Phonological and Orthographic Working Memory: Implications for Working Memory Models

Brenda Rapp[1], Jeremy Purcell[1], Randi Martin[2]; [1]Johns Hopkins University, [2]Rice University

Neuroimaging and neuropsychological evidence suggests that the left parietal lobe supports working memory for phonological representations derived from speech perception (e.g., Vallar & Papagno, 1995; Martin,

Wu, Jackson, Freedman, & Lesch, 2003; Yue, Dial, & Martin, 2016) and working memory for orthographic representations involved in spelling (Rapp, Purcell, Hillis, Capasso, & Miceli, 2016; Rapp & Dufor, 2011). Given that dissociations between orthographic working memory (OWM) and phonological working memory (PWM) have been reported (Rapp, Shea, Mis & Martin, 2016), some distinct brain regions are presumably involved. Historically, it has been assumed that the inferior parietal lobe serves as the neural basis of a storage buffer specific to PWM (Warrington, Logue, & Pratt, 1971; Vallar & Papagno, 1995). However, it is possible that the same parietal region is involved for the two domains because it carries out some general function, such as in directing attention to representations maintained elsewhere. Shared parietal substrates for phonological and orthographic WM would be consistent with embedded processes models of WM, which assume that WM consists of the activated portion of LTM, with frontal-parietal regions involved in bringing these representations in to the focus of attention (Cowan, Li, Moffitt et al., 2011). The present study, which examined lesion localization for individuals with selective PWM or OWM, is the first to directly address whether the same or distinct parietal regions are involved in WM in the two domains. Methods: Nine individuals with left-hemisphere strokes were separated into an OWM deficit group and a PWM deficit group. The OWM deficit group (5 individuals; 3 females) had well-documented OWM deficits in spelling, without deficits in LTM for orthography or in PWM in speech perception. The PWM deficit group (4 individuals; 0 female) had well-documented PWM deficits for speech, without deficits in LTM for phonology or in OWM in spelling. The neuroimaging modalities included 1 CT scan and 8 T1-weighted MRI scans. MRIcron was used to draw and overlay each lesion. Enantiomorphic normalization was carried out via SPM12; this approach derives non-linear normalization parameters from intact tissue in the undamaged homologous region of the intact contralesional hemisphere (Nachev, Coulthard, Jäger, Kennard, & Husain, 2008). Normalized lesion maps were overlaid on a template brain; coordinates are reported in MNI space. Results and conclusions. The results of the lesion overlays revealed non-overlapping brain regions for the two groups in the parietal lobe and elsewhere. The parietal region for the PWM group was in the supramarginal gyrus while the region for OWM group was more posterior and superior. These parietal regions showed good convergence with regions activated in fMRI studies of OWM (-28, -54, 57; Rapp & Dufour, 2011) and PWM (-55, -36, 23; Wu et al., 2003; Yue et al., 2016) for neurotypical individuals, showing domain-specific topography. Thus, the results appear more consistent with these parietal regions supporting domain-specific WM processes rather than a unitary attentional function predicted by embedded process accounts of WM.

Language Therapy

D72 Electrophysiological predictors of efficacy for treatment of reading and language impairments

Paul Fillmore[1], Michaela Ritter[1]; [1]Baylor University

Introduction. Much research has focused on phonological awareness intervention (PAI) for facilitating early reading skills in young children with and without language impairment (LI), and those at-risk for a reading disability (RD). However, there are limited data regarding the influence of PAI for school-age children, and efficacy in this population is a critical issue to explore. Additionally, it is crucial for both diagnosis and treatment to have an understanding of the relevant patterns of brain function associated with LI and RD, and what changes might result from successful treatment. Thus, the aims of the current study were to investigate the effects of phonological awareness intervention on reading abilities of school-age children and to identify the relevant brain systems associated with LI, RD and with treatment efficacy. Methods. The study utilized participants from Camp Success (n=55, age 5-16 years), a four-week intensive language and literacy intervention. All participants were identified with language impairment and met diagnostic criteria for reading and phonological impairment. Reading outcome measures consisted of oral reading fluency measures from Read Naturally, selected subtests of the TILLS, and the Test of Written Spelling. The intervention was an adaptation of Goldsworthy's (2004) program, focusing on phonemic awareness and word decoding skills, and progressing in difficulty over the course of treatment. Resting electroencephalography (EEG) was collected in two five-minute intervals (eyes open, eyes closed) after completion of the four-week treatment protocol. Each session was processed using Neuroguide software for generation of EEG summary metrics (coherence, phase, power, etc.). Data were analyzed within standard frequency bands, and were compared to an age-referenced normative database via Z-scores, to assess differences between our participants and healthy controls. To evaluate the efficacy of PAI, paired t-tests were conducted for each outcome measure. To characterize the average patterns in the EEG for our sample, mean Z-scores were calculated for each measure of interest. To relate behavioral data to the EEG measures, Pearson correlations were run between each electrode/electrode pairing, and each behavioral measure, both for post-test measures and for improvement measures. Results. Most behavioral outcome measures were highly significant (mean Cohen's d=0.67, range=0.11-1.62). Several differences between our sample and the normative EEG sample were noted, including: absolute power, amplitude asymmetry, coherence, and phase. For correlations between behavioral and EEG data, several patterns were noted. For post-test measures, non-word spelling was related to both power and phase measures, and oral narratives related to coherence. For improvement scores, written spelling, non-

word spelling and written narrative recall were related to different aspects of both power and phase. Specific spatial patterns will be discussed in further detail. Conclusions. We found that PAI for school-age children is of significant benefit. Furthermore, we found several measures of difference between the EEG's of our population and a normative sample. In addition, several of these EEG measures were predictive, not only of behavioral variance at post-test, but of response to treatment. Further research will highlight the diagnostic power of these measures, and if they can yield meaningful information for planning of therapeutic intervention.

Control, Selection, and Executive Processes

D73 Modulating the left inferior frontal cortex by task, task challenge and tDCS

Davide Nardo[1], Katerina Pappa[1], John Duncan[2], Peter Zeidman[3], Martina Callaghan[3], Alexander Leff[1,3,4], Jennifer Crinion[1]; [1]Institute of Cognitive Neuroscience, University College London, London, UK, [2]MRC Cognition and Brain Sciences Unit, University of Cambridge, Cambridge, UK, [3]Wellcome Trust Centre for Neuroimaging, University College London, London, UK, [4]Department of Brain Repair and Rehabilitation, Institute of Neurology, University College London, London, UK

Background. The left inferior frontal cortex (LIFC) is a key region in spoken language processing. Indeed, previous studies from our lab have shown that anodal transcranial direct current stimulation (tDCS) delivered to the LIFC enhances spoken naming reaction times (RTs) more than sham tDCS [Holland et al., Curr Biol 2011], and modulates effective connectivity between the LIFC and premotor cortex during naming [Holland et al., Neuroimage 2016]. A matter of more recent debate is whether the LIFC's role is domain-specific (i.e., linguistic), or domain-general (i.e., involved in multiple challenging cognitive functions) [Fedorenko & Thompson-Schill, Trends Cogn Sci 2014]. In this study we directly addressed how the LIFC is modulated by different tasks and task challenges in a concurrent tDCS/fMRI experiment. Method. 17 healthy right-handed English native speakers underwent an fMRI study in a 2 x 2 x 2 x 2 (Task x Challenge x Modality x tDCS) factorial design. Subjects were asked to perform both a linguistic (picture naming) and a non-linguistic (size judgment) task in two sessions one week apart. Stimuli were 480 pictures of monosyllabic objects. Task challenge (low vs. high ambiguity) was manipulated by varying: i) visually, the amount of noise overlapping the picture (5 vs. 15 squiggly lines); ii) aurally, the cue delivered concurrently with the picture (initial phoneme vs. noise). All subjects received both tDCS conditions (either anodal or sham on each session) delivered to the LIFC, with the order counterbalanced across subjects. Overt spoken responses (object names, yes/no replies for size judgement) were recorded online, and RTs were computed. Results. RTs data showed a significant main effect of Challenge ($p<.001$) for both visual and auditory modality (i.e., higher ambiguity resulted in slower RTs), no significant main effect of Task (i.e., tasks were behaviourally matched overall), and no significant main effect of tDCS. Significant tDCS x Challenge ($p=.027$) and tDCS x Task x Challenge ($p<.005$) interactions were found for the visual modality with anodal tDCS facilitating on-line performance. fMRI data ($p<.05$ FWE-corrected) showed that both tasks engaged a common bilateral network including the LIFC, supplementary motor area, visual, auditory and premotor cortices. In contrast to the behavioural data, there was a main effect of Task with the LIFC significantly activated more in the naming than in the judgment task. Mirroring our RTs results, there was a main effect of Challenge revealed in visual and auditory sensory cortices, and no significant main effect of tDCS. Furthermore, the tDCS x Challenge and tDCS x Task x Challenge interactions in the visual modality were replicated, with left premotor cortex and LIFC respectively showing neuro-modulatory effects of anodal tDCS ($p<.001$-uncorrected). Conclusion. Our data suggest that the LIFC is domain-general (i.e., involved in both cognitive tasks), yet activated more during naming, even though behavioural performance was matched across tasks. Both behaviourally and neurally there were complex interactions between task, task challenge, and tDCS. Anodal tDCS facilitated on-line performance (faster RTs), and modulated BOLD activity of the task-engaged frontal cortices in the vicinity of the stimulating electrode.

Speech Motor Control and Sensorimotor Integration

D74 Manual directional gestures facilitate learning of Mandarin tones

Anna Zhen[1,2], Stephen Van Hedger[1], Shannon Heald[1], Susan Goldin-Meadow[1], Xing Tian[2]; [1]The University of Chicago, [2]New York University Shanghai

Action and perception interact in complex ways to shape our cognition. For example, gestures can impact learning and verbal communication, especially among non-native speakers. However, the processes through which motor and visual gestural information can influence auditory learning are still not entirely clear. We hypothesize that this cross-modal learning benefit is caused by the common representation of certain features such as direction among motor, visual, and auditory domains. To test this hypothesis, the present study examined the role of manual and visually displayed directional pitch gestures in helping native English speakers learn the tones in Chinese vowels and words. Two types of hand gestures were included – iconic pitch gestures that mimic the directional dynamics of 4 Chinese lexical tones and rotated pitch gestures that are generated by rotating the iconic pitch gestures 90 degrees. Moreover, we parametrically manipulated the involvement of modalities (motor, visual and auditory) activated during learning by assigning participants to conditions in which

they performed pitch gestures, watched videos of pitch gestures, or did not receive any gesture information. 65 participants received one of five types of training yielded by the factors of gesture type and training modality: 1) performing iconic pitch gestures (3 modalities, visual, auditory, and motor modalities), 2) performing rotated pitch gestures (3 modalities, visual, auditory, and motor), 3) watching pitch gestures (2 modalities, visual and auditory), 4) watching rotated pitch gestures (2 modalities, visual and auditory), or 5) no gestural (motor or visual) information (1 modality, auditory). The learning effects were quantified by the improvement in tone identification performance either immediately or a day after training. Tones recorded by different speakers were also used to test whether learning can be generalized. We found that participants who performed pitch gestures, regardless of iconic or rotated gestures during learning outperformed the other groups in identifying the tones in Chinese vowels. Moreover, these learning effects generalized to novel, untrained monosyllabic Chinese words. In contrast, participants who learned by watching rotated gestures were not any better at identifying the tones in Chinese vowels and words than participants who were given auditory training only. The accuracy rates in these two groups were the lowest of the five training groups. These results provide support that motor and sensory systems may have the same coordinates representing directions and that reinforcement across different modalities help individuals direct attention to the relevant acoustic features for learning.

D75 Brain lesion associated with impaired sensorimotor processing of speech auditory feedback in aphasia

Roozbeh Behroozmand[1], Lorelei Phillip[2], Karim Johari[1], Leonardo Bonilha[3], Chris Rorden[4], Gregory Hickok[5], Julius Fridriksson[2]; [1]Speech Neuroscience Lab, Department of Communication Sciences and Disorders, University of South Carolina, 1224 Sumter Street, Columbia, SC 29201, USA, [2]The Aphasia Lab, Department of Communication Sciences and Disorders, University of South Carolina, 915 Greene St., Columbia, SC 29208, USA, [3]Department of Neurology, Medical University of South Carolina, Charleston, SC 29425, USA, [4]Department of Psychology, University of South Carolina, Columbia, SC 29208, USA, [5]Department of Cognitive Sciences, University of California, Irvine, Irvine CA 92697, USA

The present study sought to illuminate the brain network involved in speech sensorimotor processing by studying patients with post-stroke aphasia using the altered auditory feedback (AAF) paradigm. We utilized the combination of neuroimaging-based lesion-symptom-mapping analysis and behavioral testing to examine the pervasiveness of speech sensorimotor deficit and its relationship to the brain regions implicated. We recruited 16 patients with aphasia and 16 age-matched healthy control subjects to complete a speech task under AAF. The task involved producing a steady vowel sound while listening to the pitch-shifted real-time feedback of their speech. The implementation of this task allowed us to develop an objective biomarker of speech sensorimotor impairment by measuring the degree to which each subject behaviorally responded to AAF stimuli to compensate for errors in their speech auditory feedback signal. Results indicated that compensatory speech responses to AAF were significantly diminished in patients with aphasia compared with the control group ($F(1,30) = 16.02$, $p < 0.001$). The correlation analysis revealed a strong and direct relationship ($r = 0.6$, $p = 0.015$) between AAF responses and speech repetition ability, as indexed by the Western Aphasia Battery (WAB) scores. A region-of-interest lesion-symptom-mapping analysis revealed that the early phase (50-150 ms) of diminished AAF responses in aphasia were correlated with damage to auditory cortical regions within the superior and middle temporal gyrus, whereas the middle (150-250 ms) and late (250-350 ms) phases of diminished AAF responses were correlated with damage to the inferior frontal gyrus and supramarginal gyrus areas, respectively. These findings suggest that damage to the auditory, motor and auditory-motor integration networks are associated with impaired sensorimotor function for speech error processing in patients with aphasia. In addition, based on the results of the correlation analysis, we argue that specific aspects of language impairment (i.e. speech repetition deficit) are accounted for by dysfunctions of the speech sensorimotor integration network as revealed by diminished responses to AAF. These findings provide new insights into the connection between pathologically-diminished integrative function underlying speech auditory feedback processing and the implicated brain lesions associated with language deficits in patients with post-stroke aphasia.

D76 Investigating voice imitation using fMRI and real-time anatomical MRI of the vocal tract

Carolyn McGettigan[1], Sheena Waters[1], Clare Lally[1], Daniel Carey[1,2], Elise Kanber[1], Valentina Cartei[3], Marc Miquel[4,5]; [1]Royal Holloway, University of London, UK, [2]Trinity College Dublin, IRE, [3]University of Sussex, UK, [4]Queen Mary University of London, UK, [5]Barts NHS Trust, London, UK

Perceptually, fundamental frequency (F0; closely related to pitch) and formant spacing (an index of vocal tract length; VTL) are important cues for the extraction of indexical characteristics such as sex and body size from the voice. Behavioural research has further shown that talkers instinctively modulate these cues to emulate various physical and social attributes (Cartei et al., 2012; Hughes et al., 2014). Here, I will give an updated report of the first combined acoustic, articulatory and neurobiological investigation of these paralinguistic aspects of vocal behavior. We scanned native speakers of British English while they performed a voice imitation task. Using synthetic modulations of participants' own speech (recordings of the monosyllables "BEAD" and "BARD"), we generated target voices with varying F0 and apparent

VTL. There were four modulated voice targets: 1) LowF0-LongVTL, 2) HighF0-ShortVTL, 3) LowF0-ShortVTL and 4) HighF0-LongVTL. A pilot study (McGettigan et al., 2015, SNL abstract) had shown that participants were more accurate at reproducing the acoustic properties of the biologically typical combinations of F0 and VTL (i.e. targets 1 and 2) than the less typical combinations (i.e. targets 3 and 4); further, vocal tract MR images (collected at 8 frames per second) indicated that participants were more successful at lengthening and shortening the vocal tract appropriately for the more typical voice targets. In the current study, we collected sagittal real-time images of the vocal tract and whole-brain BOLD fMRI from a new set of participants (N=26 to date) while they listened to, and repeated, the four target voices as well as their unmodulated voice. From the real-time anatomical MRI images, we tracked the frame-by-frame coordinates of the lips and larynx to index the relative changes in vocal tract length for each modulated voice. In separate runs, we recorded BOLD fMRI to separately measure activations related to sensorimotor transformation (ST) and imitation of the voices, respectively. The functional data reflect previous findings (Carey et al., 2017, Cerebral Cortex) for ST and imitation, where ST was associated with activation in bilateral sensorimotor cortex, superior temporal gyri and sulci, cerebellum, hippocampus and subcortical nuclei, while activation during imitation itself was more restricted to sensorimotor cortex and anterior cerebellar sites. Comparisons of the different target voices reveals significant effects of modulations in apparent VTL, in particular during ST for the atypical voices: here, voices with a longer apparent VTL generated greater activation in bilateral insulae extending to ventral IFG in the left hemisphere, and in the left posterior planum temporale. Comparisons based solely on difference in pitch have revealed little activation – however, contrasts exploring the interaction of F0 and VTL have indicated modulations in the response of bilateral STG/STS and subcortical sites including the caudate and thalamus. Ongoing analyses will link the BOLD response during ST and imitation to individual differences in the degree of vocal tract modulation (as determined from vocal tract images). Further, we will explore the effects of expertise in vocal control of pitch and VTL by comparing performance across control participants and highly trained singers.

D77 Speech encoding in the human subthalamic nucleus

Witold Lipski[1], Ahmad Alhourani[1], Tara Pirnia[1], Peter Jones[1], Christina Dastolfo-Hromack[1], Leah Helou[1], Susan Shaiman[1], Michael Dickey[1], Lori Holt[1], Robert Turner[1], Julie Fiez[1], Mark Richardson[1]; [1]University of Pittsburgh

Speech production is disrupted in many neurological diseases that involve the basal ganglia. Notably, hypophonia and hypokinetic dysarthria (characterized by decreased motor gain) are prevalent in patients with Parkinson's disease (PD). Deep brain stimulation (DBS) of the subthalamic nucleus (STN) produces predictable improvements in other motor symptoms of PD but does not result in consistent improvement in speech and can negatively impact language function. However, neurophysiological models of speech production typically do not account for the involvement of basal ganglia nuclei. To examine the role of the STN in speech production, we recorded STN neuron activity, STN local field potentials (LFP), and spoken acoustics while 14 PD subjects performed a speech task during awake, microelectrode recording-guided DBS surgery. On each trial, subjects were asked to read aloud a consonant-vowel-consonant syllable presented on a computer screen. Spike waveforms were sorted into single- and multi-unit recordings. LFP signals were bandpass filtered into canonical bands (delta 2-4Hz, theta 4-8Hz, alpha 8-12 Hz, beta 13-30Hz and gamma 50-90Hz). Power changes were calculated as a z-score relative to baseline, after applying a Hilbert transform to estimate signal amplitude and phase. First, we found evidence for the participation of STN neurons in speech production. Nearly half of the unit recordings (22 of 45; 13 subjects) showed either increases or decreases in firing rate when aligned to speech onset. STN LFP recordings also showed evidence for modulation related to speech production. Consistent with tracking the motor aspects of speech, we found an increase in gamma power in 13/14 subjects locked to the onset of speech, but not locked to cue presentation. In contrast, theta power increases were locked to cue presentation rather than speech onset (11/14 subjects), and this modulation was associated with an increase in inter-trial phase consistency (ITPC) (7/14 subjects), suggesting a role for theta-encoding in cognitive processing prior to speech onset. Likewise, we observed alpha and beta power decreases locked to cue presentation, but not to speech onset. In a subset of these recordings, we observed differences in both alpha and beta ITPC that were specific to whether the presented stimulus was a real word or a non-word. Lastly, we observed delta power and ITPC increases in relation to both cue presentation and speech onset (11/14 subjects), further suggesting that several types of speech-related information transfer occur within the STN. These results provide a foundation for developing a detailed model of basal ganglia participation in speech.

D78 Articulatory gesture encoding in human sensorimotor cortex during continuous speech production

Josh Chartier[1], Gopala K. Anumanchipalli[1], Edward F. Chang[1]; [1]University of California, San Francisco

To speak, we must coordinate over 100 muscles to precisely actuate our lips, jaw, tongue, larynx, and other vocal tract articulators. It is an extraordinary motor control feat, yet nearly all of us produce fluent speech. Our previous work focused on short consonant-vowel syllable production, and demonstrated that the human ventral sensorimotor cortex (vSMC) is functionally activated along somatotopic representations of articulators. However, natural continuous speech is far more complex and dynamic than single syllables because of co-articulation between

adjacent segments and execution of motor plans over longer duration. To address this, we studied the encoding of kinematic properties in the human vSMC during natural sentence production. We recorded high-density intracranial electrocorticography signals, while speakers produced a set of sentences designed to cover all phonetic contexts in American English (MOCHA-TIMIT). We first developed a method to estimate vocal tract kinematic parameters from phonetic transcriptions and produced acoustics (acoustic-to-articulatory inversion). We then fit linear kinematic-trajectory models to each electrode using kinematic parameters to predict neural activity. We found single electrode encoding of dynamical representations of highly specific, coordinated out-and-back trajectories of articulators (e.g. tongue protrusion, lip closure, etc). Kinematic trajectories of electrodes clustered into four main categories differentiated by place of vocal tract constriction. Furthermore, electrodes in each trajectory category showed activations during the production of phonemes with similar places of articulation. Each trajectory category appeared to be spatially localized in the sensorimotor cortex. Lastly, the kinematic-trajectory model better explained electrode activity when compared against phoneme and single articulator representations. We have used natural continuous speech to demonstrate the neural representation of articulatory gestures in speech production.

Poster Session E

Friday, November 10, 10:00 – 11:15 am, Harborview and Loch Raven Ballrooms

Language Development

E1 Evoked and oscillatory EEG activity differentiates language discrimination in young monolingual and bilingual infants

Loreto Nacar[2], Carlos Guerrero-Mosquera[1], Marc Colomer[1], Nuria Sebastian-Galles[1]; [1]Center for Brain and Cognition, Universitat Pompeu Fabra, Spain, [2]Infant Studies Centre, University of British Columbia, Canada

Language discrimination is one of the core differences between bilingual and monolingual language acquisition. Here, we investigate the earliest brain specialization induced by it. Following Bosch and Sebastian-Galles (1997), we hypothesize that bilingual native language discrimination is a complex process involving both language discrimination and identification. We recorded the brain activity of monolingual (N=28) and bilingual (N=28) 4.5-month-old infants using EEG. Infants were passively listening to sentences in their native/dominant language (Spanish or Catalan), and two foreign languages: one of the same rhythmic class (Italian) and one of a different rhythmic class (German). To separate discrimination and identification effects, we defined two different windows of analysis. The early window of analysis (150-250 ms) was selected to explore the response of familiarity to each language by measuring the latencies of the P200 component. Four electrodes (F3, FC5, F4, and FC2) localized on the frontocentral region defined our Region Of Interest (ROI). We run a repeated measures ANOVA with a between factor, Group (Monolingual, Bilingual) and a within factor, Language (Native, Italian, German). The ANOVA yielded a significant Group by Language interaction $F(2,167)=3.55$ $p=0.036$. For each of the groups separately, we run a one-way-ANOVA with the factor Language. The ANOVA was significant for the monolingual group $F(2,81)= 3.743$ $p=0.028$; but was not for the bilingual group ($F<1$). Planned paired t-test comparisons revealed a significant difference for the Monolingual group between Catalan and German ($t(13)=-2.883$ $p=0.007$) and Italian and German ($t(13)=-2.313$, $p=0.029$) but not between Catalan and Italian ($t<1$). The same analysis for the bilingual group did not reach significance for any of the comparisons. The late window of analysis (400 - 1800 ms) was selected to analyze the identification response reflected in the theta oscillations. Ten electrodes (FC6, CP2, P4, F4, F8, F3, FC5, CP1, P3, F7) localized on the fronto-temporo-parietal regions defined our Region Of Interest (ROI). We ran a repeated measures ANOVA. The main effects of Group and Language did not reach significance ($F<1$) but it yielded a significant interaction of Group by Language $F(2,24) = 15.37$; $p<0.001$. We ran separate one-way ANOVAs for each group on the Language factor. Only the Bilingual group showed significant differences $F(2,81) = 3.25$ $p=0.045$. Planned comparisons only showed significant differences for the Bilingual group when comparing the Native language against German ($t(13)= 2.30$; $p=0.029$) and the Native language versus Italian ($t(13)= 2.17$; $p=0.038$). The results indicate different language discrimination strategies for bilingual and monolingual infants. While monolingual infants show early discrimination of their native language based on familiarity, bilinguals perform additional processing related to language identification. Such additional processing originates in the bilingual group at a higher power in the Theta band for the native language as compared to the foreign languages, reflecting bilinguals' additional processing of the prosodic properties of the familiar language. This is the earliest evidence found for brain specialization induced by bilingualism.

E2 The relationship between lexical development and neural measures of speech discrimination in monolingual and bilingual toddlers

Valerie Shafer[1], Carol Tessel[2], Michelle MacRoy-Higgins[3], Nancy Vidal[4], Yan Yu[5], Alahna Cogburn[1], Richard Schwartz[1]; [1]The Graduate Center, CUNY, [2]Florida Atlantic University, [3]Hunter College, [4]Iona College, [5]St. John's University

Considerable variability in rate of vocabulary growth is observed in first language acquisition. Some models of phonological development suggest that there is a strong relationship between the number of words in a

child's vocabulary and phonological development. For a child acquiring two languages, the relationship between vocabulary and phonology can be complex because the two languages often differ considerably in both phonology and vocabulary. The question addressed in this study is the relationship between language experience (input), lexical growth and phonological development in monolingual English and bilingual English-Spanish children. Behavioral measures of phonological and lexical development, and neural measures of speech perception were obtained from 10 monolingual and 10 bilingual children at multiple time points between six months and five years of age. Neural measures were collected form 65 electrode sites to an English-only vowel contrast (/I/ in 'bit" versus /ɛ/ in "bet") in an oddball paradigm designed to elicit the mismatch negativity (MMN) and neural measures of stimulus encoding (e.g., T-complex). Vocabulary was estimated from the MacArthur communicative development inventories and from 30-minute language samples. Language input was measured from a Language Background Questionnaire asking parents to rate the amount of input in different contexts (e.g., home) and from different people (e.g., mother). Language outcome was measured using the English and Spanish Preschool Language Scales (PLS) and receptive vocabulary measures (Peabody PPVT and TVIP). Results revealed considerable variability in vocabulary size, with English receptive vocabularies on the MacArthur ranging from 7 to 111 at 12 months of age but similar group means. Between 18 and 27 months of age, monolingually-exposed children showed larger English productive vocabularies (range 56-709) than the bilinguals (range 7-448). Three bilingual children showed vocabulary growth below the 15th percentile, but two had strong Spanish vocabularies. Most of the English monolingual children had a clear MMN from 300 to 400 ms after onset of the English vowel change. In contrast, only three bilingual children showed an MMN and these children had larger English vocabularies than the bilingual children showing no MMN. Monolingual children also showed increasing positivity from 100-200 ms at the left temporal sites (T-complex) with increasing age to the frequent vowel stimulus, whereas bilingual children generally showed increasing negativity with increasing age. After three years of age, all but two of the children showed language scores in the normal range. These two children were bilingual; one exhibited age-appropriate scores in Spanish and the other performed poorly in both languages. Amount of Spanish input did not directly affect the results. The bilingual child with the largest MMN had a large vocabulary at 24 months, age-appropriate language scores in both English and Spanish and balanced input. The bilingual child with the lowest English language scores had a small English vocabulary, poor language scores in both languages, balanced English and Spanish input, and no MMN. These findings suggest that the MMN measure of English vowel discrimination at 24 months of age is more closely related to current English vocabulary size than to later-age English language outcomes.

E3 N170 sensitivity to orthographic and visual-spatial processing in Chinese L1 and L2 kindergartners

I-Fan Su[1], Hyun Kyung Lee[1], Lirong Luo[1], Yanling Zhou[2]; [1]The University of Hong Kong, [2]The Education University of Hong Kong

Visual-spatial and orthographic processing skills contribute to early stages of learning to read, particularly in a morphosyllabic writing system such as Chinese. In addition, the parietal-occipital N170 component is sensitive to different classes of visual stimuli, and suggestively associated with perceptual expertise developed through plastic changes in the visual system. This study examined the visual-spatial and orthographic sensitivity of the N170 in emergent readers of Chinese. Kindergarten children speaking Chinese as a first language (L1) and as a second language (L2) identified question marks in a stream of stimuli presented whilst recording their electrophysiological responses. The non-attended stimuli varied in script (Chinese characters, Korean Hangul characters vs. Chinese random strokes). Chinese vocabulary and word reading, Cantonese morphological, phonological and lexical tone awareness, Chinese orthographic memories, basic visual skills, and copying skills were also assessed behaviourally. L1 children outperformed L2 children on all Chinese reading related and orthographic knowledge measures, but did not differ on any basic visual, hand-eye coordination and pure copying skills. At the N170 component, significant scriptal effects showed a greater N170 for Chinese followed by Korean and random strokes, indicating that the kindergarten children could passively distinguish familiar Chinese characters from unfamiliar stimuli. The hemisphere-by-script interaction suggest that the right hemisphere may be engaged in coarse-grained visual-spatial analysis as Chinese and Korean differed from random strokes, whilst the left hemisphere is engaged in finer-grained visual-spatial and orthographic analysis as children differentiated Chinese and Korean scripts. Moreover, given that no group differences between L1 and L2 Chinese speakers were found, the challenges emergent readers face during early stages of learning to read Chinese as a second language possibly do not arise from assumed greater visual-spatial or orthographic demands indexed by the N170.

E4 The Function of Cerebellum VI in Reading---Evidence from Cerebro-Cerebellar Functional Connectivity

Chen Ang[1], Xiaoxia Feng[1], Hehui Li[1], Manli Zhang[2], Xiujie Yang[2], Mengyu Tian[3], Yue Gao[1], Xiangzhi Meng[2], Guosheng Ding[1]; [1]Beijing Normal Univ., Beijing, China, [2]Peking Univ., Beijing, China, [3]Inst. of psychology, Chinese Acad. of Sci., Beijing, China

Background: Previous research showed that the cerebellum, particularly cerebellum VI, plays an important role in reading. The engagement of cerebellum VI in language processing was found in typical developed readers (Stoodley & Stein, 2011) and in dyslexia readers (Feng et al., 2016; Stanberry et al., 2006), but whether there are different functions between the left and right cerebellum need further exploring. Stanberry (2006) found dyslexia readers had abnormal cerebro-cerebellar functional connectivity during phonological task. A recent study also found cerebellum VI compensated for reading impairment through the connections with specific brain regions for different reading tasks (Feng et al., 2016). Reading difficulties may be caused by impairments of either phonological awareness (PA) or rapid naming (RAN) (Norton et al., 2014). However, it is not clear whether and how the function of cerebellum VI is related to the performance in PA and RAN. Here we used resting-state MRI to explore how the intrinsic cerebro-cerebellar functional connectivity of cerebellum VI related to PA and RAN. There are two goals: 1. Test the hypothesis that the role of cerebellum VI in different language tasks is implemented through functional connection to different cerebral regions responsible for the tasks. 2. Compare whether function of the left and right cerebellum VI differs with an examination of their relevant cerebro-cerebellar functional connectivity associating different tasks. Method: Resting-state MRI data and PA/RAN scores were collected from fifty-seven typically developing readers(mean age = 10.19 years, standard deviation = 0.96). Left and right cerebellum VI were chosen as ROIs from a meta-analysis study (E, Chen, Ho, & Desmond, 2014), and then the correlations between ROI-wise cerebro-cerebellar functional connectivity and reading performance were analyzed. Results: For the PA task, the correlated functional connectivity was found between either the right or the left cerebellum VI with bilateral insula. For the RAN task, the correlated functional connectivity was found between either the right or the left cerebellum VI with the left postcentral gyrus. The left and the right cerebellum VI did not show significant difference in term of the cerebro-cerebellar functional connectivity associating different tasks. In conclusion, the connections between bilateral insula and cerebellum VI were related to PA, and the connections between left postcentral gyrus and cerebellum VI were related to RAN. The results verified the hypothesis that the cerebellum VI functions through the connection to different cerebral regions to carry on different language tasks, and the function of the left and right cerebellum VI may not differ. These findings deepen our understanding of the how cerebellum involved in reading.

E5 Early specialization of phonological and semantic processing in 5- to 6-year-old children

Yael Weiss[1], James R Booth[1]; [1]University of Texas at Austin

Previous studies in older children and adults have investigated specialization for different components of language processing, but this has not been established in young children. Using fMRI, this project examined early specialization of different brain regions for phonological and semantic processing in 5- to 6-year-old children. This project has the potential to advance our understanding of the neural mechanisms underlying language acquisition in early childhood, while also laying the groundwork for future investigations of language impairment in this age range. Children (5.5-6.5 year-olds, N=42) were given sound and meaning judgments at the word level. In the semantic task, children determined whether two sequentially presented auditory words (i.e. "truck – car"; "flower – phone") were related in their meaning. In the phonological task, children determined whether two sequentially presented auditory one-syllable words (i.e. "sit – fit"; "duck – hat") shared a sound (onset or rhyme). Based on literature in older children and adults, we predicted that a direct comparison of semantic and phonological related tasks should reveal greater activation for meaning judgments in left middle temporal (MTG) as well as ventral inferior frontal gyrus (vIFG) and for sound judgments in left superior temporal gyrus/inferior parietal lobule (STG/IPL) as well as dorsal inferior frontal gyrus (dIFG). As predicted, sound judgments showed greater activation in the left IPL, whereas meaning judgments showed greater activation in the left MTG, suggesting early specialization of phonological and semantic processing. There were no task differences in the IFG, suggesting that frontal cortex is not yet specialized in this age range, which is consistent with the delayed maturation of the frontal cortex. In general, the results of this study indicate that by the age of 5-6-year-old, typically developed children already show some specialization of different brain regions for phonological and semantic processes.

E6 A sensitive period for the modification of the language network in blindness

Rashi Pant[1], Shipra Kanjlia[1], Connor Lane[1], Marina Bedny[1]; [1]Johns Hopkins University

Evidence from blindness suggests that regions outside of the classic language network can be recruited for language processing as a result of early experience. In congenital blindness, in addition to classical language areas, visual cortices also become involved in language processing. (Roder et al., 2002, European JoN.; Amedi et al., 2004, Nat Neuro; Bedny et al., 2011, PNAS). Here we asked whether this modification of the language network follows a sensitive period. Do visual cortices also take on linguistic functions in adult-onset blindness? Previous studies find that in congenitally blind people, visual cortices are more active during auditory sentence processing than during a control task with non-words (Roder et al., 2002, European JoN; Bedny et al., 2011, PNAS; Lane et al., 2015, JoN). Furthermore, in congenitally blind but not blindfolded sighted individuals, activity in the

visual cortex increases with the grammatical complexity of sentences, showing greater activation for sentences with syntactic movement than for matched sentences without it (Lane et al., 2015, JoN). We scanned 11 adult-onset blind (blindness onset after age 17) participants during the same auditory sentence comprehension and working memory control tasks used by Lane et al. (2015) and compared their visual cortex activity to that of 18 congenitally blind adults and 17 blindfolded sighted participants. All blind participants had at most minimal light perception and were blind due to pathology of the eyes or optic nerves. Participants heard a sentence followed by a yes/no question about who did what to whom. Half the sentences contained syntactic movement, i.e. had an object-extracted relative clause. In the working-memory-control task participants listened to a list of non-words (target list) followed by a shorter probe list. Participants decided whether the order of non-words in the probe matched the order of the same non-words in the target. We found that the visual cortex of adult-onset blind participants responded to sentences more than non-words when compared to the sighted participants, but this effect was much smaller than in the congenitally blind ($P < 0.05$). Furthermore, unlike in the congenitally blind, the degree of response to sentences in visual cortex correlated with the duration of blindness over the course of decades ($r = 0.73$, $P < 0.05$), suggesting a different mechanism of plasticity in adulthood. Crucially, unlike the visual cortex of the congenitally blind, the visual cortex of adult-onset blind participants did not respond to grammatical complexity (group-by-condition interaction $P < 0.05$), suggesting that the visual cortices play a less specific role in linguistic processing in this population. In sum, we find that even in adulthood, cortical areas that did not evolve for language processing can become responsive to spoken language. However, these responses are less specific and qualitatively different from cortical specialization for language during development and may not be functionally relevant to sentence processing.

E7 Brain white matter of children shows structural changes specific to language training performance

Clara E. M. Ekerdt[1], Clara Kühn[1], Alfred Anwander[1], Jens Brauer[1], Angela D. Friederici[1]; [1]Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany

Children acquire their native language at a rapid pace during a time when the brain is also undergoing major changes. We set out to explore the relationship between learning during this period of language acquisition and structural brain changes. The current study investigated white matter changes after eight training sessions over three weeks of language training in 4-year-old children, using diffusion weighted MRI images collected before and after training. Children were divided into three groups, word learning, active control, and passive control. During the training period, children in the word learning group learned 60 novel fictional characters and their labels. We used a word-picture matching task with answers recorded by button press of the participant. Employing the same set-up, the active control group performed a sentence-picture matching task without novel items. The children excelled at the word learning task, the group reaching above chance performance in the second training session. The active control group did not show improvement on the trained task. To examine white matter changes, we conducted a whole brain tract-based spatial statistics (TBSS) analysis to investigate the differences between groups in fractional anisotropy (FA) change from pre- to post-scan. Additionally, we correlated performance over all training sessions with FA change in the word learning group. In the group comparison between word learning and passive control groups, the word learning group showed greater FA changes in bilateral pre- and postcentral white matter, stretching posterior to parietal white matter in the left hemisphere. To ensure that this effect was not driven by button pressing in the word learning group, we included the active control group in the analysis. When comparing all three groups, only the left hemisphere FA increase remained. Interestingly, the correlational analysis in the word learning group, correlating FA increase from scan 1 to scan 2 with accuracy over all training sessions, reveals a negative correlation between FA increase and overall accuracy in left pre- and postcentral white matter, which overlaps with the group analysis result. The correlation shows that children for whom learning was more effortful showed a larger FA increase in this region. That is, children who needed more exposure to learn the association between character and label showed larger FA increases in this region. While children at the age of four have not yet mastered all aspects of language, for example the development of understanding complex syntax stretches through the early school years, they are adept word learners. This is reflected in the behavioral data, where ceiling performance was reached already by the sixth training session. Previous studies investigating structural brain changes following word learning in adults have found changes in the white matter following training. Our results provide evidence that it is possible to measure plasticity of the white matter in children using diffusion weighted MRI images following a short word learning training program. Furthermore, the changes in white matter reflect individual differences in the ability to learn new word-object pairings.

E8 Language Training Induces Changes in Cortical Thickness of the Developing Brain

Clara Kühn[1], Clara E. M. Ekerdt[1], Elisabeth Wenger[2], Riccardo Cafiero[1], Jens Brauer[1], Angela D. Friederici[1]; [1]Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany, [2]Max Planck Institute for Human Development, Berlin, Germany

The developing brain is subject to quite a number of maturational changes especially in early childhood. During the first years of life, the volume of a typically developing brain increases considerably as the cortical surface area expands and the cortical thickness decreases. Sensory input has a strong impact on brain development. In the domain of language, the developing brain is shaped by the way children perceive, process, and produce natural language. This observation leads to the question of whether language learning processes and brain development can be influenced by intervention and how the subsequent changes in brain and behavior are related. To shed light on these questions we examined whether children could be trained in specific language features (i.e., syntactic sentence structures and lexical item learning) and how the resulting changes in behavior would be reflected in the brain, specifically in cortical thickness and surface area. We conducted a 3-week training study with 4-year old children and collected structural MRI data before and after the training period. Participants were assigned to one of three groups: semantic training, syntax training, or control. Here we report results from the semantic (n = 19) and control groups (n = 20). The semantic group underwent a lexical training of 60 pseudo animals and their corresponding labels, which consisted of novel words. We hypothesized an increase in cortical thickness for children who underwent language training and a decrease for children who did not receive training, as well as a stronger surface area expansion for children who received training. We expected these effects to be strongest in language related regions of the brain such as inferior frontal regions, temporal regions and inferior parietal regions. We also looked at entorhinal and parahippocampal cortices as lexical-semantic learning heavily draws on memory processes. To compare changes in cortical thickness and surface area from pre- to posttest between the semantic and the control group we conducted a multivariate analysis of covariances in these regions. We showed that cortical thickness in left pars triangularis (BA45) in the inferior frontal gyrus changed differently for children in the semantic training group compared to the control group. While the control group showed a typical developmental decrease of cortical thickness from pre- to posttest, the semantic group retained their initial thickness level. Left pars triangularis has been implicated in semantic processes on the word level, e.g., lexical semantic access or categorization as well as processes on the sentence level, e.g., plausibility. We did not find a correlation between the change in cortical thickness and behavior. There were no differences between the groups in surface area change. Our results show that the semantic training had an effect on cortical thickness development, but not on surface area development. We interpret the differential trajectories of cortical thickness in semantic vs. control groups as semantic training attenuating typical developmental decreases in cortical thickness in this age group. The behavioral relevance of the observed attenuation of developmental decrease in cortical thickness remains to be investigated.

E9 Language exposure is associated with the cortical thickness of young, low-SES children

Rachel Romeo[1,2], Julia Leonard[2], Sydney Robinson[2], Meredith Rowe[3], Allyson Mackey[2,4], John Gabrieli[2,3]; [1]Harvard Medical School, [2]Massachusetts Institute of Technology, [3]Harvard Graduate School of Education, [4]University of Pennsylvania

Children's early life experiences are associated with their neuroanatomy and corresponding cognitive functions. One such experience is language exposure; the quantity and quality of the language children hear during these early years is associated with their overt language abilities throughout childhood and into adulthood. Furthermore, linguistic input varies with by socioeconomic status (SES), such that children from lower SES families typically hear fewer words than their higher-SES peers. Despite this strong behavioral literature, there is currently no evidence that directly relates children's language experience to brain structure. Here, we examined how variation in spoken language experience at home is related to children's language skills and cortical thickness. An SES-diverse group of families with typically-developing, native English-speaking children (n = 55) in pre-Kindergarten and Kindergarten (ages 4 to 6 years) were recruited. SES was measured by a composite of parental education and income. Children completed standardized behavioral assessments of their verbal skills (vocabulary and grammar) and non-verbal cognitive abilities, as well as a high-resolution MRI scan. Families then completed two full days of real-world audio recordings from the child's perspective (via a child-worn audio recorder), from which three measures were estimated: the number of words spoken by an adult, the number of utterances by the child of interest, and the number of time-locked conversational turns between the child and an adult. As expected, SES was significantly correlated with children's language scores (r = 0.62) and both language exposure measures (adult words: r = 0.32, and conversational turns: r = 0.27) were also correlated with SES. However, whole brain correlations revealed significant associations between language exposure measures and cortical thickness throughout much of the temporal lobe, while SES alone was not significantly correlated with thickness of any regions. This suggests that language exposure is more strongly related to cortical structure than SES and may be the factor driving SES differences in language-related brain development. Furthermore, an interaction was found between SES and the correlation between the number of adult words and thickness of a posterior region of the left superior temporal sulcus ("Wernicke's area"). Lower-SES children displayed a strong positive relationship between the number of adult words and the thickness of Wernicke's area, whereas higher-SES children exhibited no significant relationship between adult words

and Wernicke's thickness. To our knowledge, this is the first evidence that directly relates measures of language exposure to measures of brain structure. Results indicate that that the amount of words children hear is related to the thickness of regions subserving speech and language processing, and that language experience is more strongly related to brain structure in low SES environments. This suggests that that children from lower SES families may be more sensitive to their proximal language exposure than their higher SES peers. This may be in part due to a lack of other environmental protective factors in lower SES families, such as access to libraries and high-quality preschool. This highlights the importance of family-based early interventions to bolster the language environments for lower SES children.

Language Genetics

E10 Becoming a balanced, proficient bilingual: Predictions from age of acquisition & genetic background

Kelly A. Vaughn[1], Arturo E. Hernandez[1]; [1]University of Houston

Genetic variants related to dopamine functioning (e.g., the ANKK1/TaqIa polymorphism within the DRD2 gene and the Val158Met polymorphism within the COMT gene) have previously been shown to predict cognitive flexibility and learning (e.g., Colzato et al., 2010; Stelzel et al., 2010). Additionally, researchers have found that these genetic variants may also predict second language learning (Mamiya et al., 2016), although this relationship may change across the lifespan (Sugiura et al., 2011). The current study examined the role of the ANKK1/TaqIa and Val158Met polymorphisms along with age of second language acquisition (AoA) in order to predict levels of bilingual proficiency in Spanish-English young adult bilinguals. The ANKK1/TaqIa polymorphism is located within the DRD2 gene, and codes for D2 dopamine receptors that are found subcortically. Individuals with the A1+ genotype (i.e. carrying at least one A1 allele) compared to individuals with the A1- genotype (i.e., carrying no A1 alleles) show a reduction in D2 receptors, which leads to increased subcortical dopamine (Laakso et al., 2005), and greater flexibility during cognitive tasks (Stelzel et al., 2010). The Val158Met polymorphism is located within the COMT gene, and is related to the breakdown of prefrontal dopamine. The polymorphism has three genotypes, Val/Val, Val/Met, and Met/Met. Each Met allele is related to increased prefrontal dopamine (Chen et al., 2004), and decreasing flexibility but increasing stability during cognitive task performance. Bilingual proficiency was calculated as the sum of proficiencies in English and Spanish based on the Woodcock-Muñoz Language Survey - Revised (Woodcock, Muñoz-Sandoval, Ruef, & Alvarado, 2005), multiplied by a number that represented the amount of balance between the two languages. This led to a measure of bilingual proficiency that gave a slight boost to individuals who are more balanced in their proficiency in English and Spanish. Data was analyzed using a multiple regression model that included the two genotypes and AoA and controlled for socioeconomic status. Results indicated a three-way interaction such that the relationship between the genetic variants and bilingual proficiency depended on AoA. At earlier AoAs, having the genetic variant associated with higher levels of subcortical dopamine (A1+) predicted the highest levels of bilingual proficiency. At later AoAs, individuals with the genetic variant associated with cortical dopamine levels that are balanced between stability and flexibility (Val/Met) predicted the highest levels of bilingual proficiency. These results fit with theories about the development of language as a subcortical process early in life and as a cortical process later in life (Chandrasekaran, Koslov, & Maddox, 2014; Hernandez & Li, 2007), as well as the importance of both stability and flexibility in bilingual language development (Green & Abutalebi, 2013). Finally, this study raises questions about the direction of causality between bilingualism and cognitive control, which is central to the debate over the "bilingual advantage." Most studies regarding a bilingual advantage in cognitive tasks suggest that bilingualism influences cognitive control outcomes. The results of the current study provide an alternative to this perspective, suggesting instead that genetic variants associated with dopamine and cognitive flexibility may influence language proficiency outcomes.

Perception: Orthographic and Other Visual Processes

E11 Orthographic processing and print tuning are atypical in adults with a history of institutionalization: an ERP study

Irina Ovchinnikova[1], Tatiana Logvinenko[1], Marina Zhukova[1], Sergey Kornilov[1,2,3,4], Elena Grigorenko[1,2,3,4,5]; [1]Saint-Petersburg State University, Saint-Petersburg, Russia, [2]University of Houston, Houston, TX, USA, [3]Baylor College of Medicine, Houston, TX, USA, [4]Haskins Laboratories, New Haven, CT, USA, [5]Yale University, New Haven, CT, USA

Suboptimal early caregiving environments are associated with negative developmental outcomes. Children left without parental care and placed in institutional settings (baby homes) represent a particularly vulnerable population. Although general cognitive deficits are well documented in this population (van Ijzendoorn et al., 2011), less is known about their language and literacy development (Eigsti et al., 2011; Helder et al., 2014). Moreover, there is currently a dearth of research on the long-term effects of institutionalization on cognitive and language development, as well as literacy. Motivated by these considerations and recent studies pointing to the pivotal role of input in shaping the developmental trajectories for a host of language- and reading-related traits, this study investigated, for the first time, neural indices of orthographic processing in a sample of

adolescents and young adults with and without history of early institutionalization. A total of 58 Russian-speaking individuals in the age range from 16 to 37 years (M = 22.16, SD = 5.86; 36 were men) participated in the study – 27 individuals raised in institutional settings (IC) and 31 individuals raised in biological families (BF). The groups did not differ on age, sex, and SES. The EEG data were collected as the participants were viewing orthographic strings and performing a lexical decision task. The findings reported here are based on the analysis of two experimental conditions: 1) real high-frequency CCVCC Russian nouns (RW) and 2) strings of false-font symbols (FF) of the same length and structure. Each condition included 40 trials. The EEG signal was recorded using the actiCHamp EEG amplifier with 64 active Ag/AgCl electrodes placed in a 10-20 montage cap. EOG was recorded using a bipolar montage. The signal was re-referenced online to common average, and standard pre-processing techniques were used. Data were averaged for correct trials only separately for the two conditions. Statistical analyses revealed that the amplitude of the left-lateralized parietal N170 component was more negative for RW compared to FF in both groups (p's < .05) in the 100-300ms after the visual presentation of the target – an effect consistent with prior literature. Crucially, the size of the N170 condition effect (FF – RW; indexing coarse print tuning) was significantly smaller in the IC group compared to the BF group (p < .05) in the 250-300ms time window. Importantly, the amplitude of the difference waveform in the left but not in the right parietal electrode cluster correlated significantly with participant's behavioral performance on a spelling task (Spearman's = .31 and = .23, p = .02 and .09, respectively). Our study found atypical patterns of brain activity in response to orthographic strings in young Russian-speaking adults with a history of institutionalization, potentially indexing reduced neural specialization (e.g., coarse print tuning) and lateralization of print processing. The results suggest that literacy development is affected by suboptimal early care environments, and that these effects have a neural basis detectable even in young adulthood. This research was supported by the Government of the Russian Federation (grant No 14.Z50.31.0027; E.L.G., Principal Investigator).

Methods

E12 Measuring an Individual's Semantic Storage Loss due to Temporal Lobe Damage

Carlos Roncero[1], Jim Nikelski[1], Stephan Probst[1], Alex Theil[1], Howard Chertkow[1]; [1]Lady Davis Institute, Jewish General Hospital

Objectives: Developing a simple means of semantic syndrome classification with anatomic validation is now clinically important given the correlation between Primary Progressive aphasia (PPA) subgroups and molecular pathology. Anomia is a cognitive sign in both Alzheimer Disease(AD) and Frontotemporal dementia (FTD). Past group comparisons (e.g., Lambon-Ralph & Jefferies, 2004) have suggested that anomia is often caused by either an underlying executive impairment that impedes retrieving the object name from memory (seen in frontal or parietal lesions due to cerebrovascular disease or the logopenic variant of Primary Progressive aphasia), or a loss of storage of the concept itself from semantic memory (more seen in the semantic variant of Primary Progressive aphasia, where damage localizes to temporal pole region). We wished to validate a simple approach to distinguishing these syndromes at the individual patient level. Methods: Following the literature, an approach to patient classification was developed focussing on three characteristics of the syndrome of semantic storage loss: 1) naming scores are unrelated to a subject's executive function, 2) subjects fail to retrieve object names even when cues are given, and 3) they fail to correctly recognize concepts even when executive requirements are lowered. Tests requiring thirty minutes total time were developed to operationalize these characteristics. Scores were combined to produce an omnibus semantic memory storage loss score for each participant, with a higher score indicating increasing evidence of semantic storage loss. Semantic storage loss stores were assessed with raters blind to clinical diagnosis or neuropsychology results. FDG-PET with regional semi-quantitative assessment of hypometabolism was carried out on all subjects. Extensive complementary neuropsychological evaluation was also carried out. Results: Twenty subjects with anomia (14 FTD patients and 6 AD patients with PPA logopenic variety) were tested. Xx Subjects scored over 26 (indicating evidence of semantic storage loss) while xx subjects scored below 15 (no semantic storage loss). Subsequent analyses found that these scores correlated strongly with: (a) presence of left and right anterior temporal lobe damage on FDG-PET; (b) whether anomia in a participant was demonstrably due to executive impairment or concept loss on extended neuropsychological testing. This correlation held both for the FTD and the AD subjects. Conclusion: It is possible to classify patients with anomia and predict FDG-PET localization at an individual level in terms of semantic syndromes, using a 30 minute omnibus semantic memory storage loss score. Underlying cause of the anomia and its localization may be important factors to consider in non-invasive neuromodulation therapy for anomia.

Language Disorders

E13 Characterizing connected speech in French-speaking Alzheimer's disease and semantic variant of primary progressive aphasia patients

Maxime Montembeault[1,2], Mariem Boukadi[1,2], Audrey Sheehan[1,2], Robert Jr Laforce[3,4], Maximiliano A. Wilson[3,5], Isabelle Rouleau[6], Simona M. Brambati[1,2]; [1]Centre de recherche de l'Institut universitaire de gériatrie de Montréal, [2]Université de Montréal, [3]Université Laval, [4]Centre de recherche du

Centre hospitalier universitaire de Québec, [5]Centre de recherche de l'Institut universitaire en santé mentale de Québec, [6]Université du Québec à Montréal

Introduction: Language assessment plays a critical role in the clinical characterization of several neurodegenerative diseases, such as Alzheimer's disease (AD) and semantic variant primary progressive aphasia (svPPA). While these patients have been well characterized with clinical tests of language functions featuring single-word measures (e.g., word naming), much less is known in these populations in terms of connected speech. This approach provides a very complete and ecological measure of language functioning. However, only one study has previously compared AD and svPPA patients, and no study has investigated connected speech in French-speaking svPPA patients. Therefore, the aim of this study is to characterize and compare connected speech production in French-speaking svPPA and AD patients on a wide range of linguistic variables. Methods: In this study, 13 AD patients, 9 svPPA patients and 12 cognitively unimpaired elderly adults (CTRL) performed a picture description task (picnic scene from the Western Aphasia Battery) in which they were asked to describe the visually presented scene using complete sentences. All participants were French-speaking. Speech samples were recorded during a face-to-face interview and then transcribed using a modified version of the Quantitative Production Analysis. Variables of interest within five main linguistic domains (phonological production, disruptions to fluency, semantic, lexical, and syntactic) were extracted for each subject. Kruskal-Wallis H tests followed by Dunn's post-hoc tests were used to investigate differences between groups. Results: In comparison to CTRL, AD patients presented significant impairments in fluency (higher number of pauses and false starts) and in semantic (higher number of semantic paraphasias and lower efficiency) domains. In comparison to CTRL, svPPA patients also presented significant impairments in fluency and semantic domains, but on a higher number of variables (fluency domain: higher number of pauses, abandoned sentences, and comments on word-finding difficulties; semantic domain: higher number of semantic paraphasias, lower efficiency, and number of semantic units). Additionally, they presented important lexical impairments (lower narrative-to-total-words and nouns-to-verbs ratios, higher pronouns-to-narrative-words ratio), and, to a lesser extent, syntactic impairments (lower mean utterance length). Finally, two indices were significantly different between the two patients' groups: svPPA patients presented a lower number of semantic units and a higher number of circumlocutions in comparison to AD patients. Discussion: Our results suggest that connected speech impairments in French-speaking patients are overall consistent with the ones identified in English-speaking patients. svPPA patients appear to present difficulties on a higher number of fluency, semantic and lexical variables than AD patients, and their deficits appear consistent with their semantic breakdown. In line with previous reports, syntactic impairments in svPPA patients were restricted to a single measure of syntactic complexity. On the other hand, AD patients presented significant fluency and semantic impairments, which have also been found in past studies. Lexical impairments, which were previously reported, were not significant in the present study, even though a trend was observed in that direction. In conclusion, this study highlights the richness of the information provided by connected speech assessment and the usefulness of such tools in supporting the diagnosis of French-speaking patients with neurodegenerative diseases.

E14 Brain bases of acquired reading impairments in stroke

William Graves[1], Olga Boukrina[2], A. M. Barrett[2]; [1]Rutgers University - Newark, [2]Kessler Foundation

The ability to read is an essential part of today's society and its disruption, for example, as a result of stroke, represents a significant handicap. While much work has been devoted to studying the cognitive components of typical reading and their neuroimaging correlates, little is known about the brain lesion - reading deficit associations after stroke. In this study, we sought to identify what brain areas are necessary for supporting the cognitive components of reading: orthography (visual word form), phonology (auditory word form) and semantics (word meaning), by examining the patterns of reading deficits in a cohort of left stroke survivors. We studied 23 patients (Age = 62 y., SD = 11 y.; 13 females) undergoing rehabilitation. All but one were within the first 5 weeks post-stroke, a period likely to reveal reading deficits. Patients completed computerized touch-screen tests of semantics, phonology, and orthography. In the semantic task, patients matched one of two words (or pictures) to a target based on meaning similarity. In the phonology task, the match among pseudoword stimuli was based on rhyming. In the orthography task, patients selected the most word-like string, where strings either matched or mismatched English orthographic properties. We used a subtraction analysis to identify lesion locations in patients who performed below chance on these tasks as compared to patients scoring above chance. This analysis revealed lesions in supramarginal gyrus, Heschl's gyrus, and the superior longitudinal fasciculus, associated with phonological deficits. A voxel-based lesion-symptom mapping analysis, considering continuous scores along all 3 reading components, supported this result. It additionally revealed correlates of orthographic function in the precentral gyrus, insula, thalamus, and the inferior fronto-occipital fasciculus; and semantic function in the hippocampus, caudate, and adjacent white matter. Our results support the notion that the same neural structures underlie phonology in speech and print, and implicate frontal and subcortical regions in orthographic processing.

E15 Effect of rTMS on Brain Activation and Naming Performance in Chronic Aphasia: Results from a Pilot Participant

Michelle Gravier[1], Steven Forman[1,2], Michael Dickey[1,2], William Hula[1,2], Patrick Doyle[1,2]; [1]VA Pittsburgh Healthcare System, [2]University of Pittsburgh

INTRODUCTION Repetitive transcranial magnetic stimulation (rTMS) is a non-invasive brain stimulation technique that can focally modulate activity in targeted brain regions. Multiple sessions of 1Hz inhibitory rTMS targeting right hemisphere Pars Triangularis (RH PTr) in people with chronic aphasia can result in improved naming abilities (e.g. Naeser et al., 2005). These improvements accrue over time, and may persist even after rTMS has ended (Barwood et al., 2012). It has been proposed that rTMS induces this improvement by reducing compensatory activity in the RH PTr, allowing for recruitment of more efficient left hemisphere (LH) brain areas (Heiss & Thiel, 2006; Hamilton et al., 2011). However, existing neuroimaging evidence has not definitively established this hypothesized link between reduced RH PTr activation and improved naming. The goal of this study was therefore to investigate the neurological mechanisms underlying the effect of rTMS on naming performance in one individual with chronic aphasia. METHOD The participant was a 44 year-old male, 14 years post stroke onset with moderate to severe non-fluent aphasia and marked word-finding difficulties. MRI: The participant underwent functional magnetic resonance (fMRI) scans at three time points: prior to receiving rTMS ("baseline"), immediately following the first rTMS session ("post-rTMS"), and following conclusion of the rTMS series ("post-treatment"). Scans were acquired using a 3.0 Tesla Siemens scanner. The participant was asked to name black-and-white picture stimuli (Snodgrass and Vanderwort, 1980) as quickly and accurately as possible while in the scanner. An individualized map of brain activity was generated for the contrast of naming > baseline (crosshair fixation) for each scan. Activation maps for all contrasts were thresholded voxel-wise at p=0.05 (cluster-corrected using Family-Wise Error). All processing was performed using SPM12. rTMS: The subject received 1200 pulses (20 minutes) of 1Hz rTMS at 90% of motor threshold to RH PTr in 10 daily sessions, over two weeks. Naming: The participant's naming performance was assessed with the Philadelphia Naming Test (Roach et al., 1996) prior to the TMS sessions and again one week after the final TMS session RESULTS From pre-rTMS to post-rTMS, the participant demonstrated significant naming improvements ($p<0.05$) on the Philadelphia Naming Test (PNT). This improvement was accompanied by a decrease in naming-related (picture>crosshair) activation in the targeted brain region (RH PTr) from baseline to post-rTMS (immediately following the first rTMS session). This change in RH PTr activation was maintained at the post-treatment time point. However, functional activation did not shift towards perilesional LH, but instead increased in RH temporal regions. DISCUSSION The finding that the rTMS-induced naming improvement was associated with a decrease in RH PTr activation is consistent with the hypothesized mechanism behind TMS effects in chronic aphasia (Heiss & Thiel, 2006). However, the observed inter-hemispheric RH activation shift stands in contrast to previous findings (Martin & Naeser, 2009). The significant size of this participant's LH lesion (extending to much/all of the LH) may have precluded LH recruitment. These preliminary results thus leave open the question of whether rTMS would have been more beneficial for participants with more intact LH cortex.

E16 The dyslexic brain before and after literacy - unifying structural signs

Ulrike Kuhl[1], Angela D. Friederici[1], Michael A. Skeide[1]; [1]Max Planck Institute for Human Cognitive and Brain Sciences

Longitudinal studies following children from a preliterate age on are the gold standard for disentangling potential causes from consequences of dyslexia (Goswami, 2015). Here we overcome power limitations of recent pioneering work (Clark et al., 2014) by examining one of the largest longitudinal samples ever studied (N=16 children developing dyslexia, N=16 matched controls). Moreover, we extend the scope from cortical thickness to multimodal measures of cortical surface anatomy, including folding, gyrification and sulcus depth. Crucially, we unify these indices in a single multivariate model using an innovative random-forest classification method (Breiman, 2001). Our results reveal a co-occurrence of transient effects only present at a kindergarten age and continuous effects persisting into second grade. While transient differences (maximum accuracy: 85%) were observed in the left occipito-temporal cortex close to the "visual word form area" (Skeide et al., 2016), persisting differences were observed in phonological processing areas (superior temporal sulcus) (maximum accuracy: 82.5%) (van Attefeldt et al., 2004) and semantic processing areas (angular gyrus) (maximum accuracy: 90%) (Carreiras et al., 2009). This is in line with large-scale behavioral studies identifying phonological awareness (Ziegler et al., 2010) and rapid automatized naming (Moll et al., 2014) as most reliable predictors of literacy skills. These findings illuminate the developmental dynamics that ultimately lead to the most common learning disorder. References: Breiman, L. (2001). Random forests. Machine learning, 45(1), 5-32. Carreiras, M., Seghier, M. L., Baquero, S., Estévez, A., Lozano, A., Devlin, J. T., & Price, C. J. (2009). An anatomical signature for literacy. Nature, 461(7266), 983-986. Clark, K. A., Helland, T., Specht, K., Narr, K. L., Manis, F. R., Toga, A. W., & Hugdahl, K. (2014). Neuroanatomical precursors of dyslexia identified from pre-reading through to age 11. Brain, 137(12), 3136-3141. Goswami, U. (2015). Sensory theories of developmental dyslexia: three challenges for research. Nature Reviews Neuroscience, 16(1), 43-54. Kraft, I., Cafiero, R., Schaadt, G., Brauer, J., Neef, N. E., Müller, B., ... & Skeide, M. A. (2015). Cortical differences in preliterate children at familiar risk of

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E18 Agrammatic performance in aphasia: A ventral-stream problem?

Dirk-Bart Den Ouden[1], Alexandra Basilakos[1], Leo Bonilha[2], Ezequiel Gleichgerrcht[2], Svetlana Malyutina[3], Chris Rorden[1], Julius Fridriksson[1]; [1]University of South Carolina, [2]Medical University of South Carolina, [3]National Research University Higher School of Economics, Moscow

Introduction: Agrammatism in aphasia is not a homogeneous syndrome, but rather a characterization of a non-uniform set of language production and comprehension behaviors in which grammatical markers and complex syntactic structures are omitted, simplified or misinterpreted. Likely for this reason, a neural predictor of agrammatism has been elusive, with different neurolinguistic models of syntactic processing predicting damage to inferior frontal cortex, anterior temporal cortex, or posterior superior temporal cortex to result in agrammatic performance. Two recent dual-stream models of language processing emphasize a dorsal pathway between inferior frontal gyrus and posterior superior temporal gyrus or sulcus (pSTG) to support the assignment of grammatical relations or syntactic structuring (Friederici, 2012; Bornkessel-Schlesewsky & Schlesewsky, 2013). Following these models, damage along this pathway and/or its end nodes should result in agrammatism. We performed multimodal lesion-symptom mapping (LSM) to investigate the association between agrammatic performance, as reflected in a variety of syntax-related variables, and structural regional and connectivity damage after stroke. Methods: 75 Stroke survivors participated in this study (all > 6 months post-stroke; mean age 59.5, sd 10.1; 25 females). 53 Participants had aphasia (mean WAB AQ 67.0, sd 21.1), of whom 13 were classified as agrammatic, based on picture-description data, with a focus on omission of grammatical morphemes. Participants performed subtasks of the Northwestern Assessment of Verbs and Sentences to assess production of verb argument structure patterns and different cued sentence types, as well as comprehension of different sentence types. All underwent neuroimaging (Siemens 3T MRI), collecting T1, T2 and Diffusion Tensor Weighted images. Lesions were manually drawn based on visual examination of structural images. After regressing out lesion sizes from the behavioral data, voxel- and connectome-based LSM was performed using linear regression analysis with permutation thresholding and a one-tailed alpha level of .05. Results: After regressing out lesion size, no individual (sub)cortical region was predictive of 'agrammatism' as a binary category. Impaired performance on verb argument structure production was predicted by damage to pSTG, as well as to a small section of white matter underlying middle superior temporal gyrus, inferior to the Sylvian fissure and typically part of a ventral pathway between temporal and inferior frontal cortex. Damage to this region was also predictive of impaired sentence production and comprehension, as well as of relatively greater impairment on noncanonical than canonical sentence structures in cued production, which was also predicted by pSTG lesions. Whole-brain connectome effects did not survive the regressing out of lesion size, but we are following up with analyses of specific connections of interest. Conclusion: Results confirm that no single lesion pattern is predictive of the clinical impression of 'agrammatism' as a syndrome. However, specific tasks that require different levels and types of syntactic processing do rely on certain regions to be intact, most notably pSTG and parts of a ventral pathway between posterior temporal and inferior frontal cortex. Interestingly, this ventral pathway is not typically considered to support syntactic processing critically, so these clinical data shed new light on the neural architecture underlying syntactic processing.

E19 Patterns of grey matter changes in the acute phase of post-stroke aphasia

Mariem Boukadi[1,2], Karine Marcotte[3,4], Maxime Montembeault[1,2], Alex Desautels[4], Simona Brambati[1,2]; [1]Department of Psychology, Université de Montréal, [2]Centre de recherche de l'Institut universitaire de gériatrie de Montréal (CRIUGM), [3]École d'orthophonie et d'audiologie, Université de Montréal, [4]Centre de recherche de l'Hôpital du Sacré-Cœur de Montréal

Introduction: In the wake of a stroke, dynamic changes can take place in the brain beyond the primary lesion site and may contribute to the patterns of impairment or recovery of language in post-stroke aphasia (PSA). While there is extensive evidence of the functional reorganization of the language network in PSA, little is known about potential structural changes. Previous studies have found grey matter (GM) volume increases as well as decreases in regions remote from the primary lesion site in chronic stroke patients. These distant cortical effects have been attributed to secondary degeneration and reorganization, respectively. However, little is known about how early these changes can be observed post-stroke. The aim of this study was to determine whether remote GM changes are found in the acute phase (i.e., ≤ 3 days) of PSA. Methods:

Data were obtained from 18 right-handed cognitively unimpaired controls (CTRL) and 9 PSA patients having suffered a first ischemic stroke in the left middle cerebral artery territory. The two groups were matched on age, sex, and education. All participants underwent a magnetic resonance imaging protocol including a T1 brain image using a 3T Skyra scanner. PSA patients were scanned within 3 days following the stroke. Using voxel-based morphometry on SPM12, we investigated differences in GM volume profiles between our two groups. Images were pre-processed using the automatic lesion identification (ALI) toolbox in order to delineate the lesion and ensure proper classification of brain tissues. Independent-sample t-tests were then performed to compare whole-brain GM volume in CTRLs vs. PSAs. Results: Compared to CTRLs, PSAs showed decreased GM volume in the right anterior cingulate cortex (ACC) and the left thalamus ($p \leq .05$, FWE corrected for cluster size). Interestingly, PSAs also showed a trend towards increased GM volume as compared to CTRLs in the middle temporal gyrus (MTG) in the contralesional (i.e. right) hemisphere ($p < .005$, uncorrected). Conclusion: Our findings suggest that remote GM atrophy is present in the acute phase post-stroke in language-related regions among PSA patients. Both the thalamus and the ACC have been acknowledged to play an important role in language processing. The GM volume reduction of the thalamus could be due to the degeneration of the thalamocortical radiations. This could in turn explain the right ACC atrophy, given that thalamic nuclei project white matter fibers to this region. Our results also revealed that the right MTG, the contralesional homologue to a damaged language region, shows GM hypertrophy. This finding is consistent with two studies that found significantly increased GM volume in the exact same region in chronic PSA patients. It is also in line with functional neuroimaging studies that suggest a compensatory role for the right hemisphere in PSA. In conclusion, this study provides important insights into the structural reorganization of the language network in the acute phase post-stroke. Longitudinal studies are necessary to better explain these patterns of GM volume reduction and augmentation in relation to degenerative and compensatory mechanisms.

E20 Functional subspecialization of Broca's area in the controlled selection of verbal and nonverbal representations and fluent sentence production.

Denise Y. Harvey[1,2], Myrna F. Schwartz[1]; [1]Moss Rehabilitation Research Institute, [2]University of Pennsylvania

The left inferior frontal gyrus (LIFG) has long been implicated in language production, as stroke-related damage to this region often results in an inability to fluently produce sentences, called "Broca's aphasia". However, the LIFG has also been shown to play a more general role in controlling the selection of mental representations from among competing alternatives. This suggests that faulty cognitive control underlies impairments in fluent sentence production. Indeed, individuals with Broca's aphasia, as compared to those with fluent forms of aphasia (hereafter, "NonBroca's"), perform poorly on tasks that require controlled selection of verbal representations (Schnur et al., 2006). Whether nonverbal representations are similarly affected remains unclear. Thus, the goal of the current study was twofold: (1) to establish the scope of controlled selection impairments in post-stroke aphasia; and (2) assess whether impaired selection is associated with LIFG damage and/or the ability to fluently produce sentences. We collected behavioral and structural neuroimaging data from 18 chronic aphasic speakers. Nine participants presented with Broca's aphasia, and were contrasted with a group of nine NonBroca's participants closely matched for performance on measures of verbal and nonverbal processing that minimize control demands. To assess controlled selection abilities, participants named pictures (verbal) and matched associatively related pictures (nonverbal) in blocks of trials depicting objects from the same-semantic category (i.e., high selection demand) versus different categories (i.e., low selection demand). Fluency was assessed using two measures from the Quantitative Production Analysis of narrative speech: proportion of closed-class words and proportion of words in a sentence (relative to all words). We quantified percent damage to the LIFG based on lesion overlap in Brodmann area (BA) 44 and 45. Correlational analyses controlled for the contribution of total lesion volume. Participants were slower to respond in the related compared to the unrelated blocks in both tasks ($p < .0001$). However, the magnitude of this effect did not differ based on aphasia classification (Broca's versus NonBroca's participants; $p = .85$). Individual estimates of controlled selection ability were correlated with percent damage to a posterior region within the LIFG (BA 44) ($r = .49$, $p < .05$). However, controlled selection abilities were not correlated with measures of fluent sentence production ($r's < .2$, $p's > .46$). Instead, fluent sentence production was correlated with percent damage to a more anterior LIFG region (BA 45) ($r's > -.49$, $p's < .05$). The findings from this research indicate that the LIFG is involved in both controlled selection over competing mental representations (whether verbal or nonverbal) and fluent sentence production. However, the results suggest a functional subdivision between different regions that comprise of the LIFG: a posterior region involved in controlled selection (BA 44) and an anterior region involved in fluent sentence production (BA 45). Thus, the presumed relationship between LIFG-mediated controlled selection impairments and nonfluent aphasia may instead reflect the co-occurrence of damage to adjacent regions (as constrained by the vascular architecture). Taken together, this research sheds light on how LIFG damage may differentially contribute to language impairments in aphasia.

E21 Lower axon density in residual temporal white matter is related to semantic paraphasia prevalence

Emilie McKinnon[1], Jens Jensen[1], Julius Fridriksson[2], Chris Rorden[2], Joseph Helpern[1], Leonardo Bonilha[1]; [1]Medical University of South Carolina, [2]University of South Carolina

Introduction: It is well-recognized that secondary white matter (WM) loss occurs after ischemic strokes, but the importance of residual WM integrity in shaping post-stroke language deficits (aphasia) is not completely defined. While most lesion-based neuropsychological studies use the post-stroke lesion to define the relationship between structural brain integrity and aphasia severity, diffusion MRI (dMRI) can be used to quantify the degree of WM compromise beyond the necrotic stroke lesion and inform on the impact caused by loss of WM. Biophysical modelling provides biological interpretations of dMRI, permitting the assessment of the microstructural properties that are mostly affected by the stroke, and the ones with the highest clinical significance. In this study, we investigated the relationship between damage to WM networks beyond the stroke lesion and semantically related errors during a confrontation naming in individuals with aphasia. We used diffusional kurtosis imaging (DKI) to model WM axonal water fraction (AWF) (Fieremans, 2011) and assess the integrity of WM axons in contrast with the extracellular space. We hypothesized that axonal loss, identified as AWF decrement, in the residual temporal lobe would be a strong determinant of semantic processing deficits and linearly related to semantic paraphasias. Methods: Twenty-four subjects (age=57±11y; 75%male; MRI time post-stroke=28±32m; WAB-AQ=53±23; semantic paraphasias=15±11%) with chronic (> 6 months) post-stroke aphasia underwent the Philadelphia Naming Test (PNT) and MRI imaging. Structural images (T1 and T2) and DKI (b=0, 1000, 2000 s/mm2, 64 directions) were acquired. Diffusional Kurtosis Estimator (Tabesh, 2011) was used to estimate diffusion and kurtosis tensors, from which AWF was calculated. A probabilistic WM mask was created using the clinical toolbox in SPM12. The WM mask and the JHU WM atlas were warped into native diffusion space using the nonlinear deformation field calculated by the clinical toolbox. The following regions of interest (ROI) were defined for both ipsilateral and contralateral sides: whole-hemisphere WM, temporal lobe WM (defined by the inferior longitudinal fasciculus) and parietal lobe WM (defined by the superior longitudinal fasciculus). All ROIs excluded the WM that was part of the stroke lesion. Correlation coefficients were performed to evaluate the relationship between the number of semantic paraphasias and AWF, controlling for the total lesion size. Results: Average AWF was significantly lower in the left-hemisphere, the left temporal and the left parietal lobes ($p<0.001$) compared with their right homologues. A decrease in AWF in the left compared to the right temporal (but not in the whole-hemisphere, and not in the parietal lobe) was associated with an increase in semantic paraphasias ($r=0.53$, $p=0.009$, controlling for lesion size). Conclusion: Our results suggest that widespread axonal loss occurs in the left hemisphere after a stroke. Importantly, axonal loss within the left temporal lobe is directly associated with semantic processing problems and this relationship is independent from lesion size, indicating that residual WM integrity plays an important role in post-stroke language deficits.

E22 An adaptive semantic matching paradigm for reliable and valid language mapping in individuals with aphasia

Melodie Yen[1], Dana K. Eriksson[2], Andrew T. DeMarco[3], Stephen M. Wilson[1]; [1]Vanderbilt University Medical Center, [2]University of Arizona, [3]Georgetown University

Recovery from aphasia depends on neural plasticity, that is, functional reorganization of surviving brain regions such that they take on new or expanded roles in language processing. A significant roadblock to understanding this process is that it is challenging to identify language regions in individuals with aphasia. Tasks commonly used to engage language processing, such as narrative comprehension and picture naming, are limited in terms of reliability (test-retest reproducibility) and validity (identification of language regions, and not other regions). On the other hand, paradigms that are effective in identifying language regions in people without aphasia (for instance, semantic decision tasks in presurgical patients) are often too challenging for people with aphasia. We designed an adaptive semantic matching task whereby each individual is presented with dynamically selected stimuli that are challenging yet within their competence, so that language processing can be fully engaged in people with and without language disorders. In this study, we evaluated the feasibility, reliability and validity of this adaptive semantic matching paradigm. Experiment 1: Sixteen individuals with chronic aphasia each performed the semantic task, a narrative comprehension task, and a picture naming task, on two separate occasions. We found that all patients succeeded in learning and performing the semantic task. Left-lateralized frontal and temporal regions were robustly activated, except when these regions were lesioned. The consistency of activation patterns across the two sessions were compared in terms of Dice coefficients of similarity. The semantic paradigm resulted in more reproducible patterns of activation (Dice coefficient = 0.59 ± 0.15) than the narrative (0.38 ± 0.15) or picture naming (0.32 ± 0.20) paradigms (both $p < 0.0001$). Experiment 2: To assess validity (defined as ability to demonstrate left-lateralized language networks in neurologically normal individuals), thirteen healthy controls performed the same three tasks. We found that the adaptive semantic matching paradigm produced much more left-lateralized activation patterns (Lateralization index = 0.75 ± 0.19) than the narrative (0.32 ± 0.36) or picture naming (0.05 ± 0.20) paradigms (both $p < 0.0001$). Experiment 3: To

determine whether different kinds of linguistic processing would highlight different parts of the language network, we developed two adaptive phonological matching tasks (syllable count matching and rhyme judgment) with the same structure as the semantic paradigm. Seven healthy controls performed the semantic task and the two phonological tasks. Core language regions in the left inferior frontal gyrus and left posterior superior temporal sulcus were activated in common by all three tasks. However, there were significant differences between the semantic and phonological tasks, with the semantic task differentially recruiting a broad range of additional left temporal regions ($p < 0.05$, corrected), while the phonological tasks differentially recruited the left ventral precentral sulcus and supramarginal gyrus ($p < 0.05$, corrected). Activations for the phonological tasks were not as robust as for the semantic task in individual participants. In sum, the adaptive semantic matching task makes it possible to identify language regions in individuals with aphasia, and will be useful in future studies of neural plasticity in recovery from aphasia.

Language Therapy

E23 Interventions for Primary Progressive Aphasia: A scoping review

Yara Inuy[1], Vânia de Aguiar[1]; [1]Department of clinical Speech and Language Studies, Trinity College Dublin, Dublin, Ireland

BACKGROUND: Primary progressive aphasia (PPA) is a neurodegenerative disorder characterised by a progressive deterioration of language skills. It affects the ability to communicate, as well as quality of life. Several studies have tested a variety of language interventions for PPA, reporting beneficial gains following the therapy. However, no evidence-based clinical recommendations have been put forward to date. The paucity in the literature poses a challenge for clinical practice, as it leads to scarce understanding of the neuroplastic potential of individuals with PPA, and limited knowledge regarding the cognitive mechanisms of improvement, which could be used to optimise treatments. As a consequence, there can be negative assumptions as to whether language rehabilitation for PPA is worthwhile. This study provides a comprehensive detail of the available literature on language rehabilitation in PPA, characterising goals and procedures of interventions and examining the scope of interventions in relation to models of healthcare provision. METHOD: A scoping review was conducted, which adopted both qualitative and quantitative methods. Through literature search and following exclusion criteria, 33 eligible language intervention studies were identified. Treatment characteristics were coded using the TIDiER checklist (Hoffman et al., 2014). A thematic content analysis was undertaken to map the characteristics of interventions regarding therapy goals and procedures. Secondly, a quantitative content analysis was used to study whether there was an unbalance in the number of impairment-oriented intervention studies when compared to function-oriented studies. Finally, clinical guidelines summarising research findings and rating the level of recommendation for each treatment approach were elaborated, using the SORT taxonomy (Ebell et al., 2004). RESULTS: The majority of the articles included in the dataset were single case studies. Furthermore, a statistically significant predominance of studies focusing on impairment-oriented interventions over function-directed was demonstrated. The intervention studies primarily focused on improving word retrieval for nouns, although a few studies had other intervention goals. In terms of procedures, the majority of the research activity on interventions for PPA shares similarities with the studies on treatments for aphasia following stroke. Behavioural tasks focus mostly on lexical-semantic naming therapy, word-picture matching, and less often, sentence and discourse level tasks as well as tasks involving written output. Pharmacological and neuromodulatory techniques have been trialled in recent research, as treatment adjuvants. All studies reported significant treatment effects. Despite the variety of treatment approaches studied, there few studies for each treatment procedure, and the level of evidence is weak for most procedures investigated. DISCUSSION AND CONCLUSION: A wide variety of goals and procedures is reported in intervention studies for PPA, showing positive treatment effects for the individuals treated in those studies. However, for each approach the evidence is limited, with lack of replication of treatment findings, and the evidence base consisting mostly of single-case studies, single-case series, or studies with small cohorts. Hence, the evidence of effectiveness for treatments is weak. In addition, the small number of function-oriented studies indicates that the functional outcomes of these interventions are not well understood.

Speech Motor Control and Sensorimotor Integration

E24 Decoding the cortical sensitivity of spoken acoustic variability in persons with aphasia

Caroline Niziolek[1], Sara Beach[2], Swathi Kiran[1]; [1]Boston University, [2]Harvard Medical School

Although aphasia is primarily considered a disorder of language, higher-level linguistic deficits are often accompanied by lower-level deficits in auditory perception, feedback processing, and the stable production of consonants and vowels. This project investigates the functional source of low-level speech production deficits in aphasia by assessing the extent to which persons with aphasia (PWA) are sensitive to deviations in their own speech feedback. We consider two measures of feedback sensitivity: detection, the cortical sensitivity to acoustic deviations in one's own speech, and correction, the extent to which these deviations are behaviorally corrected online. Ten PWA and ten age-matched controls took part in a

magnetoencephalography (MEG) study. PWA were 51-59 years of age (mean=54.9; SD=3.0), had chronic aphasia (months post-stroke: mean=83.9; SD=45.7), and were assessed using the Western Aphasia Battery (WAB-R) and Psycholinguistic Assessments of Language Processing in Aphasia (PALPA). Participants produced 200 repetitions of three monosyllabic words ("eat", "Ed", "add") while neural activity was recorded from 306 channels (Elekta Neuromag Triux). This "speak" condition was interleaved with a "listen" condition in which recorded audio from the speak trials was played back to participants through earphones. To assess detection ability, we compared the auditory M100 response between the listen and speak conditions, using the difference between the two, or speaking-induced suppression, as an index of how well the feedback matched the intended sound. Feedback sensitivity was defined as a reduction in suppression for deviations from typical vowel acoustics, and was measured separately for left and right auditory cortex. To further probe feedback sensitivity, we trained a machine learning classifier (Meyers, 2013) to distinguish both coarse (word identity) and fine-grained (acoustic prototypicality) phonemic information in the whole-brain MEG signal and tested it on held-out portions of the data. To assess correction ability, formants for each vowel were calculated in two time windows, the onset and midpoint of the syllable. Vowel centering was defined as formant movement toward the median over the time course of the syllable, lessening acoustic deviation. Evidence for detection of self-produced acoustic deviations was found in both controls and PWA. In controls, speaking-induced suppression was consistently modulated by acoustic deviation only in the left hemisphere; that is, only left auditory activity was relatively greater during the production of more deviant utterances. In contrast, PWA showed only weak activation of left auditory regions, but speaking-induced suppression in the right hemisphere was modulated by acoustic deviation. Further, both word identity and acoustic prototypicality can be read out from the neural data of PWA and controls passively listening to their own speech. Behavioral correction was also largely intact: PWA had greater acoustic variability than controls at vowel onset, but both groups exhibited vowel centering, significantly decreasing variability over the course of the syllable. The hemispheric shift of modulatory responses in PWA is suggestive of plasticity in the neural mechanisms that underlie this sensitivity, and may also enable the neural decoding accuracy and intact behavioral correction seen in PWA. These analyses inform theories of error detection and correction in aphasia.

Meaning: Combinatorial Semantics

E25 Reconfiguration of the semantic and default mode networks induced by variations of semantic context during comprehension of written narratives *Francesca Martina Branzi[1], Gina F. Humphreys[1], Paul Hoffman[2], Matthew A. Lambon Ralph[1]; [1]University of Manchester, [2]University of Edinburgh*

In everyday settings, such as watching a movie or listening to a talk, it is necessary to accumulate and integrate information over time. Importantly, despite integration processes requiring reconfiguration of semantic context to encode information about the changing environment, the neural foundations of this phenomenon are still largely uncharacterised. In this functional magnetic resonance imaging (fMRI) study, we investigated whether and how areas of the semantic control network (SCN) and the default mode network (DMN) reconfigure when participants are processing variations of semantic context during comprehension of written narratives. Twenty-two healthy volunteers were asked to read short narratives divided in two paragraphs. For each narrative, the same second paragraph (target) was preceded by different first paragraphs (prime) that could be either high-congruent or low-congruent with the target in terms of meaning. Both high- and low-congruent primes could be integrated with the target and allow a coherent narrative representation to emerge, though a greater reworking of the evolving semantic context was required after low-congruent primes. Therefore, by comparing brain responses for the same target preceded by low- vs. high-congruent primes, we measured integration processes triggered by variations of semantic context. In order to tease apart domain-general and semantic-specific control processes recruited when shifting between different mental representations, we also measured brain responses for the same target preceded by a different cognitive context/task (i.e., string of numbers that participants had to read silently). We hypothesized that changes of semantic context would induce increased demands on controlled semantic integration processes within the SCN. In accord with this prediction, we found that when the semantic context changed (low-congruent condition) reading times were slower than in high-congruent conditions and SCN areas (e.g., inferior frontal gyrus, posterior middle temporal gyrus) were extensively recruited. When the task context changed (control condition) reading times were similar to those of low-congruent conditions, but brain activations revealed a reduced involvement of SCN areas and an increased involvement of some areas of the saliency network. We also tested one hypothesis that some parts of the DMN (e.g., the posterior angular gyrus, see Andrews-Hanna et al., 2010) would be recruited as a function of the degree of change of the cognitive context/task (see Crittenden et al., 2015). If correct, we expected to observe maximal recruitment of these areas in the control condition (change from the number task to the semantic task) as compared to low- and high-congruent conditions (no variation of task context). However, we found an opposite pattern of results, suggesting that rather than being sensitive to control demands, these areas support semantic context

integration processes. In summary, these results reveal that some areas of the DMN and SCN support integration processes induced by variations of semantic context that allow complex semantic representations to emerge.

E26 The Processing of Conceptual Shifts: an ERP Study

Natalia Bekemeier[1], Dorothea Brenner[1], Katja Biermann-Ruben[1], Peter Indefrey[1,2]; [1]Heinrich-Heine-University Düsseldorf, Germany, [2]Donders Institute for Brain, Cognition and Behaviour, Centre for Cognitive Neuroimaging, The Netherlands

The theory of concept types and determination (Löbner, 2011) differentiates between four concept types – sortal (a stone), individual (the sun), relational (his ear), and functional (his father) – and posits that these require a certain inherent determiner type. If a given concept is combined with an incongruent determiner, it is shifted to the respective type: a stone (sortal) – his stone (relational). In a series of auditory behavioural studies, Brenner (2015) provided evidence for an overall concept type (CT) congruence effect, with congruent determiners triggering faster lexical decision times (RT) on the subsequent noun than incongruent ones. This facilitating effect was considered to reflect early post-lexical build-up of noun phrases. The objective of the present ERP study was to establish neural correlates of concept type shifts, i.e. to find out whether the determiner congruence effect could be indexed by such classical ERP components as N400, LAN or P600. We argued that if congruent or incongruent determination affects the lexical retrieval of the noun, it should be reflected in the amplitude of the N400 component. If, however, concept type shifts are supported by the same neuronal mechanisms that underlie (morpho-) syntactic processing, incongruent determination should trigger LAN or/and P600. To test our hypothesis, we compared the processing of nouns of four concept types in congruent (C) and incongruent (I) determiner phrases with the processing of nouns in nominal phrases with matching, semantically mismatching and gender mismatching adjectives. The incongruent condition was built in such a way that the determiner, though grammatically correct, was only likely within a certain context: sortal (C/ I) – ein Stein/ der Stein (a stone/ the stone), individual (C/ I) – der Papst /sein Papst (the pope/ his pope), relational (C/ I) – sein Ohr/ das Ohr (his ear/ the ear), functional (C/ I) – seine Mutter/ eine Mutter (his mother/ a mother). The violation conditions in the nominal phrases were less subtle: control – genaues Datum (exact date), semantic mismatch – schlichtes Datum (simple/plain date), gender mismatch – genauer Datum (exact (m.) date (n.)). The results of the study revealed an N400 effect elicited by the semantically mismatching adjectives at around 300 msec post uniqueness point of the noun. The gender violation condition triggered a biphasic LAN-P600 effect. The concept type shifts failed to elicit a significant semantic or syntactic violation effect. Although behavioural studies demonstrated a facilitation effect of congruent determiner type on the speed of word recognition, we could not establish a neural correlate of this effect. The reason could be two-fold: first, the conceptual shift might be too subtle to be traced by the electrophysiological techniques; and second, considering the overall grammaticality of the conceptual shift, the present paradigm – presentation of individual phrases – might not be suitable for the investigation of determiner congruence.

E27 Making sense of real-time access to knowledge during sentence processing: What you know, what you don't know, and what you don't know you know

Melissa Troyer[1], Marta Kutas[1]; [1]University of California, San Diego

A fundamental part of understanding language involves dynamically connecting linguistic input (e.g., words) with neural knowledge representations. A well-known event-related brain potential—the N400—provides a window into the neurocognitive access to meaning via verbal input. N400 amplitude is sensitive to semantic relationships between an incoming word and the ongoing context, with decreased N400s reflecting greater ease of semantic access. For example, a word's predictability, operationalized as its offline cloze probability (i.e., the proportion of people who produce a specific word given a context), is strongly correlated with that word's mean N400 amplitude. Typically, researchers correlate mean cloze probabilities (from one group of participants) with mean ERP measures (in a separate group). The precise nature of the relationship between offline cloze probability and online predictability, especially within a given individual, however, remains an open question: does N400 amplitude index (1) all-or-nothing (pre-)activation of a word in context, or as some have suggested (2) graded/partial (pre-)activation of a word in context as a function of an individual's linguistic and world knowledge, among other factors? Because it is infeasible to estimate the entirety of someone's world knowledge in a typical laboratory experiment, we used the narrative world of Harry Potter. Undergraduate students more or less knowledgeable about Harry Potter read sentence pairs about the Harry Potter domain while we recorded EEG/ERPs. The final word of each pair was perfectly predictable from the context, assuming perfect knowledge of the Harry Potter stories. After each sentence pair, participants were asked to indicate whether they had known the stated information when they first read it or not. At the end of the ERP recording, we independently assessed the participants' knowledge of the Harry Potter domain via a trivia quiz (which determined their knowledge score, range: 11-38 questions out of 40). Unsurprisingly, high-knowledge individuals reported knowing more items than low-knowledge individuals. Also, as expected, across all participants, N400 amplitudes were dramatically reduced for items that individuals reported having known vs. not. More remarkably, knowledge scores were systematically related to N400 amplitudes, but this relationship was reliable only for items that participants reported not having known/remembered

during the online task: compared to less-knowledgeable peers, individuals with greater knowledge exhibited smaller (more positive) N400 amplitudes for items they reported not knowing. One possible interpretation is that individuals with greater knowledge have a higher threshold for willingness to report what they know. We propose an alternative, albeit non-mutually-exclusive, interpretation: namely, that high-knowledge individuals may enjoy (or suffer from) access to broader and/or deeper semantic networks, implicitly accessing information related to the ongoing context in the absence of explicit recognition. Whatever the explanation, our results rule out accounts on which (pre-)activation of words in context is strictly all-or-nothing and suggest that by as early as 200 ms, fine-grained differences in the functional organization of individual-level knowledge may at least partially determine graded semantic activation during real-time sentence reading.

E28 Robust Electrophysiological Indices of Semantic Surprisal during Natural, Ongoing Speech Processing.

Michael Broderick[1], Andrew James Anderson[2], Giovanni M. Di Liberto[1], Edmund C. Lalor[1,2]; [1]School of Engineering, Trinity Centre for Bioengineering, and Trinity College Institute of Neuroscience, Trinity College Dublin, Dublin, Ireland, [2]Department of Biomedical Engineering and Department of Neuroscience, University of Rochester, Rochester, New York, 14627

Studies of natural language processing using EEG have typically measured neural activation for short snippets of language, and contrasted EEG responses to subtle variations in linguistic stimuli. For instance, the well known N400 effect can be revealed by contrasting the time-aligned EEG response to sentences such as the "the dentist told me to brush my teeth" with "the dentist told me to brush my tree". Although such approaches have been the foundation of an extensive body of research, they tend to be grounded on artificial modulations of a small stimulus set that is constrained to be amenable to conventional analyses. How much the results generalize to natural language is unclear. Consequently, there has been a recent move toward EEG-based analyses of more natural linguistic stimuli. We here build on related work on natural speech (audio-book) comprehension that used time-stamped models of the acoustic and phonemic properties of speech to predict and disentangle associated EEG signal. This demonstrated that EEG signal exclusively associated with phonemic properties of speech could be extracted, thus supporting the inference that the acoustic stimulus had been first decoded into speech units by the experimentee's brain. We here go beyond this, and build a measure that enables the further inference that the experimentee also processed words' meanings. We do this by adding in an additional "semantic" layer to the acoustic and phonemic features of the earlier predictive model. We exploit the recently popular "word2vec" computational model of words' meanings as the basis for semantic prediction. By computing the semantic difference between a word and the words in the previous phrase we build a predictive measure of "semantic surprisal": if a new word's meaning is not correlated with the previous words' meanings then it is a surprise! Here, using a regression analysis, we demonstrate that EEG activity over centro-parietal scalp reflects the magnitude of semantic surprisal in ongoing, natural speech at a latency of 250-400 ms. Furthermore, we show that this semantic effect disappears in reversed and unattended speech, despite robust EEG tracking of the acoustics of those stimuli. This work provides a new index of semantic comprehension in natural speech, which has implications for both cognitive and clinical neuroscience.

E29 Locus of semantic and syntactic processing in normal language processing: Anterior Temporal Lobe

Jona Sassenhagen[1], Denis A. Engemann[2,3], Christian J. Fiebach[1,4]; [1]Goethe University Frankfurt, [2]Parietal project-team, INRIA Saclay - ile de France, France, [3]University Paris-Sud, Universitë Paris-Saclay, NeuroSpin center, France, [4]IDeA Center for Indidivudal Development and Adaptive Education, Frankfurt

Experimental studies often indicate the terminal node of the dorsal auditory processing stream, Broca's Area, as the primary locus of the processing of abstract linguistic units above the level of words. Yet clinical studies, experiments on naturalistic language processing, and some language processing models implicate a ventral area: the temporal pole/ATL. A possible cause for this discrepancy is that experimental manipulations do not cleanly isolate combinatoric processes. Analytic methods for separating levels of processing in lieu of experimental manipulations may provide a novel approach for solving this problem. METHODS We demonstrate results from applying two novel methods for studying language processing: multi-level encoding, and frequency-resolved inter-subject alignment. Both methods tease apart different levels of linguistic processing from brain responses to naturalistic stimuli, without any experimental manipulation. In multi-level encoding, first, rich computer- and corpus-derived descriptions of a language stimulus, spanning all levels of linguistic representation (from acoustics to semantics), are constructed. Given this rich annotation and corresponding brain activity, we estimated brain responses to, e.g., phonological features, lexical frequency, syntactic surprise ... We then predicted brain activity for a novel segment by combining responses across all levels. Comparing predicted to observed brain activity yields the goodness of fit of these encoding models. Studying the contribution of a specific representational level to the goodness of fit for different brain regions then provides a localization for this level. In frequency-resolved inter-subject alignment, we explored across which temporal scales brain dynamics of different persons processing the same language stimulus

are correlated. That is, for each sensor or brain region, we correlated the time courses of estimated neural dynamics during listening to naturalistic language stimuli between all subjects. Investigating this inter-subject alignment in narrow frequency bands (by time-frequency decomposition of brain data) detailed over what exact time windows and in what brain regions listeners are strongly aligned with each other. Inherently, syntax and combinatoric semantic phenomena play out over longer temporal windows than e.g. phonetics and phonology. RESULTS Multi-level encoding of MEG-data from a study on the processing of heterogenous, congruent German sentences (n=27) indicates that (1) >10% of brain activity can be explained by multi-level encoder models built on state-of-the-art linguistic theory, (2) combinatoric processes - those concerning units larger than words, e.g. syntax and semantics, but not e.g. lexical effects - are concentrated on the ATL ($r > .15$), but not IFG ($r < .02$). Frequency-resolved alignment of an MEG data set (n=87) from the Human Connectome Project during short story listening, but not other tasks, show (1) two spectral peaks in inter-subject alignment, corresponding to the syllable level (4.5 Hz) and to multi-word units (~.7 Hz). (2) The brain regions aligned during story comprehension over these latter, long time frames overlap with those identified for combinatoric processes by multi-level encoding. DISCUSSION Two novel, but conceptually simple methods applicable to naturalistic language processing implicate ATL as the core locus of combinatoric processes language comprehension.

Meaning: Discourse and Pragmatics

E31 Establishing a Bio-Marker of Object-State Competition

Yanina Prystauka[1,2], Zachary Ekves[1,2], Gerry Altmann[1,2]; [1]University of Connecticut, [2]The Connecticut Institute for the Brain and Cognitive Sciences

Altmann and colleagues have postulated the need to represent not simply types (e.g. onions as a kind of vegetable) and tokens (a specific onion grounded in space and time) but also token-states (the onion peeled or chopped). fMRI studies have demonstrated during comprehension of action sentences such as "The chef will chop the onion. Then, she will weigh the onion" that the different states of the onion (intact/chopped) are simultaneously active. Selecting between the situationally-relevant state-representations of the same token (the onion) at the end of the 2nd sentence results in increased activation in brain areas also recruited during Stroop interference (VLPFC). This suggests that such selection entails conflict resolution. Conflict is not found in sentences describing minimal or no change, such as "The chef will smell the onion. Then, she will weigh the onion" [1]. Moreover, introducing a new token instead of referring back to the same token, as in "The chef will chop the onion. Then, she will weigh another onion" eliminates the need to resolve the competition and doesn't cause increased activation in VLPFC [2]. The present study builds on the above, and seeks to relate research on sentence processing, cognitive control, episodic memory and meaning representation using brain oscillations and time-frequency analysis. Specifically, we ask (i) how the effects found with fMRI manifest in EEG and (ii) whether these effects differ from known effects due to lexical and referential ambiguities. EEG was acquired using a 256-channel HydroCel Geodesic Sensor Net while participants (N=26) were reading sentences (N=320) presented to them one word at a time. Half of the sentences were designed to elicit the object-state change effect and were similar to those introduced above. Another half were fillers that either had a lexically ambiguous noun, or a referentially ambiguous pronoun. A time-frequency analysis of EEG power, synchronized from the onset of the final noun in the second part of the sentence or the referentially ambiguous pronoun, revealed a significant increase in alpha and lower beta frequencies only in sentences describing significant change and referring back to the same token – an effect we believe might be an EEG marker for conflict due to multiple object-states. This finding is consistent with literature relating alpha oscillations to cortical inhibitory processing which fits the hypothesis advanced by [1]: selecting the relevant token state required inhibition of the irrelevant one. Moreover, effects in beta frequency might be related to the maintenance and prediction hypothesis [3]: maintaining the current cognitive set might require more resource in the case of the substantial change condition than in the case of the minimal change condition. 1. Hindy, N. C., Altmann, G. T., Kalenik, E., Thompson-Schill, S. L. (2012). The Journal of Neuroscience, 32(17), 5795-5803. 2. Solomon, S. H., Hindy, N. C., Altmann, G. T., Thompson-Schill, S. L. (2015). Journal of Cognitive Neuroscience. 27(12), 2324-2338. 3. Lewis, A. G., & Bastiaansen, M. (2015). Cortex, 68, 155-168.

E32 Examining individual differences in the processing of referential dependencies in Spanish: an ERP investigation

Nick Feroce[1], Lauren Covey, Robert Fiorentino, Alison Gabriele; [1]University of Kansas

Recent studies have shown variability in the processing of pronominal reference in both ambiguous contexts (Two potential referents: David shot at John as he...vs. One potential referent: David shot at Linda as he...) and in contexts of 'referential failure' in which there is no gender-matching antecedent (The boy thought that she…) (Osterhout and Mobley, 1995; Nieuwland and Van Berkum, 2006; Van Berkum and Nieuwland, 2008; Nieuwland, 2014). These contexts have been shown to give rise to a sustained, frontal negative shift (Nref) or a P600 (or both components) depending on both the task and individual differences in working memory (Nieuwland, 2014). For cases of 'referential failure,' it has been proposed that the presence of an explicit acceptability judgment task may give rise to P600s, suggesting attempts at co-reference despite the mismatch in the gender of the pronouns (Osterhout and Mobley, 1995; Nieuwland, 2014). In both ambiguous contexts and contexts of referential failure, it has been

suggested that individuals with high working memory are more likely to yield Nref, a component that indexes the inability to assign a unique referent, as opposed to P600 (Nieuwland and Van Berkum, 2006; Nieuwland, 2014). The present study further examines individual differences in the processing of referential dependencies, examining a null-subject language (Spanish) for the first time. Experiment 1 targeted ambiguous overt pronouns (One/Two referent: Álvaro/Miriam aceptó a Natalia porque ella estaba en una situación similar. 'Álvaro/Miriam accepted Natalia because she was in a similar situation.'). An offline norming study which was completed by n=187 Spanish speakers confirmed that the sentences with two potential referents were consistently interpreted as ambiguous. Experiment 2 targeted referential failure (One/No Referent: Catalina/Pablo conoció a Rodrigo porque ella estaba en la clase de matemáticas. 'Catalina/Pablo met Rodrigo because she was in math class.') N=40 native Spanish-speaking participants completed the ERP study as well as tests of working memory (counting span/reading span). In the ERP study, participants read 240 sentences (160 targets, 80 fillers) and were asked to respond to fill-in-the-blank recall questions on one third of the trials. Results of Experiment 1 for all participants showed no significant effect of ambiguity. However, correlational analyses revealed that those with higher working memory (as indexed by reading span) showed greater negativities in the 500-1400ms Nref time window, suggesting in line with previous research that sensitivity to referential ambiguity may be increased in individuals with high working memory. Results of Experiment 2 showed a significant positivity in the posterior region between 600-900ms, consistent with the P600, suggesting that participants may attempt co-reference even in the absence of an explicit acceptability judgment task. The P600 effect size for referential failure was not correlated with working memory, in line with Nieuwland and Van Berkum (2006). The study suggests that the processing of referential ambiguity and referential failure is similar cross-linguistically and is modulated by similar individual differences.

E33 The shared and dissociable neural substrates of generalized and particularized conversational implicature

Wangshu Feng[1,2], Hongbo Yu[1,3], Xiaolin Zhou[1,2,4,5,6]; [1]Center for Brain and Cognitive Sciences, Peking University, Beijing 100871, China, [2]School of Psychological and Cognitive Sciences, Peking University, Beijing 100871, China, [3]Department of Experimental Psychology, University of Oxford, OX1 3UD, Oxford, UK, [4]Key Laboratory of Computational Linguistics, Ministry of Education, Peking University, Beijing 100871, China, [5]Beijing Key Laboratory of Behavior and Mental Health, Peking University, Beijing 100871, China, [6]PKU-IDG/McGovern Institute for Brain Research, Peking University, Beijing 100871, China

In daily conversation, the listener often has to infer the speaker's intended meaning beyond the literal information conveyed by the utterance. Such non-literal meaning is conversational implicature, which can be categorized into generalized conversational implicature (GI) and particularized conversational implicature (PI). GI can be obtained without knowing the context of utterance, whereas PI is based on specific context (Grice, 1975). It is controversial whether GI and PI involve identical or distinct cognitive processes. Neuroimaging studies have found that the generation of GI elicits increased activation in mPFC, MFG, and left IFG, whereas the generation of PI engages the theory-of-mind (ToM) network, including mPFC and TPJ, and the core language network, including IFG and MTG. The current study aimed to identify the shared and distinct neural processes underlying GI and PI by comparing them in the same experiment. To this end, we presented participants with simple dialogue scenes in which one interlocutor asked a question and then another interlocutor gave a reply, following a cover story. The reply was indirectly related to the question; understanding its meaning either required knowledge of the context (PI) or did not (GI). For their respective controls (i.e., NG and NP), essentially the same sentence was used as a direct reply to the preceding question. Twenty-eight participants made binary judgment as to whether the reply was intended to provide a yes or no answer to the question while undergoing fMRI scanning. They also completed a ToM localizer task after the main task. A conjunction of the contrast between GI and its control and the contrast between PI and its control revealed activity in bilateral IFG, left MTG, and mPFC, indicating shared neural substrates for understanding GI and PI. In line with this, multivariate fMRI pattern classifiers accurately (>95%) discriminated GI and PI from their respective controls. Moreover, the classifier trained on GI from its control could cross-discriminate PI from its control, and vice versa, suggesting that GI and PI elicit shared neural representations. We also examined the extent to which language and ToM processing could classify the neural representations of GI and PI. Independently defined Language and ToM prototypical brain patterns, either by a meta-analytic database ("Language") or by the localizer task ("ToM"), were applied to discriminate GI and PI with their respective controls. The "Language" pattern could discriminate both GI/NG and PI/NP, but performed at chance level when discriminating PI/GI, indicating that both PI and GI engage the identical pattern of language processing. By contrast, the ToM pattern performed at chance level in discriminating GI/NG, while performing significantly above chance in discriminating both PI/NP and PI/GI, suggesting that the ToM-related inferential process is unique to PI. Taken together, our findings show that PI and GI processing are neither identical nor completely distinct; instead, our data suggest that, while PI

and GI have overlapping neural processes, the difference between these two implicatures is in the involvement of ToM and intention consideration.

E34 Electrophysiological Evidence for Memory Retrieval during Referential Processing

Hossein Karimi[1], Tamara Swaab[1], Fernanda Ferreira[1]; [1]University of California, Davis

Referential processing involves linking referring expressions such as pronouns with preceding referential candidates. This linking process can be more or less difficult depending on: 1) how easy it is to find a unique referent for a pronoun (resolution difficulty) and 2) how easy it is to retrieve the memory representations associated with potential referents from memory (retrieval difficulty). This is because referential processing necessarily involves encoding the referential candidates in working memory and then retrieving those representations when a pronoun is encountered (e.g., MacDonald & MacWhinney, 1990). In this study, we asked whether retrieval difficulty can affect referential processing independent of resolution difficulty. Based on previous research showing that extra semantic information facilities subsequent retrieval (e.g., Hofmeister, 2011; Karimi & Ferreira, 2016), we varied the retrieval difficulty of referential candidates by manipulating whether they were modified by a relative clause or not, creating representationally rich or bare referential candidates, respectively, as illustrated in (1). A second sentence containing an ambiguous (Experiment 1) or an unambiguous (Experiment 2) pronoun such as (2) followed each version of the initial sentences. (1) Sentence 1 a) Bare Referential Candidates (baseline): The actor walked away from the cameraman/actress. b) Representationally Rich Referential Candidates: The actor who was visibly upset walked away from the cameraman/actress who was critical of the show. (2) Sentence 2: After a while, he realized it was getting late and took a taxi home. We measured Nref amplitudes to examine the effects of resolution and retrieval difficulty on the critical pronoun in Sentence 2. The Nref is a late, slightly left-lateralized, and sustained frontal negativity whose amplitude is modulated as a function of the difficulty associated with processing a referring expression; Nrefs with reduced amplitudes reflect easier referential processing (Van Berkum et al, 1999). By comparing two ambiguous or two unambiguous pronouns together, we kept resolution ambiguity constant such that any modulations on the amplitudes of the Nref could only be attributed to the representational richness, and by extension the retrieval difficulty, of the referential candidates. We observed smaller Nref amplitudes on ambiguous (Experiment 1) and unambiguous (Experiment 2) pronouns following representationally richer, and therefore easier-to-retrieve, referential candidates, suggesting that retrieval difficulty can affect referential processing independent of resolution difficulty. The results are consistent with recent research acknowledging the role of memory processes during referential processing in comprehension (e.g., Nieuwland & Martin, 2017) and lend support to cue-based retrieval theories of language processing, according to which retrieval difficulty should determine the processing difficulty of long-distance linguistic dependencies including referential dependencies (e.g., Lewis, Vasishth, & Van Dyke, 2006). Critically, the results also motivate a modification of what the Nref is commonly assumed to index. In particular, instead of solely reflecting resolution difficulty, the Nref appears to also index the ease with which the memory representations of referential candidates are retrieved from working memory.

Meaning: Prosody, Social and Emotional Processes

E35 Men who compliment a woman's appearance using metaphorical language are more creative and masculine and attractive to women

Zhao Gao[1], Qi Yang[1], Xiaole Ma[1], Yang Li[1], Becker Benjamin[1], Keshuang Li[1], Keith Kendrick[1]; [1]University of Electronic Science and Technology of China

From an evolutionary perspective, language complexity is assumed to signal mate quality in a courtship context and in men may also be modulated by prenatal testosterone influencing early brain development. However, it remains unclear whether the language men use to pay women compliments may covertly serve the purpose of mate selection and how the signals of sexual interest and mate quality communicate through the form and/or topic of such compliments. In this study sixty-four men created compliments to impress unfamiliar women they chose to be with in different contexts (work vs. dating) and additionally provided hand scans to compute 2D4D ratio as a proxy for prenatal testosterone exposure. All compliments were coded in terms of form (literal vs metaphorical) and topic (appearance vs non-appearance), with metaphorical ones being subsequently rated by 112 women for psycholinguistic features, intelligence impression and interpersonal relation to assess their effectiveness in displaying mate quality. Results showed that in a dating context more metaphorical form and/or appearance topic compliments were produced compared to the working context. In the dating context the production of metaphorical compliments targeting appearance was positively associated with men's art creativity, but negatively associated with 2D4D ratio. Context modulated the correlation between 2D4D ratio and the production of literal compliments targeting appearance as a mediator variable. The women preferred establishing a short-term romantic relationship with the men who produced metaphorical compliments in a dating context. Findings suggest that compliments which use metaphorical language targeting a woman's appearance can signal male mate quality. Male artistic creativity is particularly signaled by the figurativeness of metaphors and masculinity by use of metaphors targeting appearance. The evolutionary implications of these findings are also discussed.

Meaning: Lexical Semantics

E36 High Definition-transcranial Direct Current Stimulation Modulates Category Verbal Fluency in Healthy Adults

Julie Fratantoni[1], ReAna Limones[1], Jeffrey Spence[1], Julia Evans[1], John Hart[1]; [1]The University of Texas at Dallas

Lexical and semantic retrieval processes are commonly disrupted in many clinical populations. Word generation or verbal fluency (VF) is one of the most commonly used tests in neuropsychological evaluations to detect such deficits. Recently, transcranial Direct Current Stimulation (tDCS) has increased in popularity for its potential to modulate language and cognition. To our knowledge, no studies have investigated how High Definition-tDCS (HD-tDCS) on the left inferior frontal gyrus (LIFG) impacts VF performance. This study used a double-blinded crossover design to determine how HD-tDCS affects VF performance in 35 healthy college students. Participants came for two sessions, one week apart, of anodal/sham stimulation over the LIFG. Immediately after stimulation participants were given the Delis-Kaplan Executive Function System (D-KEFS) Verbal Fluency Test. We used a component analysis method developed by Ledoux and colleagues to examine clustering and switching behaviors in the VF responses. Component analysis is more sensitive than the traditional measure "total number of words". A mixed linear model revealed a significant effect of stimulation for number of switches ($F(1, 45.2) = 5.21$, $p = .027$) but not for number of clusters ($F(1, 43.6) = .012$, $p = .914$). There was no significant difference in total number of correct words ($F(1, 43.4) = .335$, $p = .566$). Results indicate HD-tDCS can have a selective effect on semantic retrieval processes; showing enhanced set maintenance performance in lexical retrieval processing. This study is a first step in understanding how HD-tDCS affects VF performance in healthy individuals. Further investigation is warranted to determine potential use for rehabilitation and intervention in clinical populations.

E37 High Definition-transcranial Direct Current Stimulation Modulates Phonemic Verbal Fluency in Healthy Adults

ReAna Limones[1], Fratantoni Julie[1], Evans Julia[1], Hart John[1]; [1]The University of Texas at Dallas

Word retrieval is an essential part of daily life necessary for humans to communicate. The left inferior frontal gyrus (LIFG) has been identified as a key area involved in phonemic fluency, however, the underlying mechanisms of the retrieval process remain unclear. Several studies have shown transcranial Direct Current Stimulation (tDCS) has the ability to modulate language function and can also be used to deepen our understanding of lexical entries and their networks. This study used High Definition-transcranial Direct Current Stimulation (HD-tDCS) on the LIFG to determine how anodal stimulation modulates performance of a verbal fluency task. We used a double-blinded crossover design on 10 monolingual healthy college students. The students participated in two sessions, exactly one week apart, of anodal/sham stimulation over the LIFG. Immediately following stimulation, the Delis-Kaplan Executive Function System (D-KEFS) Verbal Fluency Test was administered. Participant responses were analyzed with a component analysis method developed by Ledoux and colleagues. Component analysis provides further information about the nature of the responses that goes beyond "total number of correct words" to examine clustering and switching behaviors. A mixed linear model showed no significant effect of stimulation in total number of correct words ($F(1, 8) = .192$, $p = .673$), number of clusters ($F(1, 8) = 1.31$, $p = .285$), and number of switches ($F(1, 8) = .148$, $p = .711$). Findings indicate that anodal HD-tDCS did not enhance or inhibit performance on a phonemic verbal fluency task. Lack of behavioral change may be an indication that broader and/or additional areas should be included as a stimulation target. Additional investigation with a larger sample size is necessary to better understand if HD-tDCS can be used to modulate word retrieval and the utility of HD-tDCS in examining lexical networks.

E38 Changing Task Demands in a Semantic Decision Task: Evidence for the Dynamic Multilevel Reactivation Framework.

Joshua Troche[1]; [1]University of Central Florida

Theories of semantic memory often fall within a spectrum from fully embodied to disembodied theories. Fully embodied theories argue for no central convergence area for semantic representations in that features are dispersed across the modal association cortices. Disembodied theories, in contrast, argue for a central convergence zone where abstracted semantic conceptualizations reside. Both extremes of this spectrum have significant shortcoming and therefore necessitate a theory that is a hybrid middle ground between embodied and disembodied. Reilly and colleagues recently described such a middle ground in the Dynamic Multilevel Reactivation Framework. This theory argues that portions of our semantic system are both embodied and disembodied and the engagement of these systems is dependent on the demands of the task. They theorize that a high order hub in the anterior temporal pole is the location of abstracted semantic representations and that as task demands change we enrich these abstracted representations with information from heteromodal and sensory cortices. In this study, we attempted to test the plausibility of the Dynamic Multilevel Reactivation Framework. Twenty-five young adult participants were shown a set of pictures while their eyes were being tracked by a RED 120hz infrared eyetracking system. The pictures, both living and nonliving objects, were grayscaled and presented to participants in a randomized order. The participants were required to complete a semantic decision task during the experiment. The semantic decision task either required them to make superordinate distinctions (e.g., Is this a living or non-living thing?), basic distinctions (e.g., Is this a plant or an animal), or subordinate distinctions (e.g., Is this a desert plant or tropical plant).

Participants would indicate their answers (98% accuracy) through button press which would immediately advance the slide. Each participant had to complete a superordinate task, a basic task, and a subordinate task in a randomized order. The stimuli were the same across all tasks. We hypothesized that participants would be able to make superordinate decisions with little need to extract additional information from the pictures shown while subordinate categories would require enrichment of the abstracted representation through extraction of sensory information from the displayed picture. We measured the following outcomes: number of fixations in AOIs, the average duration of fixation in AOIs, and revisits to AOIs. AOIs were created posthoc by analyzing the heatmaps of the semantic decisions tasks and creating AOIs around areas of significant fixation. We compared the outcome measures across the three levels of semantic decision task: superordinate, basic, subordinate. We performed a Repeated Measures ANOVA for each outcome measure. For all three outcome measures, there was a main effect and decomposition revealed that subordinate semantic decision tasks lead to a greater number of fixations, larger average fixation times, and most AOI revisits as compared to the other tasks. The results fit well with the assumptions of the Dynamic Multilevel Reactivation Framework in that subordinate decisions required enrichment of the concept through sensory information as compared to basic and superordinate tasks.

E39 Evidence for a causal link between left temporo-parietal alpha-beta desynchronisation and context-driven word production

Vitoria Piai[1,2], Joost Rommers[1], Robert Knight[3]; [1]Radboud University, Donders Institute for Brain, Cognition and Behaviour, [2]Radboudumc, Department of Medical Psychology, [3]University of California, Berkeley, Helen Wills Neuroscience Institute and Department of Psychology

Different frequency bands in the electroencephalogram have been postulated to support distinct language functions. For example, alpha- and beta-band power decreases during language production were initially linked to speech motor function. However, recent studies have suggested that alpha-beta power decreases may also index word-retrieval processes. In a paradigm designed to elicit context-driven word production, participants hear lead-in sentences that either constrain the final word of the sentence ("He locked the door with the") or not ("She walked in here with the"). The last word is shown as a picture that has to be named. Previous studies have consistently found faster picture-naming response times (RTs) for constrained relative to unconstrained sentences (i.e., the context effect), suggesting that the picture name can be retrieved before picture presentation. In the electroencephalogram, the context effect is associated with left-lateralised alpha-beta power decreases pre-picture onset, suggesting that word retrieval may be associated with power decreases in those frequency bands. This oscillatory effect has been localised to the lateral temporal, inferior parietal, and lateral frontal lobes. However, the relative contribution of temporo-parietal versus frontal areas to the alpha-beta power decreases is unknown. We recorded the electroencephalogram from patients with stroke lesions to the left-lateral posterior cortex (N = 8) or left-lateral frontal lobe, including the inferior frontal gyrus (N = 5) and from matched controls (N = 13). Individual-participant analyses indicated a behavioural context effect in all participants, except for in the two patients with extensive lesions to the temporo-parietal cortex (P7 and P9). We replicated the alpha-beta power decreases pre-picture onset in the control group and in all patients, except for in P7 and P9. Hierarchical clustering analyses of the patients' lesion profiles, and behavioural and oscillatory effects indicated that P7 and P9 had a unique combination of lesion distribution, and lack of behavioural and oscillatory context effects. These results provide evidence for a causal link between alpha-beta power decreases in the left temporal and inferior parietal lobes and context-driven word production.

E40 Neural correlates of naming practice of nouns and verbs: An fMRI study in healthy controls

Ekaterina Delikishkina[1,3], Angelika Lingnau[1,2], Gabriele Miceli[1,3]; [1]University of Trento, [2]Royal Holloway University of London, [3]International Doctorate for Experimental Approaches to Language and Brain (IDEALAB), Universities of Trento, Groningen, Newcastle, Potsdam & Macquarie University

Attempted naming can improve performance in aphasic individuals even in the absence of feedback (Howard et al., 1985; Nickels, 2002). As argued by Heath et al. (2015), neural mechanisms underlying these improvements could at least partially overlap with those that support naming facilitation in the healthy brain. We aimed to investigate neural changes associated with intensive vocabulary practice in healthy individuals. Twenty native Italian speakers (mean age 23.8 years) underwent training of nouns and verbs for ten consecutive days. During each training session they were asked to name twenty objects and twenty actions depicted in color photographs, and were instructed to repeat this procedure ten times. Two identical fMRI sessions were conducted before and after the training period. In the scanner, participants were presented with line drawings of items involved in training, as well as an equal number of untrained objects and actions that served as controls for task habituation effects. For the fMRI analysis we selected 11 left-hemispheric ROIs with a 5-mm radius centered around the coordinates reported in previous studies (Basso et al., 2013; MacDonald et al., 2015). Individual mean beta weights were extracted from each ROI as an estimate of the blood-oxygen level-dependent (BOLD) amplitude and submitted to a repeated-measures ANOVA with factors word class (nouns, verbs) and training (trained, untrained). The ANOVA revealed a main effect of training in the pars triangularis, pars opercularis,

anterior insula, anterior cingulate cortex (ACC), mid portion of the middle temporal gyrus (midMTG), posterior cingulate cortex (PCC) and precuneus, as well as a main effect of word class in the pars opercularis, midMTG and posterior inferior temporal gyrus (with verbs eliciting a greater response in comparison to nouns in all three ROIs). The lack of an interaction between the two effects suggests that practice-induced changes were not modulated by word class. Interestingly, changes in the BOLD amplitude in response to training were opposite in their direction in different ROIs — while in the anterior brain regions (including two ROIs within the inferior frontal gyrus, insula and ACC) the BOLD signal was significantly reduced for the trained items, it was increased after practice in the more posterior midMTG, precuneus and PCC. The reduced BOLD response in the frontal regions could be attributed to the facilitation of semantic and/or phonological retrieval and the increased frequency of trained items in the subjects' mental lexicon. The portion of midMTG selected for the analysis is implicated in semantic storage, and the increase of the BOLD signal for trained in comparison to untrained items may reflect the strengthening of structural representations of objects and actions as a result of practice. Higher BOLD amplitude in response to trained items in the medial parietal regions is more difficult to interpret. While not included in the classic language circuit, PCC and precuneus have been suggested to be an important part of the semantic system (Binder et al., 2009). The exact role of these areas in semantic processing and their functional and structural connections to the language circuit remain to be investigated.

E41 Entrenchment in Chinese quadra-syllabic idiomatic expressions: A fMRI study *Shu-Kai Hsieh[1], Tai-Li Chou[2], Yu-Hsiang Tseng[2], Chiung-Yu Chiang[1], Chia-Lin Lee[1,2], Te-Hsin Liu[3], Chia-Rung Lu[1], I- Ni Tsai[3], I-Wen Su[1]; [1]Graduate Institute of Linguistics, National Taiwan University, [2]Department of Psychology, National Taiwan University, [3]Graduate Program of Teaching Chinese as a Second Language, National Taiwan University*

Idiomatic expressions are commonly defined as fixed multi-word units whose semantic interpretation are mostly non-compositional, entrenched as functional pairings of form and meaning in speakers' mind. This paper aims to explore a special type of idiomatic expressions with even length, called Quadra-syllabic Idiomatic Expressions (QIEs) in Chinese, and explain their variations with reference to the interaction of construction and lexical compositionality from an experimental perspective. QIEs are divided into two types: idioms ('chengyu') and prefabs. Idiom are culturally rooted and formed through ages of constant use, well compiled in dictionary and learned in school (e.g., hua4 xian3 wei2 yi2, 'turn danger to safety'); while prefabs are more compositionally dependent, and can be understood as four-character lexical bundles (e.g., hao2 jiu3 bu2 jian4 "long time no see"). 96 Idioms and 96 prefabs are selected from a large corpus filtered by a certain threshold of frequency. Corresponding pseudo-idiom/prefabs with character replacements of different semantic distances are created (Near/Far). The total 384 words are rated by a different group of 40 native Chinese speakers on a 1–7 Likert scale regarding familiarity, comprehensibility, and the semantic distance between original words and replacements. 240 experimental stimuli are selected based on the comprehensibility rating results and divided into 4 groups: (1) Origin QIEs, (2) Near QIEs, (3) Far QIEs, (4) Random QIEs, with the top 30 Idioms and prefabs for (1) and (2); the bottom 30 Idioms and prefabs for (3). Participants are instructed to do a semantic congruency judgment during the presentation of a QIE. Two interesting results from fMRI are found. First, angular gyrus (AG, BA 39) is active in Origin QIEs and Near QIEs, but less obvious in Far QIEs and Random QIEs. This implies that origin QIEs and Near QIEs do operate semantic integration processing, but Far QIEs and Random QIEs do not. Second, left inferior frontal gyrus (IFG, BA45, 47) is significantly active in Near QIEs, but is relatively weak in Origin QIEs, Far QIEs and Random QIEs. IFG activation has been found in semantic tasks that demand higher retrieval processing. In our case, it is more active in processing Near QIEs, where we fill in the open slot of the original QIE scheme with a semantic related element. Namely, when processing Near QIEs, participants are working hard in inhibiting irrelevant properties or in choosing appropriate features. In sum, it is clear that the Origin and Near QIEs both operate AG, but IFG is only active in Near QIEs. Given the fact that the Origin and Near QIEs share the same construction, and the only difference between them is the manipulated open slot, we may assume that AG may reflect that schematicity and compositionality are both operated when we are processing meaning, and IFG indicates that there is an interaction between the construction-led schematic effect and compositional effect contributed by the composed semantic element in open slot. Hence, the results are in line with the recent cognitive constructionist proposal that the notions of schematicity and compositionality are not mutually exclusive.

E42 Different mechanisms for lexical ambiguity resolution in individuals with ASD? *Emily Coderre[1], Mariya Chernenok[2], Trevor Brothers[2], Barry Gordon[1], Kerry Ledoux[1]; [1]Johns Hopkins University, [2]University of California, Davis*

Autism spectrum disorder (ASD) is characterized by language deficits, including difficulties determining the meaning of ambiguous words like homographs. The "weak-central coherence" theory attributes these difficulties to a tendency toward enhanced local processing at the expense of global integration. We investigated local and global processing during lexical ambiguity resolution in individuals with ASD using the N400 event-related potential. Sentences (adapted from Sitnikova et al., 2002) consisted of an initial clause biasing one meaning

of a homograph. In a second clause, a critical word was congruent with the homograph's dominant meaning but was either congruent or incongruent with the biased meaning. A sentence-final control word was congruent or incongruent with both local and global context to provide a baseline for N400 effects. A local processing bias would predict no N400 effect at critical words, since they always match the homograph's dominant meaning. A global processing bias would predict enhanced N400 amplitudes when critical words are incongruent vs. congruent with the homograph's biased meaning (i.e. an N400 effect). Weak central coherence would predict greater global processing in the TD group (an N400 effect for critical words) but greater local processing in the ASD group (no N400 effect). Both groups should show N400 effects at control words. Participants were 20 adults with ASD (ages 18-68, M = 34; 16 male) and 20 age- and sex-matched TD adults. Groups were matched on age and IQ (all p's>0.24). Receptive vocabulary was lower in the ASD group ($p<0.05$) and was included as a covariate in analyses. Participants read 120 sentences for comprehension, adapted from Sitnikova et al. (2002), responding to relatedness probes after each sentence. Sentences were presented in rapid serial visual presentation format during concurrent EEG recording. Repeated-measure ANOVAs were conducted at nine scalp regions (representing frontal, central, and parietal sites and left, midline, and right lateralities) with factors of congruity, site, laterality, and group. At the control word, both groups showed centro-parietal N400 effects from 300-500 ms (all p's<0.05). N400 effect magnitude was comparable between groups (all p's>0.16), suggesting that participants successfully detected semantic anomalies. At the critical word, neither group showed N400 effects (all p's>0.17), suggesting a lack of global processing for both groups. This finding contradicts our predictions and the results of the TD group in Sitnikova et al. (2002). This discrepancy could be due to age differences (our participants had a wider age range) or working memory differences (although neither study assessed working memory). Although neither group showed congruency effects, the TD group had larger N400 amplitudes overall compared to the ASD group ($F(1,37)=6.33$, $p<0.05$). Given the frequent anomalies in the stimuli, TD participants may have adopted a local processing strategy and/or kept both meanings of the homograph in mind to later evaluate congruity. As the ASD group showed smaller N400 responses overall, they may have processed semantic ambiguity in a fundamentally different way.

E43 Spatio-temporal granularity of dorsal stream processing during word production

F.-X. Alario[1], C. Liegeois-Chauvel[2,3], A.-S. Dubarry[4], I. Wang[3], S. Alomar[3], I. Najm[3], J. Gonzalez-Martinez[3]; [1]Aix Marseille Univ, CNRS, LPC, Marseille, France, [2]Aix Marseille Univ, INSERM, INS, Inst Neurosci Syst, Marseille, France, [3]Cleveland Clinic Foundation, Cleveland (OH), USA, [4]Aix Marseille Univ, CNRS, LPL, Aix-en-Provence, France

Introduction Cognitive models of language processing have been grounded in neurobiological descriptions of brain activity, giving a primary role to the segregation of functional brain activity into distinct streams of processing [1]. The dorsal stream interfaces temporo-parietal areas with frontal areas, particularly supra-marginal gyrus, angular gyrus, etc. with inferior frontal gyrus [2]. During word production, a left lateralized dorsal pathway is thought to map auditory-phonological information with articulatory motor programs [3]. We used functional data recorded from intra-cerebral electrodes during a picture naming task to quantify dorsal stream activity [4] at a finer spatial and temporal granularity than is currently available. **Methods** Participants were epileptic patients that underwent a stereo-electro encephalography (SEEG) as pre-surgical assessment of pharmaco-resistant epilepsy [5]. They were enrolled under criteria approved by the local Institutional Review Board. In all 17 participants, the implantation included a parieto-frontal network that was either unilateral (9 left, 2 right hemisphere), or bilateral (6 patients). One patient was discarded due to poor behavioral performance. The experimental task consisted in naming out-loud simple drawings of familiar objects. The procedure was organized in experimental blocks, each with 30 trials during which five different items were presented and repeated randomly. Due to clinical constraints (fatigue, availability), the number of trials recorded varied between patients. Electrode localization was achieved by co-registration of the CT to the MRI for each individual patient then projected to a common space (MNI). Brain area labels were attributed based on Talairach coordinates. Regions sampled in only one patient were not considered. For each electrode contact, we computed intra-cerebral event related potentials (iERP) and high gamma activity (HGA) as indexes of focal processing within the area. Significant activity was detected per contact, then combined across patients. **Results** In total, 490 contacts were available (381 left, 109 right) in 22 different brain areas. From these, 398 contacts showed significant iERPs in the relevant time window (315 left, 83 right), confirming the involvement of a widespread network. Significant iERPs were detected in Supramarginal Gyrus and Angular Gyrus, peaking on average 320 ms after stimulus. Responses in Angular Gyrus were much more consistent across patients than in Supramarginal Gyrus. Significant iERPs and HGA were also detected in left IFG, peaking around 350 ms. They were most clear and consistent in Pars opercularis, compared to Triangularis and Orbitalis. **Conclusion** Dorsal stream activity during word production simultaneously involves specific sub-regions within temporo-parietal and inferior frontal areas. **References** 1. Poeppel, D. et al. (2012). J. Neurosci. 32, 14125–14131. 2. Hickok, G. (2014). Lang. Cogn. Neurosci. 29, 2–20. 3. Schwartz, M. F., et al. (2012). Brain 135, 3799–814. 4. Flinker, A. et al. Proc. Natl. Acad. Sci. (2015). 112, 2871-2875. 5. Talairach, J. & Bancaud, J. (1973). Prog. Neurol. Surg. 5, 297–354.

Computational Approaches

E44 Comprehenders Rationally Adapt Semantic Predictions to the Statistics of the Local Environment: A Bayesian model of trial-by-trial modulation on the N400

Gina Kuperberg[1,2], Nathaniel Delaney-Busch[1], Emily Morgan[1], Ellen Lau[3]; [1]Department of Psychology, Tufts University, [2]Department of Psychiatry and the Athinoula A. Martinos Center for Biomedical Imaging, Massachusetts General Hospital, [3]Department of Linguistics, University of Maryland

Introduction: When semantic information has been pre-activated by a context prior to new bottom-up input becoming available, semantic processing of the predicted incoming word is typically facilitated, attenuating the amplitude of the N400 event related potential (ERP). This N400 modulation is observed even when the context is a single semantically related "prime" word. The magnitude of the N400 semantic priming effect is larger in experimental environments that contain a larger proportion of semantically related prime-target pairs (e.g. (1), suggesting that participants adapt the strength of their predictions to the predictive validity of the wider experimental environment. Such adaptation makes rational sense: probabilistic prediction is only beneficial if these predictions actually approximate the statistical structure of the input. In the present study, we asked whether Bayesian principles of rational adaptation can explain how lexico-semantic processing in the brain, as indexed by the N400, adapts over time to changes in the broader experimental environment. Methods: We built a formal computational model of rational adaptation of lexico-semantic processing in a semantic priming paradigm. This model combined three basic assumptions: that contexts probabilistically inform lexico-semantic expectations for upcoming target words, that these expectations adapt rationally (in an optimal Bayesian manner) over time, and that the N400 component is sensitive to the amount of information (surprisal) conveyed by target words. Additional inputs to the model included distributional knowledge that participants could use to generate probabilistic predictions about the target, given the prime (specifically, frequency and forward association strength). We then asked whether this Rational Adapter model could explain how the amplitude of the N400 to target words changes after participants switch from an experimental environment with 10% semantically related prime-target pairs (a lower proportion block) to an environment with 50% of semantically related prime-target pairs (a higher proportion block). Results: The Rational Adapter model was able to explain the trial-by-trial pattern of N400 modulation across the higher-proportion block (β = -2.21, t = -2.76, p = 0.006). We further showed that the explanatory power of this model was not simply due to the inclusion of items-level information like frequency and forward association strength (β = -2.30, t = -2.11, p = 0.036). Finally, we confirmed that, given both probabilistic prediction and rational adaptation, word surprisal was a significantly better predictor of N400 amplitude than raw estimates of word probability. Conclusions: These findings provide evidence that the brain probabilistically predicts upcoming words, and that it updates these probabilistic predictions in a rational trial-by-trial fashion in responses to changes in the broader statistics of its environment. They also provide strong evidence that the N400 component indexes new (unpredicted) information: surprisal. These findings hold implications for theories of language processing, the functional significance of the N400 component, and the design of psycholinguistic experiments (in which participants are likely to adapt to trial probability). (1) Lau, Holcomb & Kuperberg, JCN, 2013

Meaning: Prosody, Social and Emotional Processes

E45 When the expressive prosody meets word predictions in spoken-language comprehension

Angèle Brunellière[1], Laurence Delrue[2]; [1]Univ. Lille, CNRS, UMR 9193 - SCALab - Sciences Cognitives et Sciences Affectives, F-59000 Lille, France, [2]Univ. Lille, CNRS, UMR 8163 - STL - Savoirs Textes Langage, F-59000 Lille, France

Over the last decade, there has been an increase of interest in predictive mechanisms in spoken-language comprehension using different methods, electrophysiological recording and visual world eye-tracking (Huettig, 2015; Kutas, DeLong, & Smith, 2011). Whereas experimental evidence is accumulated for on-line word predictions from semantically and syntactically constraining sentence contexts, much less research in the language domain has explored the influence of the expressive prosody in spoken-language comprehension. The goal of the present study is to examine whether generating predictive mechanisms can depend on the degree of expressivity of interlocutors. According to the intention and the motivation of speakers to share a message and convince listeners, particular words are produced with emphasis in realistic speech, increasing the salience of particular words relative to others and indicating their relevance towards the content of the discourse message. To achieve this goal, we will conduct an event-related potential (ERP) study during the listening of semantically constraining sentences predicting a target word. French-speaking participants were exposed to spoken, semantically constraining, French sentences followed by an article that could be either in agreement or in disagreement with the gender of the expected, yet not presented, word. In this experiment, we manipulated the degree of expressivity conveyed by the interlocutor and the gender of expected article. The processing of articles triggered a negative response around 200 ms followed by a P300 wave. Interestingly, the amplitude of these two ERP components was stronger for the trials with expressive

prosody relative to those with neutral prosody. While the negative response reflected the degree of match between the on-line word predictions from the sentence context and the presented article, this effect of word predictions did not interact with the degree of expressivity. Taken together, this suggests that the processing of expressive prosody does not interfere with on-line word predictions. The findings will be discussed in the light of a predictive coding framework.

Speech Motor Control and Sensorimotor Integration

E46 Interhemispheric functional connectivity predicts action semantic performance in stroke

Nicholas Riccardi[1], Chris Rorden[1,3], Julius Fridriksson[2,3], Rutvik H. Desai[1,3]; [1]Department of Psychology, University of South Carolina, [2]Department of Communication Science & Disorders, University of South Carolina, [3]McCausland Center for Brain Imaging, University of South Carolina

Introduction: Behavioral and neuroimaging evidence from healthy participants largely supports embodied cognitive theories wherein sensorimotor systems participate in concept representation. This contrasts with amodal theories which argue that sensorimotor activity elicited by semantic tasks is epiphenomenal. Studies of patients with brain damage can play an important role in this debate by establishing a causal role of sensorimotor networks in language comprehension. Here, we examined the relationship between action verb comprehension and resting-state functional connectivity (RSFC) in stroke patients. With unilateral stroke, regions in the unaffected hemisphere sometimes play a compensatory role, mitigating the potential decline in cognitive performance. We hypothesized that impaired connectivity between the hemispheres, especially involving the motor cortex, would adversely affect action language comprehension. Methods: RSFC scans were collected from 48 chronic left-hemisphere (LH) stroke patients. Outside of the scanner, patients completed a verb semantic similarity judgment task (VSSJ) wherein 40 action ("to throw") and 40 abstract ("to excuse") verb triplets were presented. Participants were instructed to indicate via button press which of the bottom two verbs was most similar in meaning to the top. Accuracy difference scores were created for each patient by subtracting average accuracy in the abstract condition from that in the action condition. RSFC analysis was then conducted using a network of interest (NOI) consisting of seven bilateral regions: inferior frontal gyrus pars opercularis (IFGoper), IFG pars triangularis (IFGtri), supramarginal gyrus (SMG), precentral and postcentral gyri (PrC, PoC), and posterior middle and inferior temporal gyri (pMTG, pITG). For each patient, a correlation matrix of RSFC strength was generated for all left-to-left and left-to-right NOI regions. These correlation values were then used in a general linear model as a predictor of the VSSJ accuracy for action and abstract verbs separately with alpha set to 0.01, and for the difference scores with alpha set to 0.05. Significance was determined via permutation testing (5000 permutations) using NiiStat software. Results: Accuracy in the VSSJ task for action verbs was predicted by the strength of the following connections: 1) left IFGoper to right IFGoper, IFGtri, PrC, SMG; 2) left IFGtri to right IFGtri, IFGoper; 2) left PrC to right IFGoper, SMG; 3) left SMG to right SMG. Some of these results can reflect a general cognitive decline, affecting non-semantic factors. Examining the difference score revealed two interhemispheric RSFC links that were significant predictors of specifically action performance, such that lower connectivity predicted lower action relative to abstract verb performance: 1) left IFGoper to right PrC ($p < .0005$) and 2) left IFGoper to right SMG ($p < .0005$). Conclusions: PreC and SMG are strongly associated with action execution and planning. IFGoper, beyond a role in executive functions, is part of the mirror neuron system. Our results suggest that with damage to the LH, RH motor cortex participates in action verb comprehension, and when this compensatory ability is disrupted through impaired connectivity, a selective decline for action concepts is seen. These findings support a causal role of sensorimotor areas in concept representation, and highlight the role of network connectivity.

Methods

E47 Oscillatory dynamics identify unique neural processes beyond event-related responses during auditory sentence comprehension

Julie Schneider[1], Mandy Maguire[1]; [1]Callier Center for Communication Disorders at the University of Texas at Dallas

Introduction: Event related potentials (ERPs) and time frequency analysis of the EEG can identify the temporally distinct coordination of groups of neurons across brain regions during sentence processing (Lam et al., 2016). Although there are strong arguments that ERP components are driven by the same changes in neural oscillations during similar processes (Hagoort et al., 2004; Davidson & Indefrey, 2007; Bastiaansen et. al., 2002) others argue that the lack of clear associations between the two suggests oscillatory dynamics are more than just time-frequency representations of ERP components (Wang, Zhu & Bastiaansen, 2012; Bastiaansen & Hagoort, 2015), making it unclear how the two are related. The current study seeks to examine the neural activity underlying auditory sentence processing of both semantic and syntactic errors, to clarify if ERP and time frequency analyses identify the same or unique neural responses. Methods: Thirty-nine right-handed, monolingual, English-speaking adults, ages 18-32 years (11 male; Mage=22.1, SD=3.8) completed an auditory semantic and grammatical judgement task. All sentence types included a 'target agent-action pairing' in which an inanimate agent (noun) was paired with a modal verb and action verb. In the correct sentences, the target

agent-action pairing was both possible and grammatically correct. The grammatically incorrect sentences included either the intrusion or omission of a present participle (-ing) form of the verb (i.e. will be bake, will baking). The semantic violation introduced an unsuitable pairing of actions with agents (i.e. hose-bake). Analysis: Data were epoched from -100 to 1500 msec around the target verb and a morlet wavelet analysis was applied. Single trials were averaged together to obtain a stable waveform ERP for each condition and each electrode for every subject. For the time frequency analysis, epochs were averaged across trials, within each condition, and the mean baseline power at each electrode and frequency was subtracted (Delorme & Makeig, 2004). We conducted a monte-carlo cluster correction analysis in the theta (4-8 Hz) and lower beta (13-20 Hz) bands to determine significance. The mean amplitude for each condition was computed and a Pearson correlation coefficient was computed to determine if a relationship existed. Results: As expected the semantic judgment task, t-tests confirmed a larger N400 amplitude ($t(38)= 5.25$, $p< 0.001$) and greater increase in theta power ($t(38)= -2.85$, $p< 0.01$) for semantic errors compared to correct sentences. In the syntactic judgment task, P600 amplitudes were larger ($F(2,114)=2.935$, $p=.05$) and beta power decreased ($F(2,114)=8.56$, $p<0.001$) for both grammatical error types compared to syntactically correct sentences. Importantly, the correlation identified no significant relationship between the ERPs and neural oscillatory dynamics. Discussion: Increases in theta and the N400 effect are both related to semantic processing, while decreases in beta and the P600 effect are linked to syntactic processing; however, no relationship between the event-related and time frequency responses existed. Based on these findings we conclude that event-related and time frequency responses may be gauging similar language processes, but oscillatory dynamics add to research by uncovering unique, distinct neural changes.

E48 Performance differences on reading skill measures are related to differences in cortical grey matter structure in young adults

Clinton Johns[1], Andrew A. Jahn[1], Hannah R. Jones[2], Dave Kush[1,3], Peter J. Molfese[1,4], Julie A. Van Dyke[1], James S. Magnuson[1,5], Whitney Tabor[1,5], W. Einar Mencl[1], Donald P. Shankweiler[1,5], David Braze[1]; [1]Haskins Laboratories, [2]University of Rochester, [3]Norwegian University of Science and Technology, [4]National Institutes of Health, [5]University of Connecticut

Individual differences in reading comprehension and its components often correlate with differences in functional activity in task-relevant brain regions (e.g., Clements-Stephens et al., 2012; Meyler et al., 2008). There is also some evidence that such individual differences correlate with differences in neuroanatomical structure (for review Richardson & Price, 2009). However, most evidence to date derives from contrasts between clinical (e.g., dyslexic) and non-clinical groups. Non-clinical studies of individual differences in cortical structure and cognitive ability have typically utilized small or homogeneous samples (e.g., college students). Further, such studies typically assess only a narrow range of language-related cognitive abilities and skills, such as decoding ability (Jednoróg et al., 2015), print exposure (Goldman & Manis, 2013), vocabulary knowledge (Lee et al., 2007; Richardson et al., 2010), or overall reading comprehension ability (Welcome et al., 2011). Thus, interpreting the largely heterogeneous findings of such studies presents a challenge. Therefore, we conducted an investigation of potential relations between cortical grey matter structure and individual differences on a broad battery of literacy-related skill assessments in a community-based sample of young adults with a wide range of linguistic ability. We recruited 35 right-handed native English speakers (ages 16-24 years, 17 female) from the local New Haven area. Each participant completed two experimental sessions – one scanning session, and one behavioral testing session – on separate days. During behavioral testing, participants completed a test battery, including decoding, phonological awareness, rapid naming, both oral and print comprehension, reading fluency, print exposure, working memory capacity, and reasoning ability. During the scanning session, we acquired whole-head, high resolution T1-weighted anatomical images. Subsequent analyses in Freesurfer calculated cortical grey matter volume (GMV) and thickness (GMT) for brain parcellations based on the Desikan-Killiany atlas. Whole-brain analysis revealed that individual differences on multiple battery measures were associated with differences in cortical structure. Of primary interest, decoding ability was positively correlated with GMV in left superior temporal sulcus (STS), and grey matter thickness GMT in right superior temporal gyrus (STG). Print exposure was negatively correlated with GMT of pars opercularis in left inferior frontal gyrus (IFG) and the left fusiform gyrus (including the visual word form area, VWFA). Both measures were also related to supramarginal gyrus (SMG), but with differential specificity: decoding was positively associated with GMV in left anterior SMG (aSMG), and print exposure was negatively associated with GMT in left posterior SMG (pSMG). These results are broadly consistent with previous functional findings that have associated aSMG, left IFG, left STS, and VFWA with establishing relations between different types of lexical (e.g., phonological, orthographic) information (e.g., Shankweiler et al., 2008). In addition, they confirm previous findings (Lee et al., 2007; Richardson et al., 2010) suggesting a structural role for pSMG with no functional analog: as a site related to the assembly of high-dimensional lexical representations via the binding of orthographic, phonological, and semantic information. Finally, our results suggest that while aSMG may be chiefly concerned with phonological aspects of grapheme-to-phoneme translation, pSMG may be primarily related to with orthographic aspects of this process.

E49 Behavior stability and reliability of fMRI activation in stroke aphasia

Brielle Stark[1], Grigori Yourganov[1], Alexandra Basilakos[1], Chris Rorden[1], Leonardo Bonilha[2], Julius Fridriksson[1]; [1]University of South Carolina, [2]Medical University of South Carolina

Brain changes associated with aphasia treatment have been addressed in numerous studies over the past two decades. Neural activation measured during multiple pre-testing time-points must be reliable in order to relate neural changes post-treatment to intervention and not to inherent variability. Language tasks during fMRI have been shown to elicit moderately reliable activation in neurotypical adults (Wilson et al 2016). The reliability of language tasks in stroke aphasia has been investigated in small sample sizes with varying reliability measurements. Verifying fMRI reliability in stroke aphasia is important, given the prevalence of using longitudinal fMRI language tasks in assessment of intervention. The purpose of this study was to investigate fMRI activation reliability, taking into account the stability of language impairments, in a relatively large population of stroke survivors with aphasia. Sixty participants (22 F) were recruited at the University of South Carolina and Medical University of South Carolina. Participants had one-time left hemisphere ischemic stroke; were at least six months' post-stroke (M=37.68 months, SD=46.61); average age-at-testing 60.1 years (SD=10.09); and average lesion volume 140518.23 mm3 (SD=91769.02mm3). Participants were not undergoing speech-language therapy when enrolled in the study. Twenty-five participants had Broca's aphasia, five had Wernicke's aphasia, seventeen had anomic aphasia, nine had conduction aphasia, and four had global aphasia. During two baseline fMRI scans conducted one week apart, participants named aloud 40 object pictures and remained silent during 20 abstract pictures. Responses were scored offline as correct or not correct. We tested behavior stability in two ways. To determine the stability of item-level responses for each participant, i.e. whether a correct response at session one was likewise correct at session two, we computed Cohen's Kappa. We computed Pearson's product moment correlation to measure task accuracy stability. For each participant's fMRI signal, a Dice coefficient (DC) of similarity was calculated, describing the overlap of thresholded signal (p=0.01 uncorrected) between sessions one and two. DC ranged from 0 (no overlap) to 1 (perfect overlap). DCs were calculated for voxel-wise whole-brain data and for bilateral regions of interest (frontal, temporo-parietal and motor-articulation large ROIs). Item-level naming stability was fair (M=0.34, SD=0.19) with wide range across participants (Cohen's Kappa: -0.07-0.64). Accuracy across sessions was stable (r=0.94, p<0.001). Fair reliability was shown for the group for whole-brain and ROI data (DC range: 0.2-0.39), suggesting that a picture naming task in stroke elicited poorer reliability compared to a picture naming task in neurotypical adults (i.e. Wilson et al 2016). Further, there was a wide range of participant-specific reliability in whole-brain and ROI data, in that some participants with stroke exhibited poor reliability while others exhibited good or excellent reliability. In conclusion, it is important to appreciate various aspects of behavior stability such as accuracy and item-level response, as variability may be shown in one measure and not the other. Further, fMRI reliability was highly participant-specific. Together, these results underscore the importance of multiple pre- and post-therapy assessments so that participant-specific variance is factored into outcome.

E50 A multi-modal approach to quantify the reading network using the neurochemical-neurovascular relationship to predict decoding and fluency

Lisa Krishnamurthy[1,2,3], Venkatagiri Krishnamurthy[2,3,4], Dina Schwam[5], Daphne Greenberg[5], Robin Morris[3,6]; [1]Dept. of Physics & Astronomy, Georgia State University, Atlanta, GA, United States, [2]Center for Visual and Neurocognitive Rehabilitation, Atlanta VAMC, Decatur, GA, United States, [3]Center for Advanced Brain Imaging, GSU/GT, Atlanta, GA, United States, [4]Dept. of Neurology, Emory University, Atlanta, GA, United States, [5]Dept. of Educational Psychology, Special Education, and Communication Disorders, Georgia State University, Atlanta, GA, United States, [6]Dept. Of Psychology, Georgia State University, Atlanta, GA, United States

Reading disability (RD) has been characterized by atypical connections of a specialized network of brain regions. Understanding the 'resting' connectivity and related neurochemical components of this 'reading network' in RD could help provide critical evidence of which connections are most available for learning, and which would be the best target of specific interventions. Because of this network's complexity, a multi-modal approach may provide improved understanding of RD and treatment choices. The goal of this study was to model how the network's neurochemical attributes interplay with connectivity to form the foundations of the decoding and fluency components of the reading circuit. Eighteen adults (age 20-59) with varying levels of reading proficiency were recruited. rsFC and MEGA-PRESS MRS used to identify the gamma-amino butyric acid (GABA+) and glutamate+glutamine (GLX) metabolites were acquired on each subject. The 3x3x3cm^3 voxel was placed over the posterior Inferior Frontal Gyrus (IFG) and anterior Superior Temporal Gyrus (STG). An unsuppressed water spectrum from the same area was also acquired for eddy current compensation and H2O normalization. The rsFC images were corrected for slice timing, global head motion, EPI distortions, physiological noise, spatially normalized to MNI, low-pass filtered, and smoothed. Seed-based CC analysis was applied in a whole-brain manner by seeding in the center of mass (CoM) of the MRS voxel overlap from all 18 subjects. The MRS data underwent spectral registration, aligning on Creatine (Cr), subtraction (edit-

control=difference), and appodization. The difference and control spectra were separately fitted to a simulated basis set using LCModel, and reported as a ratio with Cr. We evaluated whether removing age effects and tissue content from GABA+/Cr and GLX/Cr data improved the relationships with reading measures. Finally, we related reading behavior with rsFC and GABA+/Cr (or GLX/Cr), to determine the neurochemical-neurovascular-cognitive relationship within the reading network. As previously shown, GABA+/Cr and GLX/Cr concentration decline with age, and statistically adjusting for the sample's age effects and normalizing the data by tissue content improved GABA+/Cr and GLX/Cr relationships with reading decoding and fluency measures (assessed via R2). The rsFC measures were also of high quality, such that they were sensitized predominantly to grey matter. Seeding the voxel CoM, we found significant connections with multiple expected reading network areas. The rsFC strength was significantly related to the GABA+/Cr concentration and reading decoding and fluency. These results were integrated within a neurochemical-neurovascular-cognitive model, in which the left hemisphere (LH) connections, in tandem with the neurochemical attributes, best predicted reading levels. It has been suggested that some struggling readers, and those with reading disabilities, utilize a right-lateralized circuit for reading, which is considered much less efficient and effective than the typical left-lateralized reading network. Our model is in support of these observations, but goes beyond traditional single-modality analyses by evaluating the underlying network that supports reading, and combines that information with the neurochemistry attributes that best predict the trait. These preliminary results from combining MRS and rsFC are promising, and may help to further identify the underlying dysfunction(s) in struggling adult readers' brain circuitry.

E51 Time-generalized multivariate analysis of EEG activity reveals a cascading organization of semantic mismatch processing

Edvard Heikel[1], Jona Sassenhagen[1], Christian J. Fiebach[1]; [1]Goethe University Frankfurt

In language processing, it has been traditionally argued that the N400 and the P600 represent a double dissociation between semantic and syntactic processing. However, the P600 as a purely syntactic component has been called into question due to studies demonstrating a P600 in response to semantic violations in sentences with a high semantic constraint (i.e., high cloze probability). In light of these observations some have argued that the P600 might index a more global processing stage (Bornkessel-Schlesewsky & Schlesewsky, 2008), which implicates the additional question whether or not N400 and P600 reflect strictly sequential stages of processing. Conversely, others have argued that the observed P600 in response to semantic violations is simply a biphasic response to the N400 (Tanner et al, 2015). This is still very much debated and one reason for the lack of theoretical convergence in regards to the interpretation of semantic P600 effects could be due to the limitations of traditional univariate approaches to ERP analysis. To constrain the range of possible neural architectures represented by the biphasic N400/P600 response elicited by semantic violations – i.e., sequential vs. cascading activation of distinct processes vs. recurrent activation of a single neural mechanism – we applied a novel EEG method capable of tracking the temporal evolution of distinct cognitive processing stages over time, i.e., temporally generalized multivariate pattern decoding (generalization across time/GAT; King & Dehaene, 2014). We replicate established N400/P600 correlates of semantic mismatch in a spoken sentence paradigm, and provide evidence that early and late mismatch-sensitive processes are 1. distinct in their neural substrate, which argues against recurrent architectures, and 2. partially overlap in time, refuting strictly sequential models. Furthermore, separate multivariate pattern classifiers that were trained on N400 vs. P600 EEG patterns performed at chance outside their respective time windows (i.e., N400 vs. P600), which rules out the biphasic activation of a single system as cause of the N400/P600 pattern. These results suggest an incremental-cascading neural organization of semantic processing, i.e. a sequence of processes that are not strictly serial but overlapping in time.

E52 Investigating brain mechanisms of natural reading by combining EEG, MEG and eye-tracking

Olaf Hauk[1], Felix Dreyer[1,3], Maarten van Casteren[1], Caroline Coutout[1], Elisabeth Fonteneau[4], Béla Weiss[1,2]; [1]MRC Cognition and Brain Sciences Unit, Cambridge, [2]2Brain Imaging Centre, Research Centre for Natural Sciences, Hungarian Academy of Sciences, Budapest, [3]3Brain Language Laboratory, Free University of Berlin, Berlin, [4]Department of Psychology, University of Cambridge

Our knowledge about the neural correlates of natural reading is still very limited, because most previous neuroimaging studies have used fixed-gaze word-by-word paradigms. Eye movements are usually minimized during standard neuroimaging experiments to minimize artifacts. However, natural reading is a complex active process employing series of saccades and fixations for sampling of written text. Thus, there is a need for the investigation of neural mechanisms of reading under ecologically valid conditions. Recently, different research groups have developed novel methods for research into natural reading by combining eye tracking (ET) and EEG (Dimigen, 2011), and by applying single-trial modelling of fixation-related brain activity (Weiss, 2016). In order to enhance the spatial resolution and provide source estimation of brain correlates of natural reading, we will present spatio-temporal dynamics of EEG/MEG brain responses related to plausible and implausible visual words in minimal context, supposed to elicit the well-known N400 effect (Kutas, 1980). Participants (N=18) were instructed to read 248 four-word English sentences at their own pace and to make a judgement whether the last (target) word was plausible or

implausible. ET (SMI, 250 Hz) and EEG/MEG (Neuromag Vectorview) data were recorded simultaneously. ET data were processed by an adaptive algorithm (Nyström, 2010). Behavior of subjects was characterized by their reading speed (RS), saccade amplitude (SA), fixation duration (FD), total number of saccades (TNS) and percentage of regressive saccades (PRS). EEG/MEG recordings were cleaned using independent component analysis (ICA). Source localization of cleaned EEG/MEG activity was carried out by using individual MRI anatomies, creating a 3-layer BEM forward solution and calculating the inverse solution using L2 minimum-norm estimates. Statistical differences between brain activity related to plausible and implausible target words were assessed in source space by spatio-temporal cluster-based permutation testing. Subjects read plausible sentences significantly faster (P=0.0009) compared to implausible sentences, and significantly larger TNS (P= 0.0018), PRS (P= 0.0033) and SA (P= 0.0057) were found for implausible sentences. The latter trend was also observed for FD, but the difference did not reach the level of significance (P=0.2953). Visual inspection of fixation-related EEG/MEG data revealed prominent deflections peaking around 90 and 250 ms in occipital and occipito-temporal sensors as well as a later component more extended in time (270-460 ms) in centro-parietal sensors. The latter component showed more negative-going deflection for the implausible words (N400). Cluster-based permutation testing resulted in a significant cluster (P=0.005) comprising medial temporal, inferior frontal and supplementary motor brain regions in the left hemisphere, with stronger activations for plausible compared to implausible words. To our knowledge, this is the first study applying the combination of ET and EEG/MEG for the investigation of neural correlates of reading in an ecologically valid condition. We could demonstrate that our approach produces clean EEG/MEG data for source estimation, that the well-known N400 effect can be replicated, and that plausible spatio-temporal dynamics can be revealed during natural reading. Our results and methodological framework may contribute to the deeper understanding of the neural mechanisms of natural reading as well as on active vision in general.

Computational Approaches

E53 Lesion mapping of syntactic and lexical features derived from Natural Language Processing of narrative speech elicited by patients with chronic post-stroke aphasia

Ezequiel Gleichgerrcht[1], John Delgaizo[1], Julius Fridriksson[2], Dirk den Ouden[2], Alexandra Basilakos[2], Chris Rorden[2], Leonardo Bonilha[1]; [1]Medical University of South Carolina, [2]University of South Carolina

Background: Typically elicited by an open-ended question or prompt (e.g. "Tell me about your day") or the request to describe a scene (e.g. widely used "Cookie Theft" picture), narrative speech can provide valuable clinical information about a patient's language skills well beyond the scores of standardized language batteries. The detailed analysis of responses to such tasks, however, requires specific training and can be highly time-consuming. Method: We applied an automated computational algorithm based on Natural Language Processing (NLP) to the verbatim two-minute transcriptions of three picture description tasks (i.e., six minutes of total connected speech) elicited by 64 patients with chronic dominant-hemisphere stroke. By means of sentence boundary disambiguation, parsing, and parts-of-speech tagging, we derived 37 lexical and syntactic features, which were subjected to factor analysis through principal components. In order to identify brain areas critical to language performance, we then conducted voxel-based lesion-symptom mapping (VLSM) on factors that, together, would explain at least 50% of the variance. We employed Freedman-Lane permutation to control for both family-wise errors and for fluency (WAB spontaneous speech fluency subscore) as a potential confounder given the nature of the task. Results: Dimension reduction using Varimax rotation yielded seven factors, which altogether explained 83% of the variance. Factor 1 and Factor 2, however, were enough to explain 50.3% of the variance, so further analyses focused on these two components. Factor 1 was strongly composed of mainly syntactic features (in decreasing order of loading scores: clause width, width/height and number of verbal phrases, number of words, speech rate, number of clauses and their height, distance between noun phrase and verb phrases and so forth). Controlling for the spontaneous speech fluency subscore of the WAB, lesion mapping revealed critical voxels in the left rolandic operculum (z=-3.66). Factor 2 was strongly composed of mainly lexical features (in decreasing order of loading scores: frequency of all words, number of nouns, adverbs, and adjectives, as well as adverb, noun, verb and overall lexical variation). Controlling for fluency, lesion mapping revealed critical voxels in the precentral (z = 3.90) and globus pallidus regions (z = 3.65). Conclusion: We showed that syntactic performance beyond speech fluency might rely on areas in the rolandic operculum, while lexical performance beyond fluency may depend on areas in the precentral gyrus and subcortical structures. Our findings show that NLP applied to connected speech elicited by patients with post-stroke aphasia can shed light on the organization of language in brains with vascular damage.

Language Therapy

E54 Changed resting-state network connectivity following prosody treatment for apraxia of speech

Carl Coelho[1], Jennifer Mozeiko[1], Xiao Yang[1], Lisa Mueller[1]; [1]University of Connecticut

-Introduction- Apraxia of speech (AOS) is a neurologic speech disorder resulting in impaired capacity to plan or program sensorimotor commands necessary for movements in phonetically and prosodically normal speech (Duffy, 2013). Treatment is typically focused on sounds

or syllables initially, with prosody considered at the end of therapy (Brendel & Ziegler, 2008). New and colleagues (2015) have noted that individuals with AOS had reduced bilateral connectivity compared to stroke patients without AOS and that decreased connectivity of the left premotor cortex (PM) was correlated with AOS severity. In the current study, an intensive treatment targeting prosody was provided to an individual with mild aphasia and mild AOS. We predicted that improvement in measures of speech naturalness post-treatment would be associated with increased bilateral connectivity involving the PM. -Methods- Participant was a 43 year old, right-handed male, two years post-onset of a left CVA involving the posterior left frontal lobe and insular cortex. Pre-treatment testing revealed WAB AQ of 96, and 80% on an AOS screening (Duffy, 2013). Intensive treatment (30 hours over two weeks) was provided which consisted of drills focused on prosodic aspects of speech (stress, intonation, emotion, phrasing, & rhythm). A single-subject design was used to acquire and monitor treatment data over time. Treatment probes included samples of conversational speech, which were later rated for naturalness by naïve listeners. Structural and functional fMRI data were acquired on a Siemens 3T MRI scanner. A high resolution 1 mm3 T1-weighted structural image was collected. Preprocessing was performed using Data Processing & Analysis for Brain Imaging, (Yan et al., 2016). The participant was scanned at three time points: pre-treatment, immediately post-treatment and 7 weeks post-treatment. ROIs were selected based on the work by New et al. (2015) in order to compare findings. Connectivity of ROIs was calculated by performing correlation analysis of time series signals extracted from six ROIs. ---Results- Treatment data reflected modest-moderate gains across all of the targeted prosodic aspects of speech. Gains were maintained at the 7-week post-treatment follow-up. Naturalness of conversational speech ratings did not show considerable change. AOS screening scores improved to 91% and 93% at post-treatment and follow-up respectively. In each of the three scans, significant correlations were found in bilateral connections of IFG ($p<0.01$) and anterior insula ($p<0.01$), and in intrahemispheric connection of left IFG and left PM ($p<0.001$). Strength of connectivity in each of these ROIs increased after treatment The connection of bilateral PM, though not significant in scan 1 ($p=0.029$), increased in strength and was significant in both scan 2 ($p<0.05$) and scan 3 ($p<0.001$). ROI-wise correlation coefficients were transformed into Fisher's z values that represent the functional connectivity strength for each connection. -Discussion- • Intensive prosody treatment appears to be a viable treatment option for mild AOS and warrants replication. • Increased connectivity in bilateral IFG resembles that of healthy controls. • Increased strength of connectivity between left and right PM and between left PM and right anterior insula corresponded with prosodic improvements, providing an additional indicator of success of treatment.

Perception: Orthographic and Other Visual Processes

E55 Using a novel Local Heterogeneity Regression method to index orthographic representations in reading.

Jeremy Purcell[1], Brenda Rapp[1]; [1]Department of Cognitive Science, Johns Hopkins University, USA

Amid the rich literature regarding the neural basis of written language, one prominent theory posits that left ventral occipitotemporal cortex (vOTC) contains orthographic neural representations that are highly selective to well-known written words (Dehaene and Cohen 2011). Initial attempts to index these orthographic representations reported that the mean neural response in the left vOTC is relatively low for high-frequency words as compared to low-frequency words and pseudowords (Kronbichler et al. 2004; Mechelli, Gorno-Tempini, and Price 2003). More recently, it has been proposed that orthographic representations become sparser after learning (i.e. strong activation in a relatively small set of neurons), and that differences in the mean neural response does not capture this relative degree of sparseness (Glezer et al., 2009). Instead more advanced measures that quantify the local neural heterogeneity are better suited to detect changes in the relative sparseness of orthographic neuronal representations due to learning (e.g. Glezer et al. 2015). To build upon this work, here we introduce a novel Local-Heterogeneity Regression (Hreg) Analysis which quantifies the relative heterogeneity of the local neural responses within the context of a specific condition - such as reading words. This approach is based on the premise that sparse neural representations will have heterogeneous local responses across adjoining voxels. We apply this approach to an fMRI reading study which included high frequency (HFW), low frequency words (LFW), and pseudowords (PW). We acquired block design, reading data for the following conditions (N=40): HFW, LFW, PW, and checkerboards. Two analyses were performed: (1) A traditional random-effects univariate analysis. (2) A novel Local-Hreg analysis. The Local-Hreg analysis is a search-light analysis where, for each search-light, a general psychophysiological interaction analysis (gPPI; McLaren et al., 2012) was performed using the center voxel to predict each surrounding voxel in a pair-wise manner. For each pair-wise comparison a condition-specific (e.g. reading HFW) voxel-to-voxel interaction parameter was obtained; the Local-Hreg value is the median of condition-specific pairwise, interaction values within a searchlight. Lower average condition-specific interactions, indicate higher local heterogeneity. For both analyses we performed comparisons for HFW > LFW and HFW>PW. Results reveal: (1) in the univariate analysis: a left hemisphere vOTC cluster that shows lower mean activation for HFW relative to LFW, and (2) in the Hreg analysis: a left vOTC cluster that shows higher local heterogeneity for HFW relative to LFW. A similar finding was observed for

HFW>PW for both analyses. In summary, whereas there is a lower BOLD response to HFW, there is higher local heterogeneity for HFW relative to both LFW and PW within the left vOTC. This work provides a novel approach for examining the relative sparseness of orthographic representations, and has applications for probing the neural dynamics of representation and learning.

E56 Multimodal MRI converging evidence on the role of ventro-occipito-temporal cortex in reading: Integrating opposing views

Garikoitz Lerma-Usabiaga[1], Carreiras Manuel[1,2], Paz-Alonso Pedro M.[1]; [1]BCBL. Basque Center on Cognition, Brain and Language, Donostia-San Sebastián, Spain, [2]IKERBASQUE, Basque Foundation for Science, Bilbao, Spain.

The ventral occipito-temporal (vOT) association cortex significantly contributes to recognize different types of visual patterns. It is widely accepted that a subset of this circuitry becomes trained to perform the task of rapidly identifying word-forms. However, there are still important open questions unanswered: how is the functional contribution of the different cortical regions within the vOT to the visual word recognition? Does function relate to the structural connectivity of vOT regions with other language areas? There are previous reports of functional dissociations along the vOT. Furthermore, while some authors report structural connections between the vOT and the posterior parietal cortex (pPC) via the vertical occipital fasciculus, others highlight more anterior vOT-pPC structural connections through the posterior arcuate fasciculus. Characterizing the vOT connectivity pattern can be critical to shed further light on the computational role of the VWFA. Here we present the results of a multimodal (functional, diffusion-weighted and quantitative) study including 97 MRI sessions with young adults aimed at investigating the functional and structural connectivity patterns of the vOT reading regions. To examine how functional contrasts influence the location of the VWFA, we used those that have been reported more often in the literature. Furthermore, due to the large intraindividual variability, our analyses were performed at the individual-subject level, and half of the subjects were scanned twice to check for test-retest reliability. Finally, we examined the contribution of the vOT regions to word, pseudo-word and consonant string reading. Our results revealed a functional segregation along the anterior-posterior vOT, across different functionals contrast and that was concurrently associated with differences in vOT-pPC structural connectivity. Reading behavior was predicted by functional activation in these vOT regions and by the structural properties of the white matter fiber tracts linking vOT with other regions within the reading network. We propose a new subdivision of the vOT reading regions. Our findings constitute a step forward in the pre-lexical/lexical discussion regarding the role of the vOT in reading, suggesting the existence of an anterior and a posterior VWFAs with clearly differentiated functional roles and with white matter connectivity with different pPC regions.

Speech Motor Control and Sensorimotor Integration

E57 Combining TMS and EEG to measure electrophysiological responses to speech after suppression of primary motor cortex

Helen E Nuttall[1], Barrie Usherwood[1], Patti Adank[2], Outi Tuomainen[2]; [1]Lancaster University, [2]University College London

It has become increasingly evident that primary motor (M1) areas for speech production activate during speech perception. Such motor activation has been proposed to assist perception of speech in non-motor brain areas, such as auditory cortex. Connectivity between M1 and auditory cortex is not completely understood, and it is not known whether activity from M1 contributes to processing in non-motor speech areas. This preliminary pilot study aimed to develop methods to investigate if suppressing M1 activity using Transcranial Magnetic Stimulation (TMS) with either a biphasic or monophasic pulse shape, affects electrophysiological Auditory Event-Related Potentials (AERPs), recorded during perception of clear speech and speech in noise. We hypothesized that if M1 contributes to electrophysiological processing of speech from non-motor brain areas, then decreasing M1 activation will modulate AERPs during speech perception (H1). Conversely, if M1 does not contribute to electrophysiological processing of speech, then decreasing M1 activation will not affect AERPs (H2). We tested these hypotheses by applying repetitive-TMS to the lip area of left M1. TMS was applied at a frequency of 1 Hz to create a temporary virtual lesion in M1 lip area. To investigate the role of TMS pulse shape, half of the subjects had monophasic 1 Hz TMS, and the others had biphasic 1 Hz TMS. To measure electrophysiological processing of speech, we used electroencephalography to record AERPs (N100 and P200) to clear speech and speech in noise. Responses were analysed from Cz, which yielded the largest response. Nine normally-hearing adult subjects (aged 18-40; 4 males) participated in this pilot study. Results indicated that that TMS significantly increased the latency of the N100 component, independent of TMS pulse shape ($F(1,7) = 5.6$, $p = 0.05$). There was a trend towards an interaction between TMS and speech type on N100 latency ($F(1,7) = 4.79$, $p = 0.065$). Planned contrasts confirmed that there was a marginally significant increase in N100 latency to clear speech post-TMS ($t(8) = -2.22$, $p = 0.057$). There was no effect of TMS on N100 amplitude. For P200, there was no significant effect of TMS on latency. However, there was an interaction between TMS and TMS pulse shape on P200 amplitude ($F(1,7) = 10.44$, $p = 0.014$). Preliminary data suggest that biphasic TMS may reduce P200 amplitude, and monophasic TMS increase P200 amplitude. These data

indicate that combining TMS and EEG is an informative design that has potential to clarify the effects of TMS on the underlying electrophysiology of indirectly connected brain areas, during speech perception. Further data will inform how AERPs are modulated by TMS.

Multilingualism

E58 Processing sentences with "only" in a second language: Evidence from ERPs

Rachida Ganga[1], Marijn Struiksma[1], Emily Haoyan Ge[2], Virginia Yip[2], Aoju Chen[1]; [1]Utrecht University, the Netherlands, [2]The Chinese University of Hong Kong, China

INTRODUCTION: The focus particle 'only' activates a set of alternatives to the word that is prosodically highlighted via emphatic accentuation in a sentence, thereby contributing to a contrastive focus interpretation of the word, e.g., I have only CARRIED the bag (not PACKING the bag). Further, 'only' typically directly precedes the accented word in spontaneous speech (e.g. I have only CARRIED the bag is more common than I have only carried the BAG). Dimitrova et al. (2012) examined the processing of 'only' in native speakers of Dutch and found that in native speakers of Dutch 'only' triggers expectations of emphatic accentuation (absence of a frontal-central P300) and that accentuation on a word further away from 'only' triggers re-analysis at the end of a sentence (eliciting a frontal P600). The processing of the interface between focus particles like 'only' and accentuation in the brain has not been studied in L2. Limited behavioural research suggests that L2 listeners operate on the semantics of focus particles differently than native listeners, regardless of L2 proficiency (e.g. faster phoneme detection in the presence of focus particles in L2 but not in L1) (Sennema-Skowronek 2008). To obtain a clearer insight into the processing of sentences with focus particles in L2, we examine three research questions in advanced Dutch learners of English: (1) Does 'only' trigger expectations of emphatic accentuation on the adjacent word? (2) Does accentuation further from 'only' in a sentence trigger re-analysis? (2) Is the processing of sentences with 'only' modulated by discourse context that implies contrastive focus? METHOD: Four types of short stories were presented aurally in English to advanced Dutch learners of English (n=30). These stories differed in whether the target sentences were preceded by a context consisting of three sentences ("The dinosaur has a bucket and a suitcase. He was going to carry them and throw them. Then he changed his mind.") and whether emphatic accentuation was placed on the verb, adjacent to "only", or on the object, later on in the target sentence ("The dinosaur is only CARRYING the bucket." or "The dinosaur is only carrying the BUCKET."). A comprehension task was given in 25% of the trials to assess the attention of the participants. Using a 64-channel standard EEG setup, we recorded EEG signals starting at the onset of the verb. PREDICTIONS: Considering the similarity in the semantics of the focus particle only/alleen in English and Dutch and the use of accentuation, we may expect native-like processing, i.e. absence of P300 and presence of P600 with or without context. However, research on online processing of the prosody-information structure interface shows that L2 listeners do not integrate the two strands of information to perform anticipatory processing (Chen and Lai 2010). We may thus also expect non-native processing, i.e. presence of P300 and later and even total absence of P600 in particular without context. Data acquisition is still ongoing. We will discuss these predictions in the light of the data and implications of our results in our presentation.

E59 The perisylvian language network and language analytical abilities

Olga Kepinska[1], Egbert A. J. F. Lakke[1], Eleanor M. Dutton[1], Johanneke Caspers[1], Niels O. Schiller[1]; [1]Leiden University

Aiming at exploring the brain's structural organisation underlying successful second language (L2) learning, we investigate the anatomy of the perisylvian language network in a group of healthy adults, consisting of participants with high (N = 22) and average (N = 20) language analytical abilities. The two groups were recruited on the basis of a language aptitude test (LLAMA, Meara 2005) administered to a large group of participants (N = 307). Utilising deterministic tractography, six tracts per participant (left and right long direct segment, left and right indirect anterior segment and left and right indirect posterior segment) were virtually dissected and measurements pertaining to their microstructural organisation were collected. Our results obtained by means of linear discriminant analysis pointed to mean diffusivity (MD) values of three tracts (right anterior, left long and left anterior segments) as best discriminating between the two groups. By far the highest coefficient was obtained for the MD values of the right anterior segment, pointing to the role of the right white matter fronto-parietal connectivity for superior language learning abilities. Lower MD values were obtained for the highly skilled learners in comparison with the moderately skilled ones. The results imply the importance of attentional processes and reasoning abilities for successful L2 acquisition, and support previous findings concerning right-hemispheric involvement in language learning.

E60 Bilingualism, Age, and the "Brain Reserve"

Stefan Heim[1,2], Johanna Stumme[1,2,3], Nora Bittner[2,3], Christiane Jockwitz[1,2,3], Katrin Amunts[2,3], Svenja Caspers[2,3]; [1]RWTH Aachen University, [2]Institute of Medicine (INM-1), Forschungszentrum Jülich, [3]Heinrich Heine University Düsseldorf

There is a livid debate whether bilingualism contributes to a "cognitive reserve" delaying degeneration of the brain by years. Here, we present a large-scale (n=404) population-based study investigating the grey matter volume in cytoarchitectonically defined language areas in the left inferior frontal (IFG) and inferior parietal (IPL) cortex of

mono- and late bilingual subjects between 25.8 and 84.2 years of age. Two core findings emerged: (1) Grey matter volume in the IPL and IFG was systematically higher in bi- than monolingual subjects. (2) The difference disappeared at higher ages, and the corresponding volume decline was stronger for bi- than monolinguals, independent of education. This paradoxical effect can be modelled as the effect of ongoing degeneration in life, which is steeper for bilinguals who initially had higher volumes immediately after second language learning. Bilingualism may thus constitute an advantage in case of brain damage at younger ages but does not help prevent neurodegeneration in older seniors.

E61 The role of native writing system in picture processing: an ERP study

Yen Na Yum[1], Anna Petrova[2], Sam Po Law[2]; [1]The Education University of Hong Kong, [2]The University of Hong Kong

The present study aimed to examine the possible influence of one's native writing system in visual processing of nonverbal material. We tested two trilingual groups of participants with either Korean or Japanese as first language (L1), and both Chinese and English as later-acquired second languages (L2s), and two control groups of native speakers of Chinese and English. The two trilingual groups represent very different L1 orthographic experiences, and the two L2 writing systems are likewise known for their drastic differences in word form and mapping between orthography and phonology. A go/no-go repetition detection ERP task was employed with mixed presentation of words and pictures. Trilingual participants performed the task with English and Chinese words in separate blocks. Our analysis focused on picture trials. Within-subject responses in N170 and N400 to picture stimuli were not expected to differ between the two language conditions, while between-subject responses may differ if picture processing was influenced by literacy experience. When the trilingual groups were compared with the control participants in the respective blocks, processing of pictures in Japanese participants tended to be more similar to the Chinese control group, both showing greater negativity in N170 and less negativity in N400 relative to the Korean group. In the English condition, the Japanese group had greater N170 amplitude than both the Korean and English groups, while the three groups significantly differed from each other in the N400 (in decreasing order of negativity: Korean > English > Japanese groups). Given the differences between the Japanese and Korean trilingual groups in relation to the control groups, further analyses focused on the two trilingual groups, controlling for individual differences in picture naming accuracy and degree of usage of Chinese and English, as well as between-item differences including visual complexity and pictured object familiarity. A main effect of group was found, with the Japanese group showing greater negativity in N170 and smaller N400 than the Korean group. Interestingly, pictures were processed differently depending on the language context-- pictures embedded among Chinese characters elicited greater N170 and more attenuated N400 than pictures presented among English words. A significant interaction indicated that the language block difference in the N400 was driven by the Korean group showing greater N400 in the English than the Chinese block, but no difference was shown by the Japanese group. Following previous studies, greater N170 is taken to reflect greater visual expertise whereas greater N400 is interpreted as greater processing difficulty. As such, the patterns exhibited by the Japanese participants suggest greater ease in processing pictures and minimal influence of language context, perhaps due to their familiarity with Kanji characters and the Romaji script of Latin letters. Kanji, derived from Chinese characters, are believed to require more visuospatial analysis. This account also suggests that the Korean participants were susceptible to influence of language context. In particular, greater N400 to pictures among English than Chinese words implies greater processing demand associated with switching between alphabetic word forms and pictures.

E62 A longitudinal behavioral and fMRI study of second language learning

Kaitlyn M. Tagarelli[1], Xiong Jiang[2], Aaron J. Newman[1], Kyle F. Shattuck[2], Aron K. Barbey[3], John W. VanMeter[2], Kara Morgan-Short[4], Alison Mackey[2], Peter E. Turkeltaub[2], Elissa L. Newport[2], Michael T. Ullman[2]; [1]Dalhousie University, [2]Georgetown University, [3]University of Illinois at Urbana-Champaign, [4]University of Illinois at Chicago

Millions of adults all over the world attempt to learn second languages (L2s). This task is notoriously difficult, and many struggle to attain high proficiency, let alone retain it, which is the ultimate goal of L2 learning. Understanding the neural mechanisms involved in language learning may help shed light on why it is so difficult for adults, as well as on how it can be made easier. While growing evidence suggests that neurocognitive changes occur over the course of L2 learning, it is still unclear which brain structures and cognitive mechanisms are involved at which proficiency levels. Additionally, our understanding of how the brain retains an L2 is in its infancy. This study combines behavioral and fMRI measures to longitudinally examine L2 learning from low to high proficiency, and then again after a period of no exposure to the L2 ("retention"). Nineteen English native speakers (Mage = 20.6 ± 2.81; 9 females) were trained on a subset of Basque over three three-hour sessions, and 16 returned approximately one month later for one session to test their L2 retention. Vocabulary and grammar training occurred via a forced-choice picture-matching task, providing a continuous behavioral measure during training. fMRI data were continuously acquired during all grammar training, as well as during word-level training and a grammaticality judgment task (GJT) in early (Day 1), late (Day 3), and retention sessions.

fMRI analyses were conducted using FEAT in FSL, and clusters were considered significant when $Z > 2.3$, $k > 25$ voxels, and corrected $p < 0.05$. Learners achieved very high proficiency in vocabulary and reasonably high proficiency in grammar. For word and grammar learning, activation (compared to a sensorimotor control task) was broadly and bilaterally distributed in the brain and decreased overall but only slightly from Day 1 to Day 3, and then substantially at retention, suggesting a decrease in processing effort as learners became more proficient the L2. However, activation in some structures, particularly in the medial temporal lobe for words and the basal ganglia for grammar, increased, suggesting more specific roles for these areas according to language domain. For the GJT, activation for violation compared to control sentences was focused around the right IFG (BA44) and middle temporal lobe on Day 1. On Day 3, activation in these areas and their left hemisphere homologues increased, and there was additional activation in the right putamen. This suggests that participants' ability to distinguish good and bad sentences increased over the course of learning, eventually recruiting areas within the procedural memory system that have been shown to be involved in L1 and L2 grammar processing, at least at high proficiency. At retention, learners showed more activation for correct sentences compared to violations, specifically in the left postcentral gyrus. Overall, these findings help to broaden our understanding of the neurocognition of L2 learning and retention, have implications for neurocognitive theories of L2, and demonstrate the importance of longitudinal approaches and integrating neural and behavioral methods in language learning research.

E63 A dynamic causal modeling analysis of the role of the caudate nucleus and prefrontal cortex in bilingual language control

Roy Seo[1,2], Jose M. Ceballos[1,2], Brianna L. Yamasaki[1,2], Chantel S. Prat[1,2]; [1]Department of Psychology, University of Washington, [2]Institute for Learning and Brain Sciences, University of Washington

Bilingual language control is characterized by the information processing demands associated with dynamically selecting from co-activated languages based on the appropriate language context. Previous research suggests that this is accomplished in part using general cognitive control mechanisms including the anterior cingulate cortex (ACC: Abutalebi, et al., 2011), the left dorsolateral prefrontal cortex (DLPFC: Hernandez, Martinez, & Kohnert, 2000) and the left caudate (Crinion et al., 2006). To better understand the role of each of these regions in bilingual language control, we employed a novel, Rapid Instructed Task Learning (RITL) task, which separated the process of bilingual language control into three phases. In the first, preparation phase, a target language cue indicated which language participants were to use. In the second, rule-encoding phase, a morpho-syntactic cue indicated the relevant morpho-syntactic rule for that trial. Lastly, during the execution phase, participants were required to apply the morpho-syntactic rule provided in phase 2, in the target language provided in phase 1, to the word provided in phase 3. Twenty-three early Spanish-English bilinguals performed the RITL task in an MRI scanner. Previous research using ROI analyses of the ACC, DLPFC and left caudate revealed that the ACC activation was only significant during the preparation phase; whereas activation in the DLPFC and left caudate was observed across all three task phases. Activity in the DLPFC increased over the course of the three task phases; however, activity in the left caudate remained constant across the course of the trial. The current analysis followed up on these findings using Dynamic Causal Modeling (DCM) to examine the extent to which the processes in DLPFC and caudate were cumulative (i.e., processing in phase 1 was maintained and added to processing in phase 2) versus phase-specific (i.e., processing in each phase was unique). DCM was used because it allows for hierarchical, non-orthogonal modeling of data where general linear modeling does not. The results revealed that the best fitting model was the non-cumulative model, with exceedance probabilities of .69 compared to the exceedance probabilities of the phase-specific model, which was .31. These results extend previous research by suggesting that the ACC, DLPFC, and caudate each contribute to bilingual language control, and contribute uniquely during target-language preparation and execution phases. Hernandez, A. E., Martinez, A., & Kohnert, K. (2000). In search of the language switch: An fMRI study of picture naming in Spanish–English bilinguals. Brain and Language, 73(3), 421-431. Abutalebi, J., Della Rosa, P. A., Green, D. W., Hernandez, M., Scifo, P., Keim, R., ... & Costa, A. (2012). Bilingualism tunes the anterior cingulate cortex for conflict monitoring. Cerebral Cortex, 22 (9): 2076-2086. Crinion, J., Turner, R., Grogan, A., Hanakawa, T., Noppeney, U., Devlin, J. T., ... & Usui, K. (2006). Language control in the bilingual brain. Science, 312(5779), 1537-1540.

E64 Changing our Brains and Minds: The effect of the bilingual experience on neural structure

Vincent DeLuca[1], Christos Pliatsikas[1], Jason Rothman[1,2], Ellen Bialystok[3]; [1]University of Reading, [2]UiT The Arctic University of Norway, [3]York University

Current research suggests that speaking more than one language affects the structure of the brain and potentially cognitive processes related to executive control (Bialystok, 2016a, b). However, the connection between bilingualism and neurocognitive changes is not well understood, and results across studies are inconsistent regarding both neurological (García-Pentón et al., 2015; Pliatsikas & Luk, 2016) and cognitive effects (Valian, 2015). The variability in results between studies likely stems in small part from the fact that bilingualism is operationalized as a categorical variable, or only one experience-based factor is examined (e.g. age of second language acquisition), inevitably collapsing other factors across one another (Luk & Bialystok, 2013; Luk & Pliatsikas, 2016)). It is likely that

changes in language behavior are linked to changes in the brain as an effect of second language (L2) acquisition and use (Abutalebi & Green, 2016) and these outcomes are modulated through time as non-native language experience and ability changes (Grundy, Anderson, & Bialystok, 2017). This ongoing project examines bilingualism as a spectrum, specifically assessing the effect of specific factors within the bilingual experience, using a combination of behavioral and neuroimaging (MRI) methods. Typically developing bilingual participants (current n=24, projected n= 60+; m age= 32.88yrs, SD= 6.86) were scanned, completed an English proficiency test (the Oxford QPT; Geranpayeh, 2003), and a language background questionnaire (LBQ) (Luk & Bialystok, 2013). T1-weighted and T2-weighted images were acquired. Demographics from the LBQ, including length of second language (L2) immersion, and L2 age of acquisition (L2 AoA), were run as predictors in analyses on the acquired structural data using the VBM (Ashburner & Friston, 2000), TBSS (Smith et al., 2006), and FIRST (Patenaude, Smith, Kennedy, & Jenkinson, 2011) pipelines in FSL. Not surprisingly, L2 proficiency was found to be highly predicted by L2 AoA ($p<.0001$), thus was not included in the model. Results of VBM analysis showed length of immersion and L2 AoA to significantly predict grey matter volume (GMV) change in several areas of the brain including bilaterally the VIIb and crus of the cerebellum, anterior cingulate cortex, and left inferior frontal gyrus ($p<.004$, corrected). TBSS analysis showed fractional anisotropy (FA) value increases across the brain to also significantly correlate with length of immersion including the bilateral posterior section of the corpus callosum ($p<.002$, corrected). Results of the FIRST analysis showed contractions in the left hippocampus and left globus pallidus were found to be significantly predicted by length of immersion (all ps<.05 corrected), but not L2 AoA. The GMV and FA value increases support the proposals of the Bilingual Anterior to Posterior and Subcortical Shift (BAPSS) model (Grundy et al., 2017), suggesting that increased/sustained exposure to the L2 results in increased and more efficient use of subcortical and posterior regions, including the corpus callosum and cerebellum. The contractions in the globus pallidus, related to immersion, suggest more efficient phonological control processes (Abutalebi and Green, 2016). The results also indicate that bilingualism is a dynamic process which crucially is modulated through time with changes to linguistic exposure and use.

E65 Individual Difference-Related Neuroplasticity during Second Language Training

Jennifer Legault[1], Angela Grant[1], Shin-Yi Fang[1], Ping Li[1]; [1]The Pennsylvania State University

Second language (L2) learning is associated with a variety of learning-induced brain changes, including changes in functional activity, functional and structural connectivity, and gray matter (GM) structure. Essential to understanding this relationship between neuroplasticity and language learning is the examination of the time course of these brain changes and how they vary with individual differences in native language (L1), L2, and cognitive control performance. The current longitudinal structural magnetic resonance imaging (sMRI) study examines changes in cortical thickness (CT) and gray matter volume (GMV) in English late intermediate-level learners across one academic year of Spanish classroom training. English and Spanish performance was assessed through English and Spanish lexical decision (LD) tasks at two time points during L2 training. During these sessions, sMRI scans were conducted to measure CT and GMV. The Flanker task was administered before training to identify individual differences in cognitive control. We used Freesurfer's longitudinal mixed effects (LME; Bernal-Rusiel, Greve, Reuter, Fischl, & Sabuncu, 2012) modeling to examine gray matter changes and their relationship with behavioral measures in a priori designated regions of interest (ROIs). These ROIs were determined based on changes in functional brain networks across LD tasks during L2 training, as reported in a previous publication (Grant, Fang, & Li, 2015). Results from our LME analyses indicated that L1 and L2 performance were positively correlated with GM structure only after L2 training. Our results indicate different regions in this network were associated with L1 versus L2 performance: English LD performance (L1) was positively associated with right middle temporal gyrus CT, whereas Spanish LD performance (L2) was positively associated with right inferior frontal gyrus (IFG), anterior cingulate cortex (ACC), and middle frontal gyrus (MFG) CT. Interestingly, our previous fMRI study found Spanish LD performance to be associated with increased neural activity in the left IFG and MFG and decreased activity in the left ACC (Grant et al., 2015). Further examination into possible laterality differences between functional and structural changes can help our understanding of the relationship between functional and structural correlates of L2 acquisition. Moreover, we found greater CT in the left IFG after L2 training was associated with a lower flanker effect (indicative of greater inhibitory control). This pattern of association is particularly interesting since according to Grant et al. (2015) the functional activity in the left IFG was associated with greater flanker effect (less inhibitory control) at the beginning of training but not after L2 training. Together, these findings point to an important relationship between the IFG, cognitive control, and L2 experience in both functional and structural brain changes. The current findings add to the current literature by helping to tease apart interactions between L1 and L2 performance, cognitive performance, and GM structure over time in late L2 learners.

E66 Cortical thickness differs between bilinguals and monolinguals according to age of acquisition

Hannah Claussenius-Kalman[1], Pilar Archila-Suerte[1], Kelly A. Vaughn[1], Arturo E. Hernandez[1]; [1]University of Houston

This study aimed to investigate the relationship between second language (L2) age of acquisition (AoA) and brain structure by examining cortical thickness in a large group of bilinguals and monolinguals. Data were analyzed from eight fMRI studies at CAMRI at Baylor College of Medicine. Of 376 participants, brain scans of 364 participants were included. Six brain scans were removed due to reconstruction issues, five due to technical fMRI scanning issues, and one due to brain trauma. Brains were constructed and manually edited using FreeSurfer. Whole-brain analyses were conducted using ANOVA in QDEC to determine differences in cortical thickness according to AoA, which was grouped by simultaneous bilingual (AoA < 3; n = 26), early bilingual (AoA 4-6; n = 107), late bilingual (AoA > 7; n = 78), and monolingual (n = 153). Late bilinguals relative to monolinguals had increased cortical thickness in the left inferior parietal lobule (IPL), inferior temporal gyrus (ITG), transverse temporal gyrus (TTG), medial orbitofrontal cortex (OFC), superior frontal gyrus (SFG), right lateral occipital lobe, middle temporal gyrus (MTG), and bilateral superior temporal gyrus (STG). Late bilinguals relative to simultaneous bilinguals had increased cortical thickness in the bilateral IPL, left caudal middle frontal gyrus (MFG), SMG, medial OFC, right SFG, and lateral occipital lobe (FWE-corrected $p < .05$). No significant differences were found for monolinguals versus bilinguals, nor for monolingual versus simultaneous, monolingual versus early, simultaneous versus early, or early versus late. Using a large dataset, the present study confirms previous results showing differences in cortical thickness associated with bilingualism. Overall, increased cortical thickness for late bilinguals relative to monolinguals in the left SFG, IPL, and medial OFC may indicate connections to a fronto-parietal network. Frontal regions are commonly associated with cognitive control and working memory, while the parietal cortex is involved in visuospatial processing and attention. Research has shown that bilinguals have greater grey matter density in the left IPL (Stein et al., 2014), which is implicated in phonological working memory and lexical learning. In addition, differences in frontal and parietal regions were found for late bilinguals relative to simultaneous bilinguals, where late bilinguals had greater cortical thickness in the left SMG, medial OFC, caudal MFG (which encompasses the DLPFC), right SFG, and bilateral IPL. This is in line with models of bilingualism that associate the DLPFC and other frontal areas with language control and switching. One possible explanation is that the cortex, especially the frontal regions, finishes developing later than subcortical structures, so late bilinguals may rely on these structures more than simultaneous bilinguals during L2 acquisition (see sensorimotor hypothesis, Hernandez & Li, 2007). Finally, late bilinguals relative to monolinguals showed differences in temporal thickness (bilateral STG, right TTG, right MTG, and left ITG), but late bilinguals relative to simultaneous bilinguals did not. This may be due to prolonged plasticity of the temporal lobe. As a whole, these findings suggest a relationship between later AoA and the neuroanatomy of frontal and parietal areas, which are commonly associated with language processing and cognitive control.

E67 How experience with different prosodies shapes the bilingual brain: preliminary connectivity analyses from English-French bilinguals.

Annie Gilbert[1,2], Shanna Kousaie[1,2,3], Max Wolpert[1,2], Denise Klein[1,2,3], Shari R. Baum[1,2]; [1]Centre for Research on Brain, Language, and Music, Canada, [2]McGill University, Canada, [3]Montreal Neurological Institute and Hospital, Canada

A growing body of literature demonstrates that different bilingual experiences (for example, learning two languages from birth vs learning a second language as an adult, or learning different language pairs) will not only lead to different behavioral outcomes (i.e. proficiency differences), but will also have an impact on brain structures (Klein, Mok, Chen & Watkins, 2014, Kousaie, Chai, Sander & Klein, accepted). The goal of the present study is to investigate this behaviour-brain relationship in bilinguals by examining speakers' production of specific prosodic parameters, and how this ability might be related to brain connectivity patterns. Our previous behavioural work examining the production of prosodic cues by bilingual English-French speakers revealed that speakers who are dominant in English (more proficient in English compared to French) produce different duration patterns than speakers not dominant in English (French-dominant or balanced bilingual speakers). Using a semi-spontaneous production task, we demonstrated that English-dominant speakers produce different lengthening durations for lexical stress and phrase final lengthening (with non-stressed phrase final syllables being on average slightly longer than non-final stressed syllables), whereas non-English dominant speakers tend to produce syllables with the same duration in both cases (Gilbert, Wolpert, Kousaie & Baum, 2017). This difference might be caused by the absence of lexically-coded prosody in French, meaning that French speakers have no (or limited) experience in controlling prosody at the lexical and phrasal level simultaneously, which not only contributes to a perceived foreign accent, but may even render speech hard to interpret and yield ambiguities in their English production. A subset of 16 participants from the above cited experiment also completed a resting-state functional magnetic imaging scan (rs-fMRI) to examine brain connectivity associated with the observed duration production results. The rs-fMRI data were analyzed using a seed-to-voxel approach. Seed regions were selected from Domahs et al. (2013), who identified brain regions involved in lexical stress processing (mainly the left and right superior temporal gyri - STG). Preliminary analyses show that speakers' modulation of the duration parameter can predict the connectivity between the bilateral STG and other brain regions, including regions related to language processing and motor control. One finding of particular interest is

the observed connectivity between the left and right STG and the bilateral supplementary motor area (SMA). The production of duration modulations was correlated with the strength of connectivity between both the left and right STG seeds and the bilateral SMA. That is, participants with the most native-like syllable durations in English sentence production showed the strongest connectivity between these regions, whereas participants who were not producing different duration patterns for stress and phrase boundaries had weaker connectivity between the same brain regions. These results support the idea that not only general bilingual experience, but also the specific languages involved may have an impact on both behaviour and functional brain connectivity. Further analyses are in progress to explore connectivity across additional brain regions associated with prosodic production.

Signed Language and Gesture

E68 Neural signatures of sign language processing in bimodal bilinguals

Brendan Costello[1], Pedro Paz-Alonso[1], Manuel Carreiras[1,2,3]; [1]BCBL, Donostia-San Sebastian, Spain, [2]Ikerbasque, Basque Foundation for Science, Bilbao, Spain, [3]University of the Basque Country, Spain

Sign language (SL) provides the opportunity to examine modality effects in language processing. Previous neuroimaging evidence has shown that SL recruits a similar set of left-lateralized perisylvian regions to those engaged in spoken languages, including the inferior frontal gyrus (IFG). However, there are still many unanswered questions regarding the functional signatures of SL processing: Does regional engagement of left-lateralized perisylvian regions during language processing differ as a function of modality? Is there a specific functional signature of SL processing? To what extent does language processing rely on different neural dynamics as a function of being a native versus a L2 signer? The present fMRI study sought to investigate these questions in three different groups of hearing bilinguals: 23 native Spanish Sign Language (LSE)-Spanish bilinguals, 20 late LSE-Spanish bilinguals and 23 bilingual controls with no knowledge of LSE. In an event-related design, participants processed LSE signs, presented as (silent) videos, and Spanish words, presented either aurally (sound only) or audiovisually (a video of a model saying the word with sound). Each of these three types of stimuli was contrasted against corresponding baselines, consisting of scrambled video and/or rotated speech. A low-level visual perceptual task (indicating the orientation of an arrow that appeared on 10% of trials) was used to ensure that participants maintained attention on the stimuli; these trials were excluded from the analysis. Results confirmed that SL and spoken language recruited a similar set of left-perisylvian regions. Nevertheless, signers exhibited significant stronger regional engagement for SL processing than for spoken language processing across left-perisylvian nodes, including the IFG pars triangularis and opercularis, posterior temporal gyrus and parietal cortex. Importantly, compared to sign-naïve controls, signers exhibited reliable stronger activation in left IFG and posterior temporal gyrus extended to the supramarginal gyrus, as well as tighter functional coupling among these regions, during SL processing. Finally, L2 signers showed stronger recruitment of right superior parietal cortex (SPC) and stronger functional connectivity between right SPC-left posterior temporal gyrus for processing signs relative to native signers. These results constitute the strongest evidence so far showing differential regional and functional connectivity signatures of SL processing between signers and non-signers and between native and late signers hearing bilinguals.

Computational Approaches

E69 A computational account of word representation and processing in bilingual individuals

Claudia Penaloza[1], Uli Grasemann[2], Risto Miikkulainen[2], Swathi Kiran[1]; [1]Boston University, [2]The University of Texas at Austin

Bilingualism is exponentially increasing worldwide due to mass immigration and globalization. Nonetheless, there are no guidelines for the optimal rehabilitation of bilingual adults with aphasia (BAA). The possible language combinations in BAA, their relative competency in the two languages, and the effect of brain damage on their bilingual language representation among other factors contribute to the paucity of research in this field. It is, however, unfeasible to examine these issues clinically without large scale longitudinal studies in this population. As a potential solution to this problem, we have developed a computational model that will make a systematic examination of lexical access and treatment effects in BAA possible. The model is based on DISLEX, a simulation of lexical access based on self-organizing maps. The maps are trained to represent either semantic or phonological symbols, and are linked by adaptive associative connections that translate between semantic and phonetic representations. Following the revised hierarchical model (Kroll & Stewart, 1994), the extended bilingual DISLEX model consists of three interconnected maps: one for semantic symbols, and one phonological map for L1 and L2. By varying the timing and intensity of network training, the model can simulate a bilingual language system in which language representations and lexical access vary by age, age of acquisition (AoA), and relative proficiency (e.g., AoA effects are simulated by delaying L2 training to match healthy bilinguals). Using our preliminary computational model as the starting point (Kiran, Grasemann, Sandberg, & Miikkulainen, 2013), we extended the basic architecture of the model to accommodate a larger semantic/lexical representation database. Using data from MTURK and another ongoing research collaboration (Kiran, CoPI, Title: Funding: ASHA multicultural activities grant), we incorporated a database of 651 unique words in English (and corresponding translations in Spanish). Each word belongs to one

of 13 categories (e.g., animals, body parts, furniture) represented in the semantic space of the computational model. Corresponding English and Spanish phonetic representations (transcribed in IPA) are represented in the English and Spanish representations of the model. Additionally, each of the 651 items is represented by a set of semantic attributes (10-20 features per item) normed on healthy adults using MTURK. Thus, for each feature for each item (e.g. ant), we have a value of the probability of certainty of the feature being applicable to that particular item (e.g., moves: yes; 100%; has legs: yes, 94%; swims: no, 94%). The computational model is currently fully functional and can simulate healthy bilinguals. We have also collected data from healthy bilingual participants and utilized existing data from BAA to validate the computational architecture. In future research, the resulting models of healthy bilinguals can then be lesioned systematically to simulate the damage leading to bilingual aphasia. Retraining lesioned models in one language or the other could help understand the influence of pre-morbid language proficiency, AoA, and other factors on treatment outcomes.

Perception: Orthographic and Other Visual Processes

E70 Learning a new alphabet: Identifying changes in neural representations

Robert W Wiley[1], Brenda Rapp[1]; [1]Johns Hopkins University

Introduction: In alphabetic systems, learning to identify letters and map their identities to the sounds they represent is a key step to literacy. Recent work has investigated the neural underpinnings of various types of letter representations, both abstract and modality-specific (visual, phonological, and motoric). The longitudinal study reported here uses multivoxel pattern analysis (MVPA) to further our understanding of how different letter representations come to be instantiated in the brain by examining changes in the neural responses of adult second-language learners before and after training with Arabic letters. This fMRI study seeks to identify: 1) which brain areas show significant learning-related changes; 2) what types of letter representations are instantiated in these areas and 3) how the neural representations of Arabic letters compare to those for Roman letters. Methods: 16 native English speakers (ages 18-33) underwent a training study during which they learned to identify 34 Arabic letter-shapes representing 20 unique identities. Participants were trained in one-hour sessions until reaching criterion, or for a maximum of six sessions. Participants were scanned before and after training, completing a visual word form area (VWFA) localizer task and a symbol detection task, both of which included Arabic and Roman letter stimuli. Regions of interest (ROIs) were identified by comparing group activation from the VWFA localizer (Arabic >> checkerboards) at post vs. pre-training. MVPA was applied to the ROIs using data from the symbol detection task to identify and track different types of letter representations (visual, phonological, motoric and symbolic). Linear mixed-effects modeling (LMEM) was used to determine which types of representations best explain the observed patterns of neural activity, and to perform tests of statistical significance across regions, time-points, and alphabets. Results: 22 regions in which learning occurred were identified, indicating wide-spread neural changes in: bilateral medial and anterior ventral occipital-temporal cortex (vOTC), extrastriate cortex, Brodmann areas 44 and 45, supramarginal gyri, and left premotor and supplementary motor cortex. Among these regions, analyses revealed significant effects of time-point, hemisphere, and/or alphabet for different representational types. For example, bilateral vOTC represented visual information for Arabic letters and did so more after training, whereas this same ROI did not represent visual information for Roman letters. Additionally, there was a significant hemisphere by time-point interaction indicating an increase in the phonological/symbolic representations of Arabic letters in the left, but not the right, vOTC. Summary: The novel application of MVPA and LMEM analyses to a longitudinal letter learning study reveals that learning to identify Arabic letters: 1) produces changes in BOLD response in a widespread set of regions; 2) these regions show patterns of activity indicating the learning of multiple types of letter representations including visual, motoric, and phonological/symbolic; and 3) the regions that show the greatest change in response to learning Arabic letters do not necessarily represent the same informational content for both alphabets. The differences between the neural instantiation of representations for the two alphabets may be due either to differences in their unique properties, or the nature of letter representations at different learning stages.

Perception: Speech Perception and Audiovisual Integration

E71 White matter matters: aging of the arcuate fasciculus and middle longitudinal fasciculus and their impact on hearing and speech perception

Pascale Tremblay[1], Maxime Perron[1], Isabelle Deschamps[1], Daniel Kennedy-Higgins[2], Anthony S. Dick[3], Maxime Descoteaux[4]; [1]Université Laval, [2]University College London, [3]Florida International University, [4]Université de Sherbrooke

INTRODUCTION. The aging human brain experiences significant white matter (WM) changes. Such changes have been linked with cognitive decline. In this study, we used High Angular Resolution Diffusion Images (HARDI) with advanced tractography methods to investigate aging of two WM tracts that are thought to be involved in speech and language functions, the arcuate fasciculus (AF), with its three components (anterior, posterior and direct) and the middle longitudinal fasciculus (MdLF),

with its two different components, one connecting the temporal pole (TP) to the inferior parietal lobule (IPL) and one connecting TP to the superior parietal lobule (SPL) (Makris et al., 2013). METHODS. 14 young and 15 older cognitively healthy adults were recruited. They underwent a hearing evaluation and completed an auditory syllable discrimination task. Using a Philips 3.0 Tesla Achieva TX, a MPRAGE (1 mm3 and a HARDI sequence were acquired (TR = 8,5 ms; TE = 76.7 ms; b=1500 s/m2, 60 directions, 128 volume, no gap, 1.8 mm). Image preprocessing was completed using Freesurfer and FSL. Tractography analyses were computed using DIPY (Descoteaux et al., 2008; Garyfallidis et al., 2014). Here we report the results for the fractional anisotropy (FA) and radial diffusivity (RD). PRELIMINARY FINDINGS. We could track all components of the AF and MdLF in all participants. AF. For FA, a mixed-model ANOVA showed a main effect of Group ($F(1,26) = 18.17$, ≤ .001, $\eta 2 = .41$) and an interaction between Tracts (direct, anterior, posterior) and Group (young, older) ($F(2,52) = 6.79$, $p = .002$, $\eta 2 = .21$), which revealed a stronger age difference in the posterior tract. A 3-way interaction was found between Group, Tracts and Hemisphere ($F(2,52) = 4.69$, $p = .013$, $\eta 2 = .15$). In the anterior and posterior tracts, age-related decline was bilateral while it was unilateral (left) in the direct tract. For RD, the ANOVA showed a main effect of Group ($F(1,26) = 15.88$, ≤ .001, $\eta 2 = .38$) and an interaction between Tracts and Group ($F(2,52) = 3.7$, $p = .032$, $\eta 2 = .12$), which revealed a stronger age difference in the posterior component. MdLF. For FA, the ANOVA showed a main effect of Group ($F(1,27) = 29.19$, $p \leq .001$, $\eta 2 = .52$), as well as an interaction between Tracts (IPL, SPL) and Group, which revealed a stronger age difference in IPL ($F(1,27) = 21.42$, $p \leq .001$, $\eta 2 = .442$). No hemisphere effect was found. For RD, there was a main effect of Group ($F(1,27) = 16.95$, $p \leq .001$, $\eta 2 = .39$), and an interaction between Tracts and Group, which revealed a stronger age difference in SPL ($F(1,27) = 5.03$, $p = .033$, $\eta 2 = .157$). No hemisphere effect was found. CONCLUSIONS. Analyses are currently underway to examine whether these age differences in WM can explain age differences in hearing and speech perception. We expect that these differences in WM integrity result in an impairment in neural signal conduction in key speech and language networks of the brain leading to speech deficits.

E72 Sensitivity to phonetic competition in People with Aphasia

Kathrin Rothermich[1], David Saltzman[1], Xin Xie[2], Emily Myers[1,3]; [1]University of Connecticut, [2]University of Rochester, [3]Haskins Laboratories

Speech perception deficits are common across different types of aphasia, and neurobiological models of language have indicated that deficits concerning mapping the speech signal to meaning occur mainly following lesions in the temporal lobes (Hickok and Poeppel, 2004, 2007). However, other lesion studies have shown that damage to left frontal brain areas can lead to impairments in certain speech perception tasks, especially when stimulus materials involve phonetic competition (i.e., between similar speech sounds; Utman et al., 2001; Misiurski et al., 2005). Recent fMRI studies confirm this view by showing that the left inferior frontal gyrus (LIFG) is activated when resolving phonetic competition (Myers, 2007; Myers & Blumstein, 2008; Xie & Myers, submitted), while the left temporal lobe responds to less phonetically competitive speech (Myers, 2007). Our main goal in this study is to shed light on the division of labor between temporal and frontal areas during speech processing, specifically investigating the hypothesis that frontal regions play a key role in resolving lexical competition when the signal is phonetically more ambiguous. The current study examines the effect of aphasia following left-hemispheric lesions on the performance of resolving phonetic competition in connected speech in a naturalistic task. Fluent and non-fluent people with aphasia (PWA, N=10) as well as undergraduate students (N=13) listened to nonsensical sentences and indicated whether a target word was part of a sentence or not. Importantly, the natural variation of phonetic competition in these sentences was manipulated by exploiting variation in speech register, where conversational speech tends to have more phonetic competition and clear (i.e., hyperarticulated) speech minimizes phonetic competition. PWA were between 53-72 years of age and with chronic aphasia and a mix of aphasia types (anomic, Broca's, and conduction aphasia). Severity was assessed via the Boston Diagnostic Aphasia Examination (BDAE) battery and as well as using subtests taken from the Psycholinguistic Assessments of Language Processing in Aphasia (PALPA). Brain lesions were identified from high-resolution T1-weighted MRI scans using manual lesion mapping in MRIcron as well as by a semi-automated procedure (Lesion Identification with Neighborhood Data Analysis; Pustina et al., 2016). In typical undergraduates, we observe a significant advantage for clear speech in terms of percent accuracy (casual: 88 %; clear: 92 %), but no effect for reaction time (RT). In PWA, we see overall lower accuracy and no consistent advantage for clear speech (casual: 68 %; clear: 70 %), which seems to depend on severity. Perhaps surprisingly, PWA profit less from clear speech, which may stem from an inability to integrate fine-grained phonetic information with lexical content. To understand the exact contribution of frontal and/or temporal areas, Voxel Lesion Symptom Mapping approaches will be used further assess the relationship between specific lesion sites and task performance.

E73 Reading at the speed of speech: Convergence between visual and auditory language perception at 5 Hz

Benjamin Gagl[1,2], Julius Golch[1], Stefan Hawelka[3], Jona Sassenhagen[1], David Poeppel[4,5], Christian J. Fiebach[1,2]; [1]Department of Psychology, Goethe University Frankfurt, Frankfurt am Main, Germany, [2]Center for Individual Development and Adaptive Education of Children at Risk (IDeA), Frankfurt am Main, Germany, [3]Centre for Cognitive Neuroscience, University of Salzburg, Salzburg, Austria,

[4]Max Planck Institute for Empirical Aesthetics, Frankfurt am Main, Germany, [5]Department of Psychology, New York University, USA

Across languages, the speech signal is characterized by a ~4-5 Hz rhythm in the amplitude modulation spectrum (Ding et al., 2017). It is suggested that during comprehension, this temporal structure drives brain activity in the language system, reflecting the processing of linguistic information chunks every 200 ms. Interestingly, this is the typical eye-fixation duration in reading. To investigate this observation systematically, we first estimated the individual sampling frequency of 50 German-native speakers during reading sentences and scanning of z-strings (as a non-linguistic control task; note that several empirical investigations showed that the eye movement scan path, i.e. where the eyes fixate, is very similar in both tasks, z-string scanning and reading). For sentence reading, the individual sampling rate varied around 5 Hz, i.e., in the same frequency range as spoken language, with a low standard deviation of 0.6 Hz. In z-string-scanning, in contrast, the sampling frequency was significantly lower, i.e., 4 Hz, with a higher variance (0.8 Hz). This result suggests a remarkable temporal alignment of the information uptake in reading and speech processing. The eye movement-sampling rate in the non-linguistic task more likely reflects a mean rate at which humans reorient attention, which was identified in previous research at around 4 Hz. To substantiate and further elaborate this empirical finding, we then conducted a meta-analysis of eye-tracking studies of natural reading (83 studies between 2006 and 2016; N=772 fixation durations; FD). This analysis converges with our experimental finding, by demonstrating that the predominant fixation-based sampling frequency for German is 5.1 Hz (12 studies; 36 fixation durations). Across different languages the frequency varied between 4-5.3 Hz, with systematic differences between languages arguably reflecting the difficulty of the writing systems. For example, Chinese, a character-based writing system for which sufficiently many original studies were available (12 studies; 112 fixation durations) showed significantly lower sampling rates (i.e., 4.0 Hz) then alphabetic writing systems (Italian, English, Dutch, Spanish, Hebrew, German, Finnish, Japanese, French and Thai; average sampling frequency: ~4.5 Hz). Within alphabetic writing systems, the letter-to-sound transparency of the writing system significantly influenced the sampling frequency of reading, such that transparent languages (e.g., Dutch, German) showed sampling frequencies around 5 Hz, while opaque orthographies like English had sampling frequencies as low as 4.5 Hz. Combined, this set of results indicates that the speed of speech is reflected in the rate at which our eyes sample visual information in reading in transparent writing systems. In contrast, when encoding of the writing system becomes more difficult, the sampling rate is reduced. The present results thus invite the hypothesis that a language system, relevant for speech perception, drives voluntary eye-movements in reading, presumably to supply linguistic information in chunks at an optimal rate, ~5 Hz, reflecting a common 'uptake rate' for linguistic information.

E74 Differences in hearing acuity among "normal-hearing" young adults modulate the neural basis for speech comprehension *Yune Lee[1], Arthur Wingfield[2], Nam-Eun Min[3], Charles Jester[3], Ethan Kotloff[3], Murray Grossman[3], Jonathan Peelle[4]; [1]Department of Speech and Hearing Science, The Ohio State University, Columbus OH USA, [2]Volen National Center for Complex Systems, Brandeis University, Waltham MA USA, [3]Department of Neurology and Penn Frontotemporal Degeneration Center, University of Pennsylvania, Philadelphia PA USA, [4]Department of Otolaryngology, Washington University in St. Louis, St. Louis MO USA*

Speech comprehension requires perceiving a complex acoustic signal, and then performing linguistic operations to extract the correct meaning. We used fMRI to monitor human brain activity while adults aged 18–41 listened to spoken sentences for comprehension. All participants self-reported normal hearing, confirmed by audiometric testing, albeit with some variation within a clinically normal range. The sentences varied in their level of syntactic processing demands, containing either subject-relative or object-relative center-embedded clauses. As expected, participants showed activity related to sentence processing in a left-lateralized frontotemporal network. Although accuracy was generally high, participants still made errors, which were associated with increased activity in bilateral cingulo-opercular and frontoparietal attention networks. A whole-brain regression analysis revealed that activity in a right anterior prefrontal portion of the frontoparietal attention network was related to individual differences in hearing acuity, such that listeners with poorer hearing showed greater recruitment of this region when successfully understanding a sentence. Although left perisylvian activation was greater for syntactically complex sentences than for simpler sentences, right anterior prefrontal recruitment did not differ as a function of sentence type, suggesting a general mechanism that is independent of linguistic processing demands. Our results suggest that even modest variations in hearing ability can impact the systems supporting speech comprehension, and that auditory sentence comprehension in healthy adults entails the coordination of a left perisylvian network that is sensitive to grammatical complexity, and an executive attention network that responds to acoustic challenge.

E75 The importance of cognitive plasticity and speaker's voice in adaptation to distorted speech stimuli. *Dan Kennedy-Higgins[1], Joseph T. Devlin[2], Patti Adank[1]; [1]Department of Speech, Hearing & Phonetic Sciences, University College London, UK, [2]Department of Experimental Psychology, University College London, UK*

Everyday communication occurs in the presence of a myriad of distortions that all combine to make speech perception challenging. Whilst speech comprehension is often slower and less efficient in adverse listening conditions, listeners demonstrate significant and rapid plasticity in adaptation to the degraded incoming signal. Results of previous functional imaging studies suggest that individual differences in this rapid adaptation is dependent on the recruitment of higher level language areas beyond the temporal gyrus. Whilst activation in this region is important, the recruitment of the left inferior frontal, ventral premotor and inferior parietal regions is associated with greater levels of adaptation to distorted speech stimuli (Adank & Devlin, 2010; Davis & Johnsrude, 2003) with particular importance placed on the functional links that exist between these regions (Eisner, McGettigan, Faulkner, Rosen, & Scott, 2010). We aimed to investigate how behaviourally robust this system is in three ways, first, by using a within-group design (n=90) to examine how participants adapt to three different types of manipulations, noise-vocoding, time-compression, and speech in noise. Second, we examined the effect of mixed-speaker presentation on adaptation to distorted speech. Third, we investigated if and how individual differences in performance on an array of cognitive tasks links to perceptual adaptation to distorted speech. Following a battery of audiological and cognitive assessments, 90 participants (average age 21.4years +/- 2.74; 65 female) completed a speeded sentence verification task for sentences consisting of a noun plus predicate (e.g. Admirals are people/Admirals have fins). Sentences were blocked by distortion condition, with participants hearing 48 sentences per block (192 overall). Four different types of speech were used: clear (baseline); noise-vocoded (4 channel); time compressed (to 40% of original length) and speech in noise (-4dB SNR), in a counterbalanced order with the clear condition always presented first. Sentences were produced by four male speakers of southern British English. Accuracy and reaction times were used as indicators of adaptation. Participants adapted most to the time-compressed condition, followed by the noise condition with no adaptation occurring in the noise-vocoded condition. The results further showed that adaptation was speaker-specific, with listeners adapting to varying degrees across the four speakers. Lastly, greater overall performance was linked most closely to individual differences in performance on measures of executive functioning (e.g. working memory and vocabulary knowledge). These results suggest that cognitive mechanisms for adapting to distorted speech are affected by the type of distortion, but that the extent to which an individual adapts also depends on the speaker they are listening to as well as their individual cognitive flexibility. References: Adank, P., & Devlin, J. T. (2010). On-line plasticity in spoken sentence comprehension: Adapting to time-compressed speech. NeuroImage, 49(1), 1124-1132. doi: https://doi.org/10.1016/j.neuroimage.2009.07.032

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E76 Neural responses to environmental sounds in sentence context

Sophia Uddin[1], Shannon Heald[1], Howard Nusbaum[1]; [1]University of Chicago

Despite the fact that environmental sounds are acoustically distinct from speech, in prior studies we have found that they are quickly and easily recognized and understood in sentence context. The results show that listeners can use linguistic context to aid in understanding these sounds in much the same way as for spoken words. Given that similar behavior can arise from different neural mechanisms, we conducted an ERP study to assess N400 responses to these sounds and spoken words in sentence contexts. Listeners heard sentences ending in either an environmental sound or a spoken word. In half the sentences, the last item made sense with the preceding context ("meaningful"), and in half it did not ("nonsense"). Replicating many prior studies, nonsense sentences ending in words produced a stronger central negativity corresponding to the typical N400 than meaningful sentences (consistent with previous literature). By comparison, environmental sounds elicited two phasic ERP responses with similar scalp distribution in the same time window. The earlier response varied with meaningfulness, with a stronger negativity for nonsense sentences. The fact that the N400 is not higher-amplitude for sounds than for words suggests that listeners do not automatically treat the presence of meaningful nonspeech sounds in sentence context as nonsense. Results suggest that mechanisms for sentence understanding may be more flexible than thought previously, while some ERP differences between sounds and words may reflect relative unfamiliarity with recognizing environmental sounds in spoken sentence context.

E77 Neural correlates of sine wave speech intelligibility in human frontal and temporal cortex

Matthew Leonard[1], Sattar Khoshkhoo[1], Nima Mesgarani[2], Edward Chang[1]; [1]University of California, San Francisco, [2]Columbia University

Auditory speech comprehension is the result of neural computations that occur in a broad network that includes the temporal lobe auditory cortex and the left inferior frontal cortex. It remains unclear how representations in this network differentially contribute to speech comprehension. Here, we recorded high-density direct cortical activity during a sine wave speech (SWS) listening task to examine detailed neural speech representations when the exact same acoustic input is comprehended

versus not comprehended. Listeners heard SWS sentences (pre-exposure), followed by clear versions of the same sentences, which revealed the content of the sounds (exposure), and then the same SWS sentences again (post-exposure). Across all three task phases, high-gamma neural activity in the auditory cortex superior temporal gyrus was similar, distinguishing different words based on bottom-up acoustic features. In contrast, frontal regions were active only when the input was comprehended, which corresponded with stronger representational separability among spatiotemporal activity patterns evoked by different words. We observed this effect only in participants who were not able to comprehend the stimuli during the pre-exposure phase, indicating a direct relationship between frontal high-gamma activity and speech understanding. Together, these results demonstrate that both frontal and temporal cortical networks are involved in spoken language understanding, and that under certain listening conditions, frontal regions are involved in discriminating speech sounds.

E78 Phase entrainment of neural oscillations with tACS causally modulates fMRI responses to intelligible speech

Benedikt Zoefel[1], Alan Archer-Boyd[1], Matthew H Davis[1]; [1]MRC Cognition and Brain Sciences Unit, Cambridge, UK

Alignment between neural oscillations and speech rhythm, "entrainment", is often observed to be enhanced during speech comprehension (e.g., Peelle et al., 2013). Nevertheless, the relation between entrainment and comprehension might merely be correlational, introduced by stimulus manipulations that simultaneously reduce speech intelligibility and remove entraining cues for neural oscillations (e.g., Doelling et al., 2014). Only if we manipulate entrainment as a dependent variable and observe consequences for speech comprehension, can we can conclude that there is a causal relation between the two. This is possible using transcranial alternating current stimulation (tACS): tACS has been shown to impose a rhythm on neural oscillations (e.g., Herrmann et al., 2013) and can thus be used to manipulate entrainment in an experimental setting. However, based on behavioural measures alone, it is difficult to distinguish a specific modulation of speech processing and changes to low-level auditory processes that would affect processing of non-speech or unintelligible stimuli. We therefore combined tACS at 3.125 Hz over lateral temporal regions with concurrent fMRI to measure BOLD responses to intelligible (16-channel vocoded) and unintelligible (1-channel vocoded) rhythmic speech stimuli. Stimuli consisted of 5-syllable sentences with syllables recorded by someone speaking in time with a 3.125 Hz metronome (metronome pulses were inaudible to listeners). We manipulated entrainment by systematically varying the phase relation between tACS and speech rhythm, and measured the consequences for neural activity by comparing BOLD responses during true and sham tACS stimulation in speech-specific and auditory brain regions. We found that, for intelligible speech, the phase relation between tACS and speech rhythm significantly modulates the magnitude of the BOLD response in the Superior Temporal Gyrus (compared to a surrogate distribution). Importantly, this modulation was specific to tACS stimulation during intelligible speech; a significant interaction showed that the effect was reduced and absent for unintelligible speech and during sham stimulation. Furthermore, comparison of stimulation and sham conditions confirmed that tACS had a suppressive effect on the magnitude of the BOLD response. Our results therefore suggest that entrainment has a specific, causal influence on neural responses to intelligible speech. We anticipate that tACS may have specific neural effects on perturbing or enhancing speech perception and comprehension which we will explore in follow-up behavioural studies. These studies will further establish the causal role of neural entrainment in speech processing, and (given the BOLD suppression observed) also help to establish causal links between the magnitude of fMRI responses and speech comprehension.

Speech Motor Control and Sensorimotor Integration

E79 The Effect of Input Modality and Overt vs. Covert Production on Speech Perception in Articulatory Musculature

Naama Zur[1,2], Avi Karni[1,3], Zohar Eviatar[1,2]; [1]University of Haifa, [2]Institute of Information Processing and Decision Making, [3]Edmond J. Safra Brain Research Center for the Study of Learning Disabilities

The effects of input modality on covert and overt speech production were tested in a repetition task. The state feedback control (SFC) model suggested by Hickok, Houde, and Rong (2011) posits that speech generation involves predictions of sensory consequences to inner sensory representations of the vocal target to be conveyed, based on the state of the vocal muscles. Along these lines, the authors claim that most of speech output is based on inner representations of sensory targets, unless the target is external (could be possible if an auditory stimulus is to be repeated). In the aim to test this hypothesis, young adults were instructed to read or listen to recordings of sentences so as to consequently repeat them (repetition task). Articulatory muscle activity was recorded using surface electromyography (sEMG) in the orbicularis oris (OOI) and the thyrohyoideus (TH) muscles. The sEMG signal was analyzed in two different phases of the repetition task - stimuli presentation (input phase) and response (response phase). Both phases were compared to a baseline phase. The analysis of the results revealed reduced articulatory muscle activity compared to baseline, during the input phase. Thus, these findings show that the intention to subsequently repeat a short sentence, overtly or covertly,

significantly modulated the articulatory musculature already during listening or reading (i.e., during the input phase).

Methods

E80 Enhanced accuracy of lesion to symptom mapping with multivariate sparse canonical correlations

Dorian Pustina[1], Brian Avants[2], Olufunsho Faseyitan[1], John Medaglia[3], H. Branch Coslett[1]; [1]Department of Neurology, University of Pennsylvania, [2]Department of Radiology, University of Pennsylvania, [3]Department of Psychology, University of Pennsylvania

INTRODUCTION: Lesion to symptom mapping (LSM) is a critical tool for making inferences about the causality of brain-behavior relationships. LSM analyses are typically performed by running independent tests at each individual voxel (VLSM), also called "the mass-univariate approach". Recent studies show that VLSM might produce displaced or inaccurate results (Mah 2014, Sperber 2017, Zhang 2015). Using a different approach, multivariate methods consider all the voxels as potential predictors of behavior. From a conceptual standpoint this approach may improve the mapping of functional areas. To evaluate this hypothesis, we developed and tested a multivariate LSM method based on Sparse Canonical Correlation Analysis for Neuroimaging (SCCAN; Avants 2010, 2014). Results obtained from simulated and real data using SCCAN and VLSM were compared in their ability to detect the putative functional brain units. METHODS: Lesion maps from 131 patients with left hemispheric chronic stroke were included in the study (age: 58.2+/-11.3, months post-onset: 44+/-63, lesion size: 100+/-82 ml). To achieve simulations from known functional brain areas, we first merged three atlases (Glasser 2016, Fan 2016, Hua 2008). The lesion load of each region in the combined atlas was used to simulate the behavioral deficit of each subject. A substantial amount of noise (50%) was injected in behavioral simulations to match the typical noise of real brain-behavior relationships. LSM analyses were performed either with univariate (non-parametric Brunner-Munzel tests) or multivariate (SCCAN) methods. Several scenarios were tested, including functional units composed of one, two, and three brain regions, different sample sizes (N=20-131), and different univariate thresholding mechanisms - Bonferroni, false discovery rate (FDR), permutation-based family wise error correction (FWER). The accuracy of each method was assessed by computing (1) dice overlap, (2) average displacement, (3) center of mass displacement, and (4) peak voxel displacement, between the simulated brain region and the LSM statistical map. The accuracy scores of VLSM and SCCAN results were compared with paired Wilcoxon tests. RESULTS: SCCAN produced more accurate results compared to VLSM, typically consisting in higher dice overlap and smaller average displacement (all $p<0.001$, 93 regions tested, Figure 1). This advantage persisted at different sample sizes (N=20-131) and with different multiple comparison corrections of VLSM (FDR, Bonferroni, FWER, Figure 2). For functional units composed of multiple brain regions SCCAN identified almost all the simulated areas, while VLSM missed more simulated areas. Under no circumstance could VLSM exceed the accuracy obtained with SCCAN. Functional mapping of real aphasia scores from the Western Aphasia Battery and the Philadelphia Naming Test revealed known language-critical areas with SCCAN, while VLSM either produced diffuse maps (FDR correction) or few scattered voxels (FWER correction). CONCLUSIONS: The newly developed SCCAN mapping produces systematically more accurate results than VLSM. This method will allow researchers to collectively draw firmer conclusions on the spatial topography of cognitive systems. A new software package is made available for LSM analyses (https://dorianps.github.io/LESYMAP/). This work represents a harmonization between the statistical theory behind construct psychology and multivariate neuroimaging analysis, which defines a frontier of modern cognitive neuroscience.

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