

SNL2025

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Program

SNL2025

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SEPTEMBER 12 - 14, 2025
WASHINGTON, D.C.



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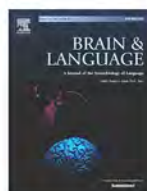
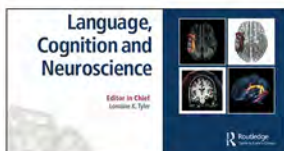


Frontiers in
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Society for the Neurobiology of Language

SNL 2025 Annual Meeting, September 12-14, 2025

Gallaudet University in Washington DC, USA

2025 Annual Meeting Program

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Schedule Overview

Friday, September 12, 2025

7:30 am - 7:30 pm	Low Stimulation Room	Ely 113
8:00 am - 6:00 pm	Registration Open	Field House
8:30 - 9:00 am	Coffee Available	Field House
8:45 - 9:00 am	Opening Remarks	Elstad Auditorium
9:00 - 10:00 am	Keynote Lecture: Fumiko Hoeft – Integrating Neural Noise and Neuroinflammatory Hypotheses: Exploring the Comorbidity of Dyslexia, Depression, and Stress	Elstad Auditorium
10:00 - 10:30 am	2025 Early Career Award Talk: Esti Blanco-Elorrieta – The neurobiology of the bilingual mind	Elstad Auditorium
10:30 - 11:00 am	2025 Dissertation Award Talk: Jacob Momsen – The Conversational Dance: Assessing the Sensorimotor Account of Multimodal Prosody	Elstad Auditorium
11:00 - 11:30 am	Coffee Available	Field House
11:00 am - 12:30 pm	Poster Session A	Field House
12:30 - 1:45 pm	Lunch Break	On Your Own
12:30 - 1:45 pm	'Lunch with a Professor' Trainee Event	Multi-Purpose Room
1:45 - 2:30 pm	Slide Session A	Elstad Auditorium
2:30 - 4:30 pm	Panel Session – Neuroplasticity in Action: Diversity in Language and Reading Across Sensory Contexts	Elstad Auditorium
4:30 - 5:00 pm	Coffee Available	Field House
4:30 - 6:00 pm	Poster Session B	Field House
6:00 - 7:45 pm	Welcome Reception – Sponsored by The University of Birmingham	Field House

Saturday, September 13, 2025

8:00 am - 6:00 pm	Registration Open	Field House
8:00 am - 7:00 pm	Low Stimulation Room	Ely 113
8:30 - 9:00 am	Coffee Available	Field House
9:00 - 9:45 am	Distinguished Career Award Talk: David Poeppel – Rhythms and algorithms: The temporal structure of linguistic experience	Elstad Auditorium
9:45 - 10:00 am	Neurobiology of Language Best Paper Award 2025	Elstad Auditorium
10:00 - 11:00 am	Slide Session B	Elstad Auditorium
11:00 - 11:30 am	Coffee Available	Field House
11:00 am - 12:30 pm	Poster Session C	Field House
12:30 - 2:00 pm	Lunch Break	On Your Own

12:30 - 2:00 pm	Lunchtime Meet and Greet with NIH	Field House
2:00 - 3:00 pm	Keynote Lecture: Fatemeh Geranmayeh – From models of language recovery after stroke to Large Language Models in stroke	Elstad Auditorium
3:00 - 5:00 pm	Symposium Session 1 – Cognitive and Linguistics Outcomes in Children with Cochlear Implants: Perspectives on Neural and Environmental Mechanisms	Elstad Auditorium
5:00 - 5:30 pm	Coffee Available	Field House
5:00 - 6:30 pm	Poster Session D	Field House
6:45 - 9:30 pm	Trainee Social Night – Sponsored by NCCR Evolving Language	Hi-Lawn (offsite)

Sunday, September 14, 2025

8:00 am - 4:00 pm	Registration Open	Field House
8:00 am - 6:00 pm	Low Stimulation Room	Ely 113
8:30 - 9:00 am	Coffee Available	Field House
9:00 - 10:00 am	Keynote Lecture: Carol Padden – The multimodal potential of human languages	Elstad Auditorium
10:00 - 10:30 am	2024 Early Career Award Talk: Adolfo M. García – Speech and language markers of neurodegeneration: Breakthroughs in automation, implementation, and diversity	Elstad Auditorium
10:30 - 11:00 am	Annual Business Meeting	Elstad Auditorium
11:00 - 11:30 am	Coffee Available	Field House
11:00 am - 12:30 pm	Poster Session E	Field House
12:30 - 1:45 pm	Lunch Break	On Your Own
1:45 - 2:45 pm	Keynote Lecture: Duane Watson – Understanding the effect of language experience on language comprehension	Elstad Auditorium
2:45 - 3:30 pm	Slide Session C	Elstad Auditorium
3:30 - 3:45 pm	Coffee Available	Field House
3:45 - 5:45 pm	Symposium Session 2 – Beyond core language: Prosody and pragmatics	Elstad Auditorium
5:45 - 6:00 pm	Closing Remarks and Outlook to SNL 2026	Elstad Auditorium

Welcome to SNL 2025

Welcome to Gallaudet University and the 2025 meeting of the Society for the Neurobiology of Language! We are excited to have the opportunity to gather in person to talk about science and build ties within our international SNL community. Our annual meeting gives us a chance to affirm our shared values for scientific research, critical thinking, and inclusivity that have guided us since our founding. We are also keenly aware of the many people in our language community who are not able to attend SNL in person, and continue to work on improving global access. As with prior years, following the conference, recordings of all talks will be made available on our website to any SNL member.

We also continue our member initiated virtual activities. So far in 2025 we have held 12 of these events, with approximately 129 attendees. We encourage you to consider organizing one of these events, and to attend others. They provide a unique way to connect to others in the field and continue our interactions beyond our annual meeting.

Gallaudet University is a fitting location for our society to convene, with a history rooted in language and inclusivity. In 1856, Amos Kendall, a postmaster general during two presidential administrations, donated two acres of his estate in northeast Washington, D.C. to establish a school and housing for 12 deaf and six blind students. He further persuaded the US Congress to provide funding. Edward Miner Gallaudet, the son of Thomas Hopkins Gallaudet, founder of the first school for deaf students in the United States, became the new school's superintendent. Today, Gallaudet University has over 1300 students and is a worldwide hub for Deaf culture, Deaf identity, and the advancement of Deaf and hard-of-hearing people globally. Gallaudet is a leader in sign language linguistics, deaf studies, accessibility, and the neurobiology of signed languages, and we are thrilled to be here.

We could not put on this conference without a cast of helping characters. Lorna Quandt, our local organizer, was instrumental in coordinating the logistics of the meeting. The Program Committee—Katrien Segaert (Chair), Valentina Borghesani, Francesca Branzi, Beth Jeffries, Simona Mancini, William Matchin, Lorna Quandt, Xin Sun, and myself—worked hard all year to deliver an outstanding scientific program and a smooth conference. And a special thanks to our team at Meeting Perfect—Shauney Wilson, Lynn Flannery, Shawna Lampkin, Kerry Miller, and Jeff Wilson—for their work with society logistics, including making sure all the many details are taken care of. We are grateful to everyone who helped make SNL 2025 a reality.

Finally, we are grateful to the many sponsors whose contributions help to support our meeting. These include the US National Institutes of Health; MIT Press; the University of Birmingham; Frontiers in Language Sciences; the Swiss National Centre of Competence in Research (NCCR) Evolving Language; and Rogue Research. Our main awards are sponsored by Brain and Language (Early Career Award and Dissertation Award) and Language, Cognition, and Neuroscience (Distinguished Career Award).

This year we are also particularly thankful for a host of new travel award sponsors who have helped facilitate trainee attendance at the meeting. These include the Journal of Cognitive Neuroscience, The Department of Chinese and Bilingual Studies (CBS) at The Hong Kong Polytechnic University, and several anonymous donors who supported The Murray Grossman Travel Award, the Sheila E. Blumstein Travel Award, the Peter Hagoort Travel award, and SNL Community Travel awards.

Wishing you a wonderful time at the conference, and don't forget to use the tag #SNL2025 on social media!!

Jonathan Peelle

Chair, Society for the Neurobiology of Language

Keynote Lecture



Fumiko Hoeft, MD, PhD

University of Connecticut

Keynote Address

Friday, September 12, 2025, 9:00 – 10:00 am, Elstad Auditorium

Chair: Xin Sun, University of British Columbia

Integrating Neural Noise and Neuroinflammatory Hypotheses: Exploring the Comorbidity of Dyslexia, Depression, and Stress

Recent advancements in our understanding of dyslexia have highlighted the complex interplay between neurobiological mechanisms and comorbid conditions such as depression and stress. The Neural Noise Hypothesis (NNH) of dyslexia proposes that dysregulated neural activity, characterized by excessive glutamatergic neurotransmission, leads to the disrupted auditory and visual processing that typifies this learning disorder. Concurrently, emerging research suggests that these neural irregularities may overlap with pathways involved in stress and depression, pointing to a shared neurobiological foundation.

This presentation explores the synthesis of the NNH with recent findings on the role of neuroinflammation in dyslexia and its comorbidities. Building on our foundational work (Hancock, Pugh, and Hoeft, TICS. 2017), and integrating recent insights into stress and mood disorders from neuroimaging studies, we propose a model where dyslexia-related neural noise may exacerbate susceptibility to depression through neuroinflammatory pathways. This model is supported by recent research by Lasnick and Hoeft (Front Hum Neurosci. 2023), which provides compelling evidence of altered neural connectivity in regions critical for emotional and stress regulation in individuals with dyslexia.

Furthermore, this talk will delve into how environmental stressors and individual resilience factors contribute to the variability in dyslexia presentations, particularly focusing on how these elements interact with neurobiological mechanisms to influence the severity and range of comorbid symptoms. By bridging gaps between disparate research domains, we aim to foster a more comprehensive understanding of dyslexia that acknowledges its potential as a multisystem disorder with significant neurobiological and psychosocial dimensions.

This integrated approach sets the stage for discussing potential interventions that target these overlapping pathways, offering hope for more effective treatments that address both the core symptoms of dyslexia and its common comorbidities.

About

Fumiko Hoeft, MD, PhD is the Campus Dean and Chief Administrative Officer of the University of Connecticut Waterbury Campus and a Professor in Psychological Sciences, Computer Science and Engineering, Educational Psychology, Mathematics, Neuroscience, Psychiatry, and Pediatrics at UConn,. She co-founded the Haskins Global Literacy Hub, which is now a collaborative partnership with Yale Child Study Center.

A leading researcher in the neuroscience of learning, she has studied reading acquisition, dyslexia, resilience, and emotional well-being for over 22 years. Initially trained as a physician in psychiatry, emergency medicine, and internal medicine, she later pursued research at Harvard, UCLA, Caltech, and Stanford, holding faculty positions at Stanford and UCSF before joining UConn in 2018.

Dr. Hoeft currently has over \$15 million in research funding as Principal Investigator, with support from NIH, NSF, USDA, and the Oak Foundation.

Her work has earned numerous honors, including awards from the International Dyslexia Association (IDA; Geschwind: 2014, Orton: 2022), Learning & the Brain Foundation (2015), International Mind, Brain & Education Society (IMBES; 2018), Society for Neuroscience (SfN; 2018), and the Connecticut Technology Council (2024), and is a nominee of the MacArthur “Genius” Award (2025). Many of these recognize her contributions to research, public engagement, and innovation in higher education.

Dr. Hoeft has published almost 200 peer-reviewed scientific articles, reviews, and book chapters and has delivered more than 300 keynotes, talks, and workshops at schools, international conferences, TEDx, and the White House. Her research has been widely featured in The New York Times, NPR, CNN, The New Yorker, and Scientific American.

Keynote Lecture



Fatemeh Geranmayeh

Imperial College London

Keynote Address

Saturday, September 13, 2025, 2:00 – 3:00 pm, Elstad Auditorium

Chair: Sophie Scott, University College London

From models of language recovery after stroke to Large Language Models in stroke

'Language' is a uniquely human faculty that not only distinguishes us from other species but also holds profound significance for individuals' identity, autonomy, and quality of life. Following a stroke, impairments in speech production and language comprehension are among the most devastating consequences, associated with poorer outcomes across virtually all post-stroke functional and quality of life measures. Understanding the organisation and recovery of speech and language has thus been a major research priority since the 19th-century foundational work of classical neuroanatomical figures.

Yet, studying language recovery remains challenging. Recovery trajectories are notoriously heterogeneous and unfold along multidimensional axes of language function. Moreover, because language function, and the broader neural architecture that supports it, is not localised but distributed, we must adopt a truly whole-brain approach to map recovery mechanisms effectively.

This calls for a reconceptualisation of how we measure and model speech production and language in the brain, particularly in the context of recovery. Whole-brain health approaches, coupled with scalable, high-resolution assessments of cognition and language, are essential. Digital cognitive tools now enable remote, longitudinal testing of language and cognition, and when combined with recent advances in automatic speech recognition, natural language processing, and large language models, promise to transform both our scientific understanding and research translation.

In this keynote, I will trace a scientific arc from traditional models of post-stroke language recovery to emerging applications of digital and computational technologies. I will discuss how integrating large-scale speech data with modern machine learning approaches may allow us not only to better characterize language recovery but also to democratise research participation and increase equity in neuroscience.

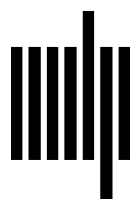
About

Dr. Fatemeh Geranmayeh is a Clinician Scientist at the Department of Brain Sciences, Imperial College London. She leads the Clinical Language & Cognition Group, focusing on post-stroke language and cognitive impairments, vascular dementia, and the deep cognitive and clinical phenotyping of patients with cerebrovascular disease. Dr. Geranmayeh's academic journey began in 2004 when she earned a First Class Honours BSc degree in Neuroscience, receiving the Goldberg-Schachmann and Freda Becker Award from the University of London. She completed her medical degree in 2006 and pursued a PhD under the mentorship of the late Professor Richard Wise, which she completed in 2015.

Her research employs advanced neuroimaging techniques to investigate the neural mechanisms underlying speech production recovery following acute stroke. In 2022, she initiated the IC3 study, a multimodal clinical study to track longitudinal cognitive and language recovery post-stroke, incorporating novel blood biomarkers, brain imaging, and automated speech recognition and cognitive assessments.

In addition to her research, Dr. Geranmayeh is a practicing neurology consultant, running a specialist vascular cognitive clinic, and co-Director of the Alzheimer's Society VIDA (Vascular and Immune contributors to Dementia) Doctoral Training Centre.

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Keynote Lecture



Carol Padden, PhD.

University of California, San Diego

Keynote Address

Sunday, September 14, 2025, 9:00 – 10:00 am, Elstad Auditorium

Chair: Lorna Quandt, Gallaudet University

The multimodal potential of human languages

The body of work on spoken language, gesture and sign language are starting to converge around understanding multimodality in language. A large part of what has driven this research in multimodality is a richer description of the diversity of sign languages around the world. Sign languages range from the very large, such as national sign languages that are used in different parts of the world such as American Sign Language but also sign languages in populous areas like India and throughout Africa. Sign languages can also be small or very small, such as those that have recently emerged in villages and families. Often described as “deaf sign languages”, the focus has been on how deafness drives the use and emergence of languages that rely on the visual modality. Less recognized is the role of hearing signers in sign language emergence

and persistence. As members of the same communities where sign languages are used, their participation sustains language learning and use across generations of signers. Hearing speakers can and do use sign language, adding to the broad repertoire of expressive possibilities in human languages. This talk will discuss cases of sign language emergence around the world, ranging from families to villages and regions, which, taken together, demonstrate the inherently multimodal flexibility of human language.

About

Carol Padden joined the faculty at University of California, San Diego in the Department of Communication in 1983, after earning a Ph.D. from the university's Department of Linguistics. She holds the Sanford I. Berman Chair in Language and Human Communication and has served as associate dean and faculty equity advisor in the School of Social Sciences from 2008 to 2013. In 2014, she became the Dean and leads a dynamic and highly ranked School spanning 11 academic departments and 5 interdisciplinary programs. Padden's areas of research include language emergence and sign language structure. With her husband, Professor Tom Humphries, she is a co-author of 2 textbooks on American Sign Language and 2 books on deaf communities in the US. She is a Fellow of the Linguistic Society of America and the American Academy for the Advancement of Science. In 2010, she received a MacArthur Fellowship.

Keynote Lecture



Duane Watson, PhD.

Vanderbilt University

Keynote Address

Sunday, September 14, 2025, 1:30 – 2:30 pm, Elstad Auditorium

Chair: Simona Mancini, Basque Center on Cognition, Brain, and Language

Understanding the effect of language experience on language comprehension

The language we experience every day is critical for language learning and vocabulary growth in children, as well as language use in adults. However, psycholinguists have traditionally measured language experience by aggregating over populations. In this talk, I will share experimental evidence suggesting that an individual's specific experience with language is linked to their preferences for different constructions. By using natural language processing tools to analyze the linguistic properties of participants' favorite websites, we compare effects of internet reading habits to effects of cognitive factors such as working memory and inhibitory control on reading difficulty. Consistent with statistical models of language comprehension, we find that adults'

everyday language experiences, from digital media to linguistic dialects, predict language processing.

About

Duane Watson is the Vice Provost for Special Initiatives and the Frank W. Mayborn Chair of Psychology and Human Development at Vanderbilt University. He received his doctorate in Cognitive Science from M.I.T. Watson began his faculty career at the University of Illinois at Urbana-Champaign in 2005 and moved to the Department of Psychology and Human Development at Vanderbilt University in 2016. Watson's research focuses on the cognitive processes that underlie human language production and comprehension. His most recent work explores the role of language experience on individual differences in language use. His research has been funded by both the National Institute of Health and the National Science Foundation. Watson is a co-founder of the SPARK Society, a scholarly organization that supports historically marginalized groups in the brain and cognitive sciences.

Panel Session

Neuroplasticity in Action: Diversity in Language and Reading Across Sensory Contexts

Friday, September 12, 2025, 2:30 – 4:30 pm, Elstad Auditorium

Chair: Valentina Borghesani, Université de Genève

This panel explores how the brain adapts to support language and literacy when sensory input is significantly altered or absent. Bringing together researchers from braille reading, language and literacy development in deaf communities, cross-modal bilingualism, and brain organization in blindness and deafness, the session highlights the extraordinary flexibility of our mind and brain underpinning communication. From the way braille reading changes orthographic morphemes for blind readers, literacy development in sign language users, cortical tracking during signed communication, to brain organization regardless of sensory input, each panelist will share key findings that demonstrate how the brain's capacity for language transcends traditional boundaries of sight and sound. The panel speakers will share insights from MEG, fMRI, and behavioral approaches, as well as information gleaned from developmental longitudinal studies and in-lab experimental paradigms. Collectively, these talks offer new perspectives on the fundamental resilience and adaptability of the brain, emphasizing the importance of sensory diversity in shaping our understanding of language acquisition, reading development, and cognitive processes. This will set the stage for what promises to be an engaging and insightful panel discussion led by participation from the audience.

Panelists:



Dr. Robert Englebretson is an Associate Professor at Rice University and will present key findings on sublexical structure in English braille, focusing on how braille orthography influences the recognition and production of certain types of digraphs and morphemes.



Dr. Brendan Costello is an Associate Group Leader at the BCBL (Basque Center on Cognition, Brain and Language) and will present key findings on mechanisms that underlie sign language processing and the impact of modality on the representation of language.



Dr. Kate Rowley is the Deputy Director of the Deafness, Cognition, and Language Research Centre (DCAL) at University College London (UCL) and will present key findings on language and literacy development in deaf children who are British Sign Language (BSL) users.



Dr. Ella Streim-Amit is an Assistant Professor at Georgetown University Medical Center and will present key findings on brain organization in people born with blindness, deafness, or without hands.

The panel will be introduced and moderated by Dr. Lorna Quandt, who is an Associate Professor at Gallaudet University, bringing expertise on the relationships between signed language processing, visual perception, and cognition.

Early Career Award



Esti Blanco-Elorrieta

New York University (NYU)

Early Career Award Lecture

Friday, September 12, 2025, 10:00 - 11:00 am, Elstad Auditorium

Chair: Ping Li, The Hong Kong Polytechnic University

The neurobiology of the bilingual mind

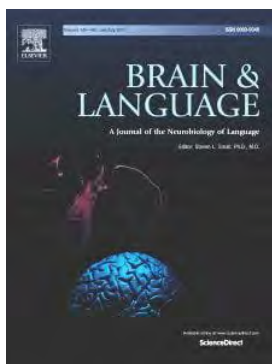
About Esti Blanco-Elorrieta. Dr. Blanco-Elorrieta is an Assistant Professor of Psychology and Neural Science at New York University, where they lead the Neuroscience of Multilingualism Laboratory. They obtained their PhD in 2020 from New York University, completed a postdoc at Harvard, and have quickly established themselves as a leading figure in the neuroscience of language, with an outstanding publication record—29 articles, most in top-tier journals—alongside \$1.7 million in grant funding and widespread international recognition, including the Glushko Dissertation Prize from the Cognitive Science Society and selection for the Forbes 30 Under 30 in Science list in 2019. Beyond their research achievements, Dr. Blanco-Elorrieta has been a dedicated contributor to our community, attending nearly every SNL annual meeting and

serving on our Board of Directors as trainee representative during their graduate and postdoctoral years.

Esti Blanco-Elorrieta's research program centers on the hypothesis that the neural organization of the bilingual mind constitutes an integrated system of two (or more) languages. The main tenets of the theory were articulated in their 2021 theoretical position article (Elorrieta & Caramazza, 2021. *Cognition*), proposing that language selection operates through activation-based mechanisms without requiring suppression of the non-target language. The model extends beyond the lexicon to semantic, syntactic, morphological, and phonological levels, offering a computationally grounded account of bilingual speech both in and outside experimental contexts.

To test the predictions of the model, Blanco-Elorrieta has conducted several distinct lines of research, combining neuroimaging, aphasiology and computational modelling. A key strength of their work is that it has always systematically addressed both comprehension and production, often within the same study, with elegant designs that engage the same representations across both, which is notoriously difficult to accomplish.

The Early Career Award is generously sponsored by [Brain and Language](#).



2024 Early Career Award



Adolfo M. García

¹Cognitive Neuroscience Center, Universidad de San Andrés, Buenos Aires, Argentina, ²Global Brain Health Institute (GBHI), University of California, San Francisco, San Francisco, CA, USA and Trinity College Dublin, Dublin, Ireland, ³Departamento de Lingüística y Literatura, Facultad de Humanidades, Universidad de Santiago de Chile, Santiago, Chile

Early Career Award Lecture

Sunday, September 14, 2025, 10:00 - 10:30 am, Elstad Auditorium

Chair: Kate Watkins, Oxford Department of Experimental Psychology

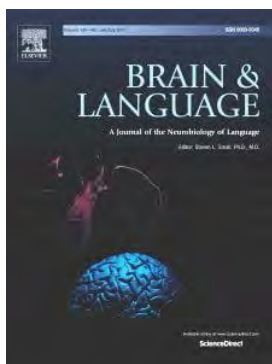
Speech and language markers of neurodegeneration: Breakthroughs in automation, implementation, and diversity

Speech and language measures are crucial for neurodegeneration research. These assessments reveal deficits linked to disorder-specific brain atrophy and connectivity patterns, informing neurolinguistic models and clinical testing. Yet, the field is undermined by low scalability (with growingly uneven clinician-to-patient ratios), limited implementation (as scientific discoveries rarely evolve to clinical application), and soaring inequity (as highly vulnerable populations are understudied). Here I will introduce our team's decade-long framework to tackle these challenges. First, I will describe our progress in automated speech and language analysis (ASLA), including mappings of speech timing alterations to superior/inferior frontal atrophy in non-fluent variant primary progressive aphasia, reduced semantic granularity to temporo-hippocampal alterations in Alzheimer's disease, and abnormal conceptual processing to frontostriatal disturbances in Parkinson's disease. Second, I will introduce our Toolkit to Examine Lifelike Language (TELL), a web-based app that turns ASLA into a clinical resource, offering real-time markers of motor speech, semantic memory, episodic memory, and emotional processing. Third, I will present our efforts to foster equity in language-based brain health research, including large cross-cultural projects (linking high- and low/middle-income countries) and the Include network (integrating 80 sites across five continents for cross-linguistic studies). In brief, through this work, we aim to foster a scalable glocal philosophy to translational neurolinguistics.

About Adolfo García. Adolfo García received his Ph.D. in Language Science in 2014 from Universidad Nacional de Cuyo (Argentina), after which he did a postdoc in Cognitive Neuroscience at the Institute of Cognitive Neurology (Argentina), and a fellowship on Brain Health at Global Brain Health Institute (UCSF, US). He specializes in the neuroscience of language, focusing on language embodiment, bilingualism, and speech biomarkers of brain health. Currently, he serves as Director of the Cognitive Neuroscience Center at Universidad de San Andrés (Argentina) and Associate Researcher at Universidad de Santiago de Chile (Chile).

Adolfo has examined how sensorimotor brain systems contribute to speech and language processes using multiple methodologies, including automated speech and language analysis and experimental paradigms in combination with MRI, fMRI, EEG, MEG, iEEG, and tDCS. He has provided spatiotemporal insights into the role of motor (e.g., frontostriatal) circuits in action-verb production and comprehension, face-recognition (e.g., right fusiform) regions in processing face-related nouns, and cerebello-cortical networks in processing social concepts. His research on bilinguals has revealed neurocognitive effects of age of language acquisition, language proficiency, and interpreting experience. As a creator of TELL, a speech testing app, he has also established speech markers of diverse brain diseases, including reduced semantic granularity in temporo-hippocampal atrophy models; and dysarthric patterns, atypical morphological choices, and altered action verb processing in frontostriatal atrophy models. He is also a co-founder of Include (a global network for crosslinguistic research on brain health), and Co-Principal Investigator of an NIH-funded project on speech biomarkers of dementia in both Latino and English-speaking individuals.

The Early Career Award is generously sponsored by [Brain and Language](#).



Dissertation Award



Jacob Momsen

Hilibrand Postdoctoral Fellow, Yale Child Study Center, Yale University School of Medicine (New Haven, Connecticut).

Dissertation Award Lecture

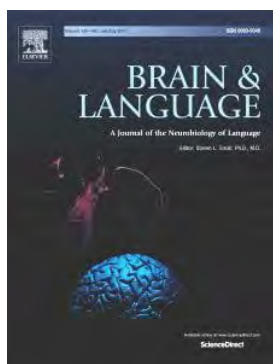
Friday, September 12, 2025, 10:00 - 11:00 am, Elstad Auditorium

Chair: Ping Li, The Hong Kong Polytechnic University

The Conversational Dance: Assessing the Sensorimotor Account of Multimodal Prosody

About Jacob Pohaku Momsen. Jacob Pohaku Momsen is a Hilibrand Postdoctoral Fellow in the McPartland Lab at the Yale Child Study Center within the Yale School of Medicine. He completed his PhD under the guidance of Drs. Seana Coulson and Alyson Abel through the Joint Doctoral Program at the University of California San Diego and San Diego State University in the summer of 2024. Prior to his graduate studies, Jacob earned his bachelor's degree from Trinity University in San Antonio, Texas, and then spent several years implementing play-based behavior therapy at a clinic for autistic youth, as well as teaching at a secondary school designed to individualize curriculum and adapt the learning environment for children with neurodevelopmental or psychiatric conditions. His dissertation work was framed around a novel hypothesis regarding the neurobiological mechanisms that support the temporal organization of attentional resources to optimally integrate verbal and nonverbal cues during spoken language processing. He is currently extending this work in clinical populations with pragmatic communication differences—e.g., autism—with the goal of advancing both speech and language science and laying the groundwork for future translational research in early diagnostic and therapeutic applications. The results of his dissertation have been published in the *Journal of Cognitive Neuroscience*, *Open Mind*, *Neurobiology of Language*, *Brain and Language*, and *Developmental Cognitive Neuroscience*, and was primarily supported by an NIH T32 Fellowship and an NIDCD Diversity Supplement Award.

The Dissertation Award is generously sponsored by [Brain and Language](#).



Distinguished Career Award



David Poeppel

Max Planck Society, New York University

Distinguished Career Award Lecture

Saturday, September 13, 2025, 9:00 - 9:45 am, Elstad Auditorium

Chair: William Matchin, University of South Carolina

Rhythms and algorithms: The temporal structure of linguistic experience

About David Poeppel. Professor David Poeppel is an internationally acclaimed cognitive neuroscientist who is currently Professor of Psychology and Neuroscience at New York University, and Director of the Max Planck Institute for Empirical Aesthetics in Frankfurt. David Poeppel is a leading figure in the field of auditory neuroscience and neuroscience of language and author of more than 230 articles in prestigious neuroscience and cognitive science journals.

This remarkable body of work is not merely a collection of scientific papers, but a transformative program of research for the neurobiology of language. Throughout his career, David Poeppel has advanced the theoretical and empirical understanding of the neural foundations of speech and

language processing and, most importantly, how the two interface. His unwavering advocacy for establishing a robust linking hypothesis between linguistics and neuroscience stands as a defining cornerstone for the field. David Poeppel's work and his influential voice have been instrumental in the growing field of neurobiology of language. He played a pivotal role in the founding and the nurturing of the Society for Neurobiology of Language.

David Poeppel's theoretical and empirical contributions are broad and profound. His Asymmetric Sampling in Time (AST) hypothesis has been foundational in revolutionizing our understanding of temporal integration and lateralization in auditory processing (Poeppel, 2003). Subsequently, the "dual-stream model" of speech processing, developed in tandem with Gregory Hickok (Hickok & Poeppel, 2007), shifted the paradigm by proposing that language processing unfolds along two interconnected neural pathways, ventral and dorsal, marking a definitive departure from the classical Wernicke-Lichtheim-Geschwind model toward a more sophisticated and empirically grounded understanding of language architecture. His collaboration with Anne-Lise Giraud (Giraud & Poeppel, 2012) produced an influential and biologically plausible framework for speech parsing in which cortical rhythms - theta and gamma in particular – encode the temporal structure of speech with remarkable precision. Together with his students and postdocs, David Poeppel carried out some of the most highly cited and impactful empirical studies in the neurobiology of language recognized for their conceptual innovation, experimental rigor, and elegance.

Last and not least, David Poeppel exemplifies the qualities of an exceptional mentor who has profoundly influenced the next generation of scientists, particularly women. He has supervised over 30 PhD students and more than 40 postdocs – many having a significant presence in the field of cognitive neuroscience at large – and inspired countless others through summer courses, engaging lectures, online debates and podcasts.

The Distinguished Career Award is generously sponsored by [Language, Cognition and Neuroscience](#).



Neurobiology of Language Best Paper Award 2025

Saturday, September 13, 2025, 9:45 – 10:00 am, Elstad Auditorium

Co-Chairs: Steve Small and Kate Watkins

The Editors-in-Chief of the society's journal, *Neurobiology of Language*, have selected two top papers from Volume 5 (2024) to receive the Best Paper Award and Honorable Mention for the current year. Both awardees will be honored on stage; the Best Paper awardee will give a short talk.

Best Paper Award

Richard Antonello, Alexander Huth

Predictive Coding or Just Feature Discovery? An Alternative Account of Why Language Models Fit Brain Data

Neurobiology of Language (2024) 5 (1): 64–79

Honorable Mention

Katie R. Jobson, Linda J. Hoffman, Athanasia Metoki, Haroon Popal, Anthony S. Dick, Jamie Reilly, Ingrid R. Olson

Language and the Cerebellum: Structural Connectivity to the Eloquent Brain

Neurobiology of Language (2024) 5 (3): 652–675

Sponsors and Exhibitors

The Society for the Neurobiology of Language thanks the following sponsors for their support of our 2025 meeting.

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National Institutes of Health

The Society for Neurobiology of Language gratefully acknowledges the generous support of the [National Institutes of Health](#) through R13 grant #DC011445. This funding plays a vital role in enhancing the SNL Annual Meeting by supporting speaker travel, materials and supplies, publication and marketing, audiovisual needs, sign language interpreting services, and more. Thanks to this support, the meeting is more accessible and impactful for a diverse range of attendees. We are deeply appreciative of the NIH's continued commitment to the success and accessibility of the SNL community.

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NSF Grant

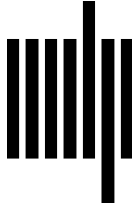
This event is supported by the [National Science Foundation \(NSF\)](#) through a conference grant that funds efforts to make SNL 2025 widely accessible for the broader community. We gratefully acknowledge NSF's commitment to ensuring that all scholars can fully engage in the Society for the Neurobiology of Language.

This material is based upon work supported by the National Science Foundation under Grant No. [2515190]. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

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Neurobiology of Language (The MIT Press)

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The Brain and Mind Institute at The Chinese University of Hong Kong

[The Brain and Mind Institute](#) at The Chinese University of Hong Kong is an interdisciplinary hub for conducting human-centered research related to the mind, brain and development. An important mission of the Institute is to develop evidence-based solutions to optimize development of Chinese children, especially those with special needs and those from low-resource settings. We published the first set of brain templates and atlases for Chinese infants between 0 to 3 months of age in 2024. Other ongoing projects include development of screening tools for autism and dyslexia in Chinese children, low-cost early intervention for children in low-resource settings, prenatal training and fetal brain development, and spoken language processing and learning. In 2025, we were awarded an Areas of Excellence project by the Research Grants Council of Hong Kong.



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Frontiers in Language Sciences

[Frontiers in Language Sciences](#) is a pioneering multidisciplinary journal advancing the understanding of language acquisition, comprehension, production, and structure through formal, cognitive, and neurobiological perspectives. Led by our Field Chief Editor **Manuel Carreiras** (Basque Center on Cognition, Brain and Language), the journal spans all levels of language, from phonology to discourse, across monolingual, bilingual, and multilingual contexts. The **Neurobiology of Language** section, headed by **Greig de Zubicaray** (Queensland University of Technology), showcases cutting-edge research on the neural bases of language using techniques such as neuroimaging, brain stimulation, electrophysiology, and computational modeling in both healthy and clinical populations.



NCCR Evolving Language

The Swiss National Centre of Competence in Research (NCCR) Evolving Language is a nationwide interdisciplinary research consortium bringing together research groups from the humanities, from language and computer science, the social sciences, and the natural sciences at an unprecedented level. Together, we aim at solving one of humanity's great mysteries: What is language? How did our species develop the capacity for linguistic expression, for processing language in the brain, and for consistently passing down new variations to the next generation? How will our capacity for language change in the face of digital communication and neuroengineering?



University of South Carolina Center for the Study of Aphasia Recovery

The Center for the Study of Aphasia Recovery (C-STAR) is a multi-disciplinary, NIH-funded research center in the Arnold School of Public Health at the University of South Carolina dedicated to advancing aphasia recovery through neuroimaging, brain stimulation, clinical trials, and community outreach.

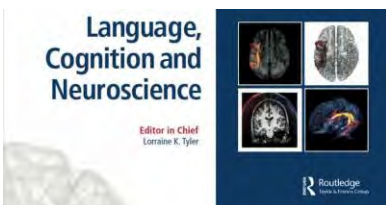
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Brain & Language (Elsevier)

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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 & Neuroscience (Routledge)

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Language, Cognition & 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.



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[Department of Language Science and Technology](#) at The Hong Kong Polytechnic University is an interdisciplinary linguistics department, ranked 51st globally (QS 2025). LST pioneers innovative research by integrating multimodal neuroimaging, machine learning, and generative AI to transform the understanding of multilingual processing, speech technology, and language education. Its work bridges theoretical inquiry with practical applications, addressing global societal challenges through impactful interdisciplinary research and collaboration.

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Symposium Sessions

Symposia Session 1

COGNITIVE AND LINGUISTICS OUTCOMES IN CHILDREN WITH COCHLEAR IMPLANTS: PERSPECTIVES ON NEURAL AND ENVIRONMENTAL MECHANISMS.

Saturday, September 13, 3:00 - 5:00 pm, Elstad Auditorium

Organizers: David Corina¹; ¹University of California, Davis

Presenters: Nabin Koirala, Claire Monroy, David Corina, Shengyun Gu

Congenitally deaf children who receive cochlear implants early in life often make great strides in language acquisition, though the determinates of successful linguistic competencies remain poorly understood and a wide variability of language and cognitive outcomes remain. A core issue of what constitutes the “best practices” for raising deaf children has a long contentious history in the Deaf community, in education and in clinical practice. Community stakeholders and professionals who live, work and research in this dynamic intersectionality are often polarized and hold strong and entrenched ideological beliefs. This symposium presents novel research which explores the role of neural plasticity and language exposure as factors underlying observed outcomes. Against a backdrop of technologically driven audiological interventions, novel tools for structural and neuro-functional assessments of deaf children, and a broader understanding of the determinants of signed and spoken language acquisition (and associated behaviors, such as reading) this symposium aims to provide the audience with a balanced and thoughtful conversation.

TALK 1: NEURAL CHARACTERISTICS INFLUENCING LANGUAGE AND LITERACY OUTCOMES IN CHILDREN WITH COCHLEAR IMPLANT.

Nabin Koirala¹; ¹University of Connecticut, Storrs, USA.

Cochlear implantation (CI) in prelingually deafened children has been an effective intervention for language and reading development. However, a substantial subset of children with CIs continue to experience difficulties in these domains, necessitating a deeper understanding of the neural mechanisms underlying variability in outcomes. The talk will discuss findings from EEG and fNIRS data in 75 children where we focused on the neural substrates of language and reading abilities in children with CIs. Findings highlight a complex interplay between neural reorganization and language-reading outcomes in children with CIs. Crucially, early intervention and hearing age emerged as critical determinants of reading success, though early auditory deprivation still imposed lasting constraints.

TALK 2: NEURAL CORRELATES OF VISUAL PROCESSING IN DEAF INFANTS

Claire Monroy¹; ¹Keele University Staffordshire U.K.

Children with hearing loss demonstrate atypical performance in tests of nonverbal cognition, such as attention, working memory, and learning. These findings have led scientists to believe that hearing loss negatively affects cognitive development, in addition to causing potential delays in language development. However, the mechanisms underlying these differences remain unclear, and prior research has largely focused on older children rather than infants. In this talk, we will present work that investigates early cognitive development in deaf and hearing babies, focusing on visual habituation—a well-established measure of information processing and learning. In a behavioral study, we found that deaf infants habituate more slowly to a visual stimulus than hearing infants, suggesting that differences in core cognitive abilities emerge in infancy. They also suggest that cognitive differences between deaf and hearing infants can explain some of the variability in language outcomes in children with hearing loss. However, simply demonstrating a difference in performance does not allow us to infer the underlying brain mechanisms that cause the difference. In this case, we still do not know whether the difference reflects a deficit or whether it could reflect an adaptation of the deaf infants to their unusual sensory environment. To address this, we are currently using electroencephalography (EEG) to test competing hypotheses about the mechanism driving the previously observed differences in visual habituation. We will present preliminary findings from this work and discuss how they may shed light on how hearing loss affects cognitive development in young infants.

TALK 3: USE OF ELECTROPHYSIOLOGY TO ASSESS SPOKEN LANGUAGE PROCESSING IN COCHLEAR IMPLANT USING CHILDREN

David Corina¹; ¹University of California, Davis

The use of electrophysiology indices, such as the auditory brainstem response (ABR), in the diagnosis of hearing loss in newborns is routine. However, the use of electrophysiological methods in the assessment of spoken language processing in cochlear implant (CI) using children is rare. We present electrophysiological data from experiments that document the time course of early auditory sensory processing and lexical recognition in early bilaterally implanted children ($n = 70$) and typically hearing (TH) controls ($n = 66$). The protocols include a novel passive speech processing task designed to elicit cortical auditory evoked potential (CAEPs) and an audio-visual lexical-semantic priming paradigm. Significant between group differences are observed in the amplitude of the P1 and N2 CAEPs. While only TH children showed responsivity to phonological information as indexed by a P300 component, largely equivalent results are observed for later occurring N400 components, indicating similar lexical-semantic processing in CI using and TH children. These data demonstrate the utility of ERPs techniques in understanding similarities and differences

in acoustic and spoken language processing in congenitally deaf CI-using children and may lead to more targeted interventions.

TALK 4: THE FAMILY LANGUAGE PROJECT

Shengyun Gu¹, Diane Lillo-Martin²; ¹Occidental College, ²University of Connecticut

The Family ASL project investigates language development by preschool age deaf and hard-of-hearing children whose hearing parents have chosen to learn American Sign Language and include it in their family's language plan. For those children with cochlear implants, this means that they are developing as Bimodal bilinguals, using both spoken English and ASL. We are following their development in both languages, and supporting their ASL through the services of an ASL specialist, who meets with them regularly online. There is variability across participants in how much they use ASL or English, but our assessments have revealed that overall, they are all making progress in both languages. In this presentation, we focus on their phonological development in both ASL and English. For ASL, we are using a self-generated elicitation task (ASL-Phonological Elicitation Task), with scoring at the feature and parameter levels. For English, we use the Goldman-Fristoe Test of Articulation, with phonemic scoring. Results indicate age-appropriate growth in both measures.

PANEL DISCUSSION

Mathew Dye¹, Matthew Hall², Kim Bianco Majeri³; ¹Rochester Institute of Technology, ²Temple University, ³Gallaudet University

Symposia Session 2

BEYOND CORE LANGUAGE: PROSODY AND PRAGMATICS

Sunday, September 14, 3:45 - 5:45 pm, Elstad Auditorium

Organizer: Anna Greenwald¹; ¹Georgetown University Medical Center

Presenters: Tamar Regev, Seung-Cheol Baek, Alexandra Zezinka Durfee, Anna Seydell-Greenwald, Jamila Minga

Since the days of Broca and Wernicke, "language" has been associated predominantly with the brain's left hemisphere. Challenging this one-sided view, this symposium will highlight aspects of language for which the right hemisphere plays an equally important and possibly dominant role: pragmatics, with a particular focus on prosody. How and in which context something is said holds crucial cues regarding the meaning of what is said, and a failure to account for this can have devastating effects on communication (and sometimes, research design). Speakers with backgrounds in linguistics, cognitive neuroscience, and speech-language-pathology will illuminate this topic from different angles, covering the spectrum from basic to clinical in individual talks, followed by an interactive

discussion with the audience. This symposium should be of broad interest to SNL attendees of all training backgrounds and at all career levels, and we hope that it will inspire many future collaborations.

TALK 1: A NETWORK OF BRAIN AREAS IS SELECTIVE FOR PROSODY—THE MELODY OF SPEECH

Tamar Regev¹, Hee So Kim¹, Niharika Jhingan¹, Sara Swords¹, Hope Kean¹, Colton Casto¹, Evelina Fedorenko¹; ¹Massachusetts Institute of Technology

Human speech carries information beyond the phonetic content: pitch, loudness and timing cues—jointly referred to as 'prosody'—can emphasize parts of the linguistic message and convey emotional and other social information. Here, we develop an fMRI paradigm to identify prosody-sensitive brain areas and then richly characterize these areas across 9 experimental tasks (25 experimental conditions; n=51 participants). We find that prosody-sensitive areas are located on the lateral temporal and lateral frontal cortical surface bilaterally, in proximity to lower-level auditory perception areas, amodal language-processing areas, and areas that process visual social cues, but crucially, we show that the prosody-sensitive areas are dissociable from all these known areas. Thus, in adult brains, speech prosody is processed by a distinct set of areas, although their proximity to other communication-relevant areas suggests that at an earlier developmental, and perhaps, evolutionary stage, prosody-processing areas may overlap with linguistic, or general social areas.

TALK 2: REPRESENTATIONAL DYNAMICS OF SPEECH PROSODY IN VENTRAL AND DORSAL SPEECH STREAMS

Seung-Cheol Baek^{1,2,3}, Seung-Goo Kim¹, Burkhard Maess⁴, Maren Grigutsch⁴, Daniela Sammler^{1,4}; ¹Max Planck Institute for Empirical Aesthetics, Frankfurt am Main, Germany, ²Philipps-University Marburg, Germany, ³Center for Mind, Brain, and Behavior, University of Marburg and Gießen, Germany, ⁴Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany

Speech prosody, often characterized by specific pitch patterns, conveys a speaker's meaning, for example, distinguishing a question from a statement. Although the neuroanatomical basis of prosody is well established in frontotemporal networks with right-hemispheric predominance, a more fundamental question remains unanswered: How is prosodic information encoded in these networks? Using magnetoencephalography and behavioral psychophysics, combined with time-resolved representational similarity and multivariate transfer entropy analyses, we examined how prosodic information is abstracted from acoustic to categorical representations across space and time. We found serial, yet joint and distributed representations of prosodic acoustics and categories bilaterally across the ventral auditory stream. Prosodic information additionally propagated along the dorsal stream, where the right premotor cortex exhibited only categorical, not acoustic representations. Altogether, our findings demonstrate the representational dynamics of prosody in ventral and dorsal speech streams, where the dorsal stream contributes particularly to prosodic

category formation—key to understanding a speaker's meaning.

TALK 3: AMALGAMATING CLASSIC AND MODERN TAXONOMIES OF AFFECTIVE APROSODIA TO REFINES POST-STROKE LANGUAGE REHABILITATION

Alexandra Zezinka Durfee^{1,2}, Shannon M. Sheppard², Argye E. Hillis²; ¹Towson University, ²Johns Hopkins University

Classic affective aprosodia taxonomy (e.g., sensory aprosodia) is limited in describing underlying behavioral mechanisms/deficits, which is central to modern aprosodia taxonomies (e.g., receptive aprosodia d/t impaired semantic access). Therefore, associations between classic and modern aprosodia taxonomies in acute right hemisphere stroke (n=36) were investigated. Classic aprosodia taxonomy subtyped some (~20%) participants, who also demonstrated underlying prosodic decoding/encoding and emotional-cognitive-linguistic deficits according to modern aprosodia taxonomy. Unclassifiable participants using classic taxonomy demonstrated varying skill profiles with modern taxonomy, including impaired access to a proposed “affective prosody lexicon” for production and/or recognition. Preliminary lesion maps indicated posterior lesions sparing inferior frontal and temporoparietal regions with receptive-only aprosodias, inferior frontal and temporoparietal regions with expressive-only aprosodias, and deep rolandic operculum and posterior parietal damage with receptiv+expressive aprosodias. Unclassifiable participants demonstrated greatest lesion overlap in subcortical/deep nuclei. Discussion includes combined classification implications for aprosodia rehabilitation.

TALK 4: ALTERED CEREBRAL ACTIVATION FOR PROSODY AFTER RIGHT-HEMISPHERE STROKE

Anna Seydell-Greenwald¹; ¹Georgetown University Medical Center

This talk will report ongoing fMRI studies investigating whether emotional prosody comprehension evokes increased left-hemisphere activation after right-hemisphere stroke in two study populations: Children and adolescents who had a large right-hemisphere stroke to the middle cerebral artery territory around the time of birth, and adults who had right-hemisphere strokes of varying sizes and locations in adulthood, more than a year prior to study. Mirroring the finding of an increased reliance on right perisylvian cortex for sentence comprehension in survivors of large perinatal strokes to the left hemisphere, survivors of large right-hemisphere perinatal strokes show an increased reliance on left-hemisphere perisylvian cortex during prosody processing. Findings after right-hemisphere stroke in adulthood are more heterogeneous and suggest a modulation by lesion characteristics, mirroring findings of increased right-hemisphere activation in adults with aphasia subsequent to left-hemisphere stroke. Results will be discussed in terms of functional reorganization after stroke.

TALK 5: RHDBANK AND ACQUIRED LANGUAGE DISORDERS AFTER RIGHT HEMISPHERE STROKE

Jamila Minga¹; ¹Duke University School of Medicine

Nearly 50% of strokes in the United States result in right hemisphere damage, yet acquired language disorders after stroke primarily focus on aphasias after left hemisphere damage. Right hemisphere brain damage (RHD) results in apragmatism, an acquired pragmatic language disorder in the ability to understand and produce contextually appropriate language, prosody, gestures, and facial expressions. Unlike aphasia, survivors with apragmatism can form sentences, produce words, and have intact fluency of expression. The language is, however, distinctly abnormal pragmatically. Growing research has outlined RHD communication features using the RHDBank, an internationally shared database for the study of language use after right hemisphere stroke during discourse. In this presentation, we highlight the importance of a diagnostic label and characterization of language production after right hemisphere stroke using existing literature and RHDBank video recorded data to stress the clinical relevance and need for greater empirical and educational consideration of RHD language disorders.

Slide Sessions

Slide Session A

Friday, September 12, 1:45 - 2:30 pm, Elstad Auditorium

Chair: Katrien Segaert, University of Birmingham

TALK 1: SEEING WHAT'S SAID: DIVERGENT EFFECTS OF VISUAL INPUT ON ACOUSTIC AND SEMANTIC SPEECH PROCESSING IN MONOLINGUALS AND BILINGUALS

Haoyin Xu¹, Seana Coulson¹; ¹Department of Cognitive Science, University of California, San Diego

Successful speech comprehension often relies not only on auditory input but also on visual cues such as facial expressions and gestures. While the role of visual context in speech processing is well documented in monolinguals, its impact on bilingual listeners—especially in naturalistic settings—remains less understood. Given the increased cognitive demands and variability in L2 fluency among bilinguals, it is unclear whether visual input imposes additional cognitive load or facilitates comprehension by providing nonverbal cues such as gestures and mouth movements. In this study, we employed temporal response function (TRF) modeling to examine how visual context influences neural speech processing in monolingual and bilingual adults, focusing on both acoustic and semantic representations. Using EEG and TRF modeling, we analyzed participants' tracking of two key features of continuous speech: the amplitude envelope (acoustic tracking) and lexical surprisal (semantic tracking). EEG data were collected from 24 monolingual English speakers and 24 Mandarin-English bilinguals as they watched TED Talk excerpts presented in both audio-only (AO) and audiovisual (AV) formats. We applied backward modeling using the multivariate TRF (mTRF) toolbox to reconstruct the speech envelope and lexical surprisal from the EEG data. Decoding accuracy was interpreted as an index of how strongly each speech feature was neurally tracked under each condition. Our results revealed a clear dissociation in tracking performance across speaker groups. Bilingual participants showed significantly improved envelope tracking in the AV condition, suggesting that visual cues enhanced low-level auditory processing (Language experience [Bilingual] × Condition [AV]: estimate = 0.72, CI = [0.01, 1.43], $p = 0.046$). However, they did not exhibit improved surprisal tracking with visual input; instead, their semantic tracking was strongly predicted by English fluency (Language fluency [English]: estimate = 0.05, CI = [0.01, 0.08], $p = 0.009$). In contrast, monolingual participants demonstrated significantly enhanced surprisal tracking in the AV condition (Condition [AV]: estimate = 0.70, CI = [0.11, 1.30], $p = 0.021$), suggesting that visual input facilitated higher-level semantic processing, though they did not benefit in envelope tracking. Linear mixed-effects models confirmed these interactions between language experience and stimulus condition across both measures. These findings suggest that visual context modulates speech processing differently based on language background. For bilinguals, visual input may support early auditory processing, possibly as a compensatory mechanism for heightened perceptual demands

in a second language. However, this benefit appears limited to acoustic features, potentially due to cognitive resource trade-offs that constrain semantic integration. Monolinguals, by contrast, seem to leverage visual input to enrich semantic predictions, highlighting the role of language proficiency in multimodal integration. Taken together, these findings demonstrate that language experience shapes distinct strategies for integrating visual information during speech comprehension. Building on this work, future research should further explore how the dynamics of audiovisual speech integration vary with language dominance and proficiency.

TALK 2: SEEING SPEECH IN A NEW LIGHT: AN MEG STUDY ON AUGMENTING SPEECH PERFORMANCE USING RAPID INVISIBLE FREQUENCY TAGGING (RIFT)

Charlie Reynolds¹, Yali Pan¹, Ana Pesquita¹, Ole Jensen², Katrien Segaert¹, Hyojin Park¹; ¹University of Birmingham, ²University of Oxford

In challenging listening environments, visual cues such as lip movements can enhance speech comprehension. Here, we hypothesise that the external modulation of visual speech signals using non-invasive rhythmic stimulation can be harnessed to improve speech understanding. We directly tested the hypothesis using a novel paradigm using Rapid Invisible Frequency Tagging (RIFT). RIFT is a technique that modulates visual stimuli at specific frequencies below the threshold of conscious perception to influence neural processing. We manipulated visual speech signals - using RIFT - to influence the integration of visual and auditory information, and measured brain responses using magnetoencephalography (MEG) alongside speech comprehension performance. 40 participants viewed naturalistic speech videos under dichotic listening conditions. One ear was presented with speech that matched the visual speech information (task relevant) while the other was presented with speech that did not (task irrelevant). Both streams of auditory speech were tagged at 40Hz. The visual flicker (55Hz) was implemented on the area whereby participants derive visual speech information: the speaker's mouth and was modulated by either task relevant or irrelevant speech amplitude envelopes. When modulated by relevant speech information, RIFT significantly enhanced performance in behavioural measures of speech comprehension. The MEG results showed significant effects of auditory and visual tagging in their respective sensory cortices across all experimental conditions. The visual tagging response was significantly stronger when the amplitude was modulated by relevant speech. This stronger tagging response predicted speech comprehension performance. These results suggest that modulating visual input with relevant auditory speech rhythms can facilitate the excitability of visual cortex perhaps leading to enhanced crossmodal integration. Non-invasive sensory stimulation through RIFT may therefore serve as a promising tool for improving speech intelligibility in complex listening environments with multiple competing speakers, particularly for populations such as older adults, individuals with hearing impairments, or those with auditory processing disorders.

TALK 3: INTERBRAIN SYNCHRONY AS A POTENTIAL BIOMARKER OF COMMUNICATIVE SUCCESS IN APHASIA: PRELIMINARY EVIDENCE FROM fNIRS HYPERSCANNING

Grace Magee¹, James Colwell¹, Joseph Licata¹, Shannon Kelley¹, Berk Tellioglu², David Boas^{1,3}, Swathi Kiran^{2,4}, Maria Varkanitsa^{2,4}, Erin Meier⁵, Meryem Yucel^{1,3}; ¹Department of Biomedical Engineering, Boston University, Boston, MA, ²Center for Brain Recovery, Boston University, Boston, MA, ³Neurophotonics Center, Boston University, Boston, MA, ⁴Department of Speech, Language, and Hearing Sciences, Boston University, Boston, MA, ⁵Department of Communication Sciences and Disorders, Northeastern University, Boston, MA

Introduction Communication is a two-way process, yet aphasia research neglects the interaction dynamics between people with aphasia (PWA) and their communication partners. Hyperscanning research indicates that greater communicative success coincides with greater interbrain synchrony (IBS) in the prefrontal cortex (PFC) and temporoparietal junction (TPJ) between healthy dyads[1,2] and that IBS varies as a function of intersubject interactivity and familiarity/closeness[3]. To assess whether IBS is a viable biomarker of communicative success, we examined IBS across language tasks with different levels of mutual interaction and alignment in dyads including healthy adults and an individual with aphasia. Methods In Experiment 1, 32 young adults (16 dyads) completed four tasks that varied in the type of expected alignment and coupling: Independent Reading of story passages (low/spurious coupling), Joint Reading of story passages (entrainment-based coupling), Joint Singing of familiar songs (entrainment-based coupling), and (4) Picture Guess, involving partners taking turns asking questions/guessing depicted objects on the other's cards (semantic alignment-based coupling). Each task contained two 120s blocks interleaved with 30s rest. In Experiment 2, one individual with anomic aphasia completed the same tasks with a familiar, trained speech-language pathologist (dyad 1) and a non-clinician stranger (dyad 2). fNIRS data were collected from 16 sources and 16 detectors per cap arranged over bilateral inferior and middle frontal gyri (IFG/MFG), dorsolateral (dl) PFC, TPJ, and supramarginal gyrus (SMG). Standard preprocessing steps were followed in Homer3[4]. [4] IBS was determined by computing wavelet coherence (R2 values)[5] between homologous brain regions in each dyad. Results In Experiment 1, Joint Singing IBS was significantly greater than Joint Reading IBS in bilateral MFG ($p < 0.01$) and TPJ ($p < 0.01$) and Picture Guess IBS in bilateral MFG ($p < 0.05$), dlPFC ($p < 0.001$), and TPJ ($p < 0.001$). Bilateral SMG IBS was greater during Picture Guess than Joint Reading ($p < 0.01$). IBS in IFG did not vary by task ($p > 0.05$). In Experiment 2, IBS increased from block 1 to block 2 across most tasks and regions for dyad 1 but decreased over time for dyad 2. Overall, across both blocks IBS tended to be lower across regions for the entire time series for dyad 1 than dyad 2 for Joint Singing, Joint Reading, and Picture Guess, but the opposite trend was observed for Independent Reading. Conclusions As expected, IBS was greatest between young adults in prefrontal regions and TPJ for Joint Singing, a task that stimulated entrainment (like Joint Reading) but also capitalized on stimulus familiarity and melody to promote alignment. Opposite trends in increasing/decreasing IBS across interactive

tasks for the PWA/clinician versus PWA/stranger dyads may be due to dyadic differences in leader/follower dynamics[6]. In dyad 1, the clinician acted as follower, modifying his speech rate/style to match the patient's with increasing behavioral alignment over time. In contrast, in dyad 2, the PWA acted as follower, trying to (unsuccessfully) keep up with the stranger (leader) who did not modify his speech rate/style, perhaps resulting in increasing disconnect over time. If replicated across additional dyads involving PWA, these findings have important implications for both aphasia care and two-person neuroscience.

Slide Session B

Saturday, September 13, 10:00 - 11:00 am, Elstad Auditorium

Chair: Esti Blanco-Elorrieta, New York University

TALK 1: USING A COMMA TO INVESTIGATE THE NODE-TRACKING FRAMEWORK FOR THE CONSTRUCTION OF PHRASE STRUCTURE REPRESENTATIONS IN THE HUMAN BRAIN

Matthew Nelson¹, Christophe Smith, Bryant Barrentine, Marshall Holland, Bentley Nicole, David Basilico; ¹University of Alabama at Birmingham

Much of what is described in the literature as models of sentence processing in the brain are essentially just different authors' views on what parts of the brain are involved in what aspects of sentence processing. There is a dearth in the literature of mechanistic models capturing how populations of neurons themselves might enact sentence comprehension. In 2017, we introduced the node-tracking framework to address this. We derived this from observations that while reading a sentence, population-level neural activity measured by high gamma power (70-150 Hz) in the left Middle Temporal Gyrus (MTG) builds up word-by-word within a phrase but declines sharply after the phrase boundary. Concomitantly, left Inferior Frontal Gyrus (IFG) activity increases transiently only at phrase boundaries, in proportion to the amount of decline in MTG activity. The node-tracking framework posits that this MTG activity pattern reflects the maintenance of open-nodes in working memory, that is, the maintenance of the nodes of a tree structure representation of a sentence open to syntactic operations while that tree structure is being built. The IFG pattern is posited to reflect the number of nodes closing, which, assuming a Minimalist Grammar, reflects the degree of Merging occurring at a given moment. This framework has been highly impactful, yet some in the field question it. A key barrier of studies following our introduction of the framework are uncontrolled word-level parameters (e.g. word frequency, etc.), which obfuscate whether reported effects are consistent with the framework or merely reflect the effect of these parameters. To overcome this barrier, we recorded intracranial activity (sEEG and ECoG) in 20 epilepsy patient volunteers while they read sentences one word at a time (RSVP) and answered questions about the sentences. We manipulated the phrase structure in matched sentence pairs that they read, as in: (1a) While the man hunted, the deer ran into the woods. (1b) While the man hunted the deer, the rabbit ran into the

woods. These sentences begin with identical sequences of words up to and including the target noun phrase 'the deer', which, through comma placement, is the subject of the main clause in (1a) but the direct object of the subordinate clause in (1b). The node-tracking framework makes clear predictions about the neural activity differences expected between 1a and 1b, which we find support for in the left MTG and IFG both within and across patients in our sample. Moreover, we observed marked ramping up activation in left MTG over the course of the opening phrases of the sentences, which is commonly reported in intracranial sentence processing studies across several groups. This ramping up is entirely explained by and consistent with open-node-related activation predicted by the node-tracking framework, thus this framework provides a parsimonious explanation for this phenomenon. Altogether, this study fruitfully advances the debate about the node-tracking framework, leading towards a presently lacking mechanistic understanding of how neuron populations enact sentence comprehension. These results may also inform future Brain-Computer Interface (BCI) treatments for communication at the sentence level.

TALK 2: A TRANSMODAL WORKING MEMORY AREA IN PRECENTRAL GYRUS AT THE INTERSECTION OF EXPRESSIVE AND RECEPTIVE LANGUAGE AREAS

Tyler Perrachione¹, Rebecca Belisle¹, Terri Scott¹; ¹Boston University

Diverse investigations into the neurobiology of language have identified a mid-precentral (PrCG) or posterior middle frontal (pMFG) region that is variously attributed to high-level receptive language (Lipkin et al., 2022), speech motor control (Belyk et al., 2021), pitch control (Hickok et al., 2023), working memory (WM; Scott & Perrachione et al., 2019), or grammatical expressive language (Rogalski et al., 2014; Silva et al., 2022). However, because this work is often based on whole-brain group averages or only one construct, it is unclear whether PreCG-pMFG contains only a single, undifferentiated language area, or whether there is more granular areal organization in individual brains. Here, we used two approaches to functionally characterize speech, language, and WM areas in PreCG-pMFG in individual brains: (i) a task-specific, hypothesis-driven function region of interest (fROI) analysis and (ii) a multi-task, hypothesis-free clustering analysis. Using individual task-specific activation maps on the cortical surfaces of N=25 young adults with typical speech, language, and hearing, we performed these analyses in an anatomically circumscribed parcel intended to broadly encompass portions of PreCG and pMFG known to be responsive to receptive or productive language. In the hypothesis-driven fROI approach, we delineated areas most strongly activated by a receptive language localizer (listening to intact vs. degraded speech; Scott et al., 2017) and, independently, a nonword repetition task (4-syllable vs. 1-syllable; Scott & Perrachione, 2019). From these, we characterized vertices as belonging either solely to the receptive language fROI, solely to the nonword repetition fROI, or common to both fROIs. In the hypothesis-free clustering approach, we performed k-means clustering across vertices based on fMRI effect sizes from 6 language and WM tasks

(receptive language localizer, nonword repetition, real word repetition, nonword discrimination, visuospatial sequencing, and auditory digit span). The resultant 7 clusters had distinct fMRI task response profiles across the 6 tasks, including 3 clusters principally responsive to (i) receptive language (language localizer task), (ii) speech (word and nonword repetition tasks), and (iii) transmodal language/WM (all 6 tasks). Notably, these 3 clusters were spatially consistent with the 3 areas delineated in the fROI approach, suggesting that the productive-receptive overlap region (fROI approach) is largely the same as the region with uniquely heightened responses for all 6 tasks (clustering approach). Taken together, the two analyses provide converging evidence for a tripartite speech-language-working memory arealization, in which we find, consistently across subjects, (1) a posterior speech-specific region, (2) an anterior language-specific region, and (3) an intervening transmodal WM area. This transmodal WM area appears to be strongly responsive to both receptive language and WM tasks, regardless of whether they are verbal (both meaningful and meaningless) or spatial. Finally, we examined whether these areas were neuroanatomically differentiated based on their relative intracortical myelin content (T1w/T2w MRI; Glasser & Van Essen, 2011). The transmodal WM area was characterized by low intracortical myelin, despite lying directly adjacent to the highly myelinated speech-specific cluster in primary motor cortex. These results expand our understanding of the granularity of functional neuroanatomy in precentral areas for language and cognition.

TALK 3: A COMMON FRAMEWORK FOR SEMANTIC MEMORY AND SEMANTIC COMPOSITION

Ryan M.C. Law¹, Olaf Hauk¹, Matthew A. Lambon Ralph¹; ¹MRC Cognition and Brain Sciences Unit, University of Cambridge

How the brain constructs meaning from individual words and phrases is a fundamental question for research in semantic cognition, language and their disorders. These two aspects of meaning are traditionally studied separately, resulting in two large, multi-method literatures, which we sought to bring together in this study. Not only would this address basic questions of how semantic cognition operates, but also because, despite their distinct focuses, both literatures ascribe a critical role to the anterior temporal lobe (ATL) in both aspects of semantics. Given these considerations, we explored the notion that common neurocomputational principles underlie the representing and constructing of semantic representations from words and word sequences, respectively. The ATL has been implicated in semantic memory (Rogers et al., 2004; Patterson et al., 2007; Lambon Ralph et al., 2017) and semantic composition (Coutanche et al., 2019; Pykkänen, 2019, 2020; Călinescu et al., 2023), with evidence from neuropsychology, neuroimaging and computational modelling. Does the overlap in functional neuroanatomy hint at shared computations across the two systems? A neural network model by Hoffman et al. (2018) offers a unifying framework. The model takes word sequences as input and predicts both the upcoming words and each concrete word's sensory-motor properties. In doing so, the model acquires representations that reflect the multimodal knowledge of each concept (McClelland & Rogers, 2003;

Patterson et al., 2007; Lambon Ralph et al., 2017) while also accounting for co-occurrence and information integration over time (McClelland et al., 1989; St. John & McClelland, 1990; Rabovsky et al., 2018). By assimilating evidence from these different strands, we propose that the ATLs provide a unified function essential to semantic representation and thus play a central role in both literatures. If so, then adjective-noun processing should be sensitive to conceptual variables from semantic memory. We integrate one such variable, concreteness (e.g., lettuce/fiction), which, to our knowledge, has been underexplored in adjective-noun processing. We also explored the processing of denotation semantics, introduced by subsective vs. privative adjectives (e.g., bad vs. fake), which significantly modulates interpretation (Kamp, 1975; Partee, 2010; Del Pinal, 2015; Fritz & Baggio, 2020). **CONTROL:** xtvq lettuce/fiction **SUBJECTIVE PHRASE:** bad lettuce/fiction (implies “this is a lettuce”) **PRIVATIVE PHRASE:** fake lettuce/fiction (implies “this isn’t a lettuce”) We recorded neural activity using electroencephalography and magnetoencephalography (EEG/MEG) as thirty-six participants silently read words and phrases in RSVP (total n=600) and answered occasional comprehension questions (n=60). Source-localized region-of-interest analyses show that the left, and to a lesser extent the right, ATLs responded more strongly to phrases, irrespective of concreteness. Decoding analyses further revealed a time-varying representational format for adjective semantics, whereas representations of noun concreteness were more stable and maintained for around 300 ms. Further, the neural representation of noun concreteness was modulated by the preceding adjectives: decoders learning concreteness signals in single words generalized better to subsective than privative phrases. Together, our results suggest that the ATLs provide a unified function for semantic memory and composition. The present framework paves the way for understanding complex meaning construction in time-extended verbal behaviours, such as narratives.

TALK 4: SHARED NEURAL FILTERS REVEAL MODALITY-INVARIANT SEMANTIC REPRESENTATIONS IN INTRACRANIAL RECORDINGS

Aditya Singh¹, Elliot Murphy², Tessy Thomas³, Nitin Tandon⁴;
¹UT Health

The human brain’s ability to extract the same meaning from different linguistic inputs (e.g., spoken versus written cues) suggests the presence of modality-invariant semantic representations. However, how such shared meaning is dynamically encoded in neural activity remains poorly understood. To address this, we recorded stereotactically placed depth electrodes (sEEG) from 15 neurosurgical patients performing two naming-to-definition tasks, in which target concepts were elicited by either orthographic or auditory cues (orthographic trials: mean = 370, s.d. = 150; auditory trials: mean = 413, s.d. = 104). We applied non-negative matrix factorization (NNMF) to trial-aligned high-gamma activity (70-150Hz), extracting low-rank spatiotemporal components that captured consistent functional groups aligned to distinct temporal segments. Clustering these trajectories revealed subject-agnostic task-related dynamics with certain stages invariant to

both modalities. Using features from the NNMF components, a classifier could predict the named concept at accuracies significantly above chance (38%/26% vs 3% chance, $p < 0.001$ paired t-test with FDR correction) for written and auditory task conditions, respectively. Using components with a sustained response during the cue period, we achieved significant pre-articulatory decoding (17% vs 3% chance, $p < 0.01$) performance of both the word and the semantic concept (45% vs 20% chance, $p < 0.05$). We trained a component-aligned decoding model using a transfer learning framework to assess cross-subject generalization. Each subject’s NNMF-derived spatiotemporal features were encoded with a subject-specific recurrent head, then mapped into a shared latent space. A shared decoder was trained on a source subject and then frozen, while new subject-specific encoders were trained to align to its latent space and decode target words. This approach allows for direct evaluation of cross-subject and cross-modality generalization while controlling model complexity. Additionally, to evaluate how neural activity tracks stimulus semantics, we compressed contextual language model embeddings into discrete codebooks using a vector-quantized variational autoencoder (VQ-VAE), producing compact, modality-agnostic targets representing meaning at a phrasal level. These enhancements revealed that shared latent dynamics across NNMF-aligned features support robust semantic transfer across individuals and modalities. By aligning interpretable neural trajectories across subjects, our framework enables scalable, cross-subject semantic decoding—advancing neuroprosthetic systems toward decoding intended meaning, not just speech output. This work shifts the framing of language decoding from “sound with meaning” to “meaning with sound.”

Slide Session C

Sunday, September 14, 2:45 - 3:30 pm, Elstad Auditorium

Chair: Tyler Perrachione, Boston University

TALK 1: STABILITY AND PLASTICITY IN THE READING CIRCUITRY: COMBINING INSIGHTS FROM LARGE-SCALE DATABASES AND A LONGITUDINAL INTERVENTION STUDY

Maya Yablonski¹, Jamie L. Mitchell¹, Hannah L. Stone^{1,2}, Mia Fuentes-Jimenez¹, Jason D. Yeatman¹; ¹Stanford University, ²University of California, Santa Barbara

Reading is a complex skill that takes years to master. While extensive research has described the brain’s reading circuitry, it remains unclear how the experience of learning to read shapes brain development, versus how existing neural mechanisms scaffold learning to read. Here, we asked 1) Is there a connectivity blueprint linking the visual and language networks that establishes the bedrock of the reading circuitry? 2) Do these connectivity patterns change with learning? We first addressed these questions using two public datasets: In the Natural Scenes Dataset, we identified text-selective responses in precision 7T adult data (N=8), and characterized distinct functional connectivity patterns at the individual level. Then, we replicated these patterns in the developmental Healthy Brain

Network (N=224; ages 7-20 years) across a wide range of reading levels (Yablonski et al., 2024). To examine whether these patterns change with learning, we conducted a longitudinal study where children with dyslexia completed an intensive reading intervention. Compared with public, large-scale cross-sectional databases, intervention designs allow for a close examination of the concurrent timecourses of change in reading ability and change in connectivity, thereby teasing apart developmental effects from the experience of learning to read. All children (N=44 intervention; N=42 controls; ages 7-13 years) completed functional magnetic resonance imaging (fMRI) scans before the intervention, immediately after its completion, six months and twelve months later. This dense sampling scheme allows us to delineate a trajectory of both short- and long-term changes in brain function and connectivity following the intervention. In each timepoint, children completed a functional localizer where they viewed text and non-text stimuli while performing tasks that did not explicitly require reading (Mitchell et al., bioRxiv; Stone et al., 2025). In addition, they completed a "resting state" scan where they watched a silent nature movie without language content. The functional localizer was used to define text-selective regions of interest (ROIs): The subregions of the visual word form area (VWFA1 and VWFA2), as well as frontal language regions on each individual's cortical surface. Then, these ROIs were used as seeds in functional connectivity analysis of the independent movie-watching data, to explore the functional connectivity patterns of the reading network. We found that VWFA2 had elevated connectivity with frontal language regions, compared with the adjacent VWFA1 and neighboring control regions. Importantly, connectivity between VWFA2 and frontal language regions was present in children with dyslexia even before the intervention, and even in children where we could not detect cortical regions that selectively responded to text (44% of children with dyslexia). Further, these patterns were stable during learning as children improved their reading skills. These findings support a view of functional connectivity as a blueprint for the emergence of text-selective regions. The controlled intervention setting, combined with multiple timepoints per subject and multimodal imaging, brings us a step further beyond the insights that can be obtained from large databases, and elucidates the relationship between the experience of learning to read and brain connectivity within individuals.

TALK 2: LANGUAGE-RELATED CORTICAL PATHWAYS IN DEAF SIGNERS: CORE INVARIANCE AND MODALITY-SPECIFIC VARIABILITY

Patrick C. Trettenbrein^{1,2}, Cheslie C. Klein¹, Emiliano Zaccarella¹, Angela D. Friederici¹; ¹Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany, ²University of Göttingen, Göttingen, Germany

Introduction: Language processing in the adult neurotypical brain is subserved by several white-matter pathways which connect inferior frontal, temporal, and parietal language-relevant cortical regions. Here, we used diffusion-weighted MRI to compare the macro- and micro-structural properties of the core and extended language network in a group of deaf signers and a control group hearing non-signers. **Methods:** This analysis

includes diffusion-weighted and structural data from 24 deaf signers (11 male; mean age = 32.25, SD = 8.69) who acquired a sign language already early in life (mean age of acquisition = 1.29, SD = 2.22) and primarily from their deaf parents (N = 19), as well as 24 hearing non-signers (11 male; mean age = 32.75, SD = 8.25). All data were pre-processed using the standardized workflow implemented in QSIprep (Cieslak et al., 2021) which integrates advanced quality control measures. We then used pyAFQ (Garyfallidis et al., 2014; Kruper et al., 2021; Yeatman et al., 2012) to perform automatic fiber quantification for generating macro- and micro-structural information derived from diffusion data for the core and extended language network and its right-hemispheric homologues (i.e., bilateral arcuate fasciculus, superior longitudinal fasciculus, posterior arcuate fasciculus, inferior fronto-occipital fasciculus, uncinate fasciculus, and the inferior longitudinal fasciculus). The pyAFQ workflow constitutes a standardized multi-step process that produces robust axonal models and tract profiles. Macro-structural differences in language-related pathways between groups were quantified by extracting the cleaned streamline counts and fitting a linear mixed-effects model accounting for possible individual-level variation in R (R Core Team, 2024). Macro-structural asymmetry of language-related pathways in both groups of participants was determined by computing a lateralization index (LI) for streamline counts (S) for every pathway as follows: $LI = (S_{left} - S_{right}) / (S_{left} + S_{right})$. In addition, we also quantified for every tract micro-structural differences in fractional anisotropy (FA), mean diffusivity (MD), and radial diffusivity (RD) by fitting linear mixed-effects models for every pyAFQ tract segment and determining significant clusters using a permutation test procedure. **Results:** We observed no statistically significant macro-structural differences between deaf signers and hearing non-signers in the core language network (i.e., left arcuate fasciculus) and any of the language-related white-matter pathways in the left hemisphere, in line with earlier work (Finkl et al., 2019; Cheng et al., 2019). However, we found a significant difference in the total number of streamlines between groups (higher in the group of deaf signers) for the right posterior arcuate fasciculus connecting parietal and posterior temporal regions. The lateralization analysis indicated similar lateralization profiles for all pathways across groups. We also observed the following micro-structural group differences: Left and right uncinate fasciculus differed in FA and MD respectively. Both right arcuate and right superior longitudinal fasciculus differed in FA as well as RD. **Conclusion:** Our data indicate the modality-independent and universal nature of the core left-hemispheric white-matter pathways subserving language processing. At the same time, the observed right-hemispheric macro- and micro-structural differences related to deafness and sign language acquisition constitute a neurobiological alteration that potentially reflects modality-specific processing demands of sign languages.

TALK 3: ERP CORRELATES DURING SENTENCE PROCESSING OF GERMAN SIGN LANGUAGE AGREEMENT VERBS IN DEAF EARLY CHILD SIGNERS

Janika Stille¹, Anne Wienholz¹, Annika Herrmann¹, Barbara Hänel-Faulhaber¹; ¹Universität Hamburg

Sign languages use the three-dimensional signing space to realize various functions, for example marking syntactic information. Agreement verbs move between locations in the signing space, that were linked with referents previously. Thus, the starting and end point of agreement verbs may mark the subject and object of an utterance. How deaf children process violations of these syntactic markings has not been investigated yet using event-related brain potentials (ERP). During sign language processing of semantically or syntactically anomalous sentences, deaf adults demonstrate similar neural correlates as hearing adults for spoken languages (e.g., Capek et al., 2009; Hänel-Faulhaber et al., 2014). Whether or not similar neural correlates are present in deaf children using sign language is currently unknown. When hearing spoken language, hearing children show an N400 for semantic violations and a P600 for morphosyntactic violations compared to correct sentences, like adults. However, children typically show a later and larger N400 and a later and smaller P600 than adults (e.g., Hahne et al., 2004; Schneider & Maguire, 2019). We expected that deaf children would show comparable neural correlates with an N400 for semantic violations and a P600 for morphosyntactic violations. This ERP study investigated the neural processes engaged during sign language processing of different verb types in deaf children who were exposed to German Sign Language (DGS) before the age of three years, i.e., early signers. Here, we focus on agreement verbs, a subset of the experiment. Twenty-six children with DGS as their first language (mean AoA = 10 months [0-30 months]), mean age = 9;11 years [8;7-11;11 years]) were presented with videos of 45 signed DGS sentences containing agreement verbs. The sentences were grammatically correct or contained either semantic (implausible object) or morphosyntactic violations (incorrect direction of movement). A probe verification task was used to keep the children engaged during the study. ERPs were recorded from 32 scalp electrodes. We analyzed mean amplitudes from the point in time when the handshape of the verb sign was fully recognizable (target handshape) until 1000ms in 100ms time windows using generalized additive mixed effects models. The data in each time window was modeled as a function of electrode position and experimental condition. For semantic violations compared to correct sentences, we observed a higher negativity at central-posterior locations that was particularly pronounced between 500-600ms. For morphosyntactic violations compared to correct sentences, we detected a central posterior distributed negativity between 600-700ms comparable to the effect for the semantic violations. Thus, deaf early child signers demonstrated an N400 effect for sentences containing semantic violations in a time window later than in adults, as previously shown for hearing children. However, the effects for morphosyntactic violations were somewhat unexpected suggesting that deaf children process this violation more like a semantic violation. Some sign language studies have reported comparable results for specific agreement violations in deaf adults (Capek et al., 2009; Hosemann et al., 2018). We will discuss other potential explanations including task effects or handling thematic role assignment (Brouwer & Crocker, 2017; Kos et al., 2010).

Poster Schedule

The first author *must* be present during the entire poster session. If the first author is unable to present, the abstract must be withdrawn or permission must be granted for another author to present.

You may post your materials on the board assigned to you at any time after the “Set-up Begins” time, but all posters must be up before the beginning of the assigned poster session. You must remove your poster promptly—no later than the “Take-down Complete” time. Any posters left up after the “Take-down Complete” time may be discarded.

Session	Date	Location	Set-up Begins	Session Hours	Take-down Complete
Poster Session A	Friday, September 12	Field House	10:00 am	11:00 am - 12:30 pm	1:30 pm
Poster Session B	Friday, September 12	Field House	2:30 pm	4:30 - 6:00 pm	7:30 pm
Poster Session C	Saturday, September 13	Field House	8:00 am	11:00 am - 12:30 pm	1:30 pm
Poster Session D	Saturday, September 13	Field House	2:30 pm	5:00 - 6:30 pm	6:45 pm
Poster Session E	Sunday, September 14	Field House	8:00 am	11:00 am - 12:30 pm	12:30 pm

Pushpins will be available. Tape, glue and other adhesives are not to be used on the poster boards. Poster boards will be numbered by SNL. No electricity is available onsite.

Poster Session A

Friday, September 12, 11:00 am - 12:30 pm, Field House

A1 - When smaller language models align better with the brain: Is the scaling law universal?

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Recent studies suggest that bigger language models appear to more closely mirror our linguistic brains. The success of large language models (LLMs) has been significantly driven by the scaling law, which states that models’ language capabilities increase with model size (Kaplan et al., 2020). This scaling law has been generalized to the domain of model-brain alignment. Several studies report that larger LLMs, often with billions of parameters, consistently produce better predictions of neural activity during language comprehension (Antonello et al., 2023; Hong et al., 2024). At the same time, AI researchers have shown growing interest in small language models (SLMs), motivated by considerations of computational and resource efficiency (Nguyen et al., 2024). Given that the human brain is a remarkably energy-efficient system compared to LLMs (Mehonic & Kenyon, 2022), an open question arises: can smaller, more efficient, and human-learning-based models generate brain-like representations that rival those of their larger counterparts? The present study systematically assesses the impact of model size by leveraging ALBERT, a family of open-source SLMs designed for efficiency (Lan et al., 2020). ALBERT includes four variant models, base, large, xlarge, and xxlarge, with parameter sizes ranging from 12M to 235M. These relatively small models exhibit progressively higher language performance, comparable or even superior to heavier models such as BERT-large (size=334M). In a previous model-brain

alignment study, the ALBERT base model surprisingly ranked among the top models (only behind the larger GPT-2 models) in predicting ECoG recordings from five participants (Schrimpf et al., 2021). To further investigate how ALBERT’s size relates to its neural prediction performance, we utilized Reading Brain, a large-scale fMRI and eye-tracking dataset about naturalistic reading, collected from fifty-two native English speakers (Li et al., 2022). For each ALBERT variant, we trained encoding models to predict the participants’ fMRI signals from model embeddings. Model-brain alignment was evaluated as the correlation between the predicted and actual fMRI time series. The results indicate a positive answer to our research question. Although the size of the base, large, xlarge, and xxlarge models increases from 12M, 18M, 60M to 235M parameters, their corresponding brain alignment scores followed a negative trend, with the average correlations being .085, .086, .080, and .082 for the whole cortex, and .092, .091, .084, and .087 within the language network (Fedorenko et al., 2024). Particularly striking is the finding that, despite having nearly 20 times fewer parameters, the base model significantly outperformed the xxlarge model in brain alignment ($p=.042$, whole cortex; $p=.024$, language network). The case of ALBERT suggests that efficient models with as few as 12M parameters not only can perform well linguistically (Lan et al., 2020) but also demonstrate decent brain alignment. Our findings imply that the scaling law may not necessarily be universal when it comes to model-brain alignment. In line with recent studies (Yu et al., 2024; Aw & Toneva, 2023), we suggest that model size is not the only path toward achieving brain-like representations, and other factors, including model efficiency and potential human-learning like mechanisms, will be crucial.

A2 - Neurology of a Mantra

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Mantra as a word comes from Sanskrit texts connoting celestial sounds. Unlike celestial voices heard in other cultures, a mantra has no language, it is defined as an acoustic vibration. We have been analyzing the production of mantra sounds through neurological reasoning for a number of years. We have developed a conceptual language model that proposes that all concepts in the brain are represented by neuronal ensembles, which develop aggregates induced by the incoming sensory stimuli. The energy in the aggregates is released through muscle vibrations that are recorded as speech. These vibrations are heard as phonetic syllables and are parsed later in groups to form words to associate with objects. We suggest that this is how words were originally created when languages formed and have then rolled through imitation, mispronunciation and phonetic substitution. We will present the model architecture and the computational algorithm.

A3 - Replicating Aphasic Picture Naming in Large Language Models

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Large Language Models (LLMs) have demonstrated remarkable capabilities in processing and generating language, potentially offering insights into neural mechanisms of language processing. We tested if stroke aphasia can be computationally modeled with lesions in large language models using picture naming, which is one of the most commonly used tasks to assess abilities of persons with aphasia (PWA). We investigated two fundamental questions: (1) Can systematic neural perturbations in a multimodal LLM replicate different types of picture naming errors observed in stroke survivors? (2) Can parameter-specific modifications be calibrated to match individual PWA picture naming error profiles? We employed LLaVA 1.6, a multimodal language model capable of processing both images and text, to analyze pictures from the Philadelphia Naming Test (PNT). We systematically introduced controlled perturbations to the model's neural network using three key parameters: (1) Gaussian noise level (the magnitude of weight modifications); (2) modification percentage (fraction of neurons in a layer to be modified, ranging from 10% to 100%); and (3) target layer (out of 40 layers). To analyze the resulting outputs, we developed an automated error classification system based on established frameworks from clinical practice. This system categorized naming responses into eight distinct categories including correct responses and seven types of errors: semantic, formal, mixed, nonwords, neologisms, unrelated, and no response. We systematically examined how response patterns changed across the entire three-dimensional parameter space created by the perturbation variables. Results showed systematic modulation in error types in different regions of parameters space. Nonword errors (neologisms, nonwords) pulled away from real word errors at near 50% unit modification and entered a no-response domain at increased perturbation strengths. Results of the layer-specific analysis revealed that, while lower layers (1–9) presented the basic response generation dynamics that turned into no-response errors, middle-to-upper layers (17–29) displayed the dynamics underlying semantic error emergence (with taxonomic errors near the middle layers and thematic errors at upper layers), whereas neologisms mainly emerged from lesions in middle layers (9–21). We then applied this framework to error profiles

from 81 stroke survivors who took the PNT. Results showed that individual response profiles could be matched for greater than 6 response categories for 85% of survivors, and for 37%, we successfully matched across all eight categories. An analysis of response types showed that each of the response categories could be matched in >95% of cases, with the exception of formal errors, which could be matched about 70% of the time. This is unsurprising, given that language models work with tokens and have impoverished phonological representations. These results show promise in the use of multimodal language models as powerful computational proxies to study aphasic language impairments. The systematic relationship between perturbation parameters and error patterns provides preliminary computational evidence supporting distributed lexical access theories and suggests possible computational similarities between such multimodal LLM and some aspects of human language processing.

A4 - Generalizable Semantic Decoding from iEEG Using Deep Nonlinear CNNs

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Direct semantic decoding of concept identities from brain activity is essential for neuroprosthetic applications but remains a formidable challenge. Although motor articulation and planning (Moses, 2021) and phonological coding (Mesgarani, 2014; Pasley, 2012) have been successfully decoded to support speech synthesis, many individuals with post-stroke aphasia cannot reliably generate these signals and thus would not benefit from those approaches. Prior work has recovered coarse semantic information via fMRI (Mitchell, 2008; Huth, 2016) and classified broad semantic categories with EEG (Rupp, 2017; Murphy, 2011), yet decoding a small, fixed set of categories does not guarantee scalability to a full vocabulary. Here, we tested whether deep nonlinear decoders can map brain activity onto a continuous semantic embedding space, capturing complex signal-meaning relationships. We recorded intracranial EEG from awake neurosurgical patients as they viewed rapid presentations of concrete concepts (e.g., “hammer,” “lion”) and made semantic category decisions. In total, 100 concepts were trained, each shown as three different images, 10 times each (3,000 trials; 500 ms ITI). We evaluated two decoder classes: 1) linear Ridge regression to assess linear decodability, and 2) a 12-layer deep convolutional neural network (CNN) to capture nonlinear patterns, each decoding continuous word2vec embeddings. Training used preprocessed, epoched data from left-hemisphere electrodes; Ridge models received flattened channel-by-time vectors, while CNNs processed 2D spatiotemporal inputs. Models trained on 90% of stimuli and were tested on three held-out conditions: 1) unseen trials of trained images, 2) novel images of trained concepts, 3) images of entirely novel concepts. Performance is the average rank-accuracy across four non-overlapping splits (chance=50%). Both models decoded held-out trials of trained images above chance (Ridge=59%, CNN=57%; $p < 0.001$) and extended to novel images of trained concepts, with the CNN performing significantly better than Ridge (64% vs. 58%; $p = 0.0174$), indicating stronger abstraction of semantic-level features. Critically, for entirely novel concepts, Ridge failed to exceed chance performance (52%; $p = 0.1508$) whereas the CNN achieved 66% ($p < 0.001$), demonstrating its ability to generalize

mappings into continuous semantic space. These results demonstrate that deep nonlinear decoders can be trained to generalize to unseen stimuli and extend semantic decoding from discrete categories into continuous embeddings. Despite the training complexity of a deep CNN model, it performed better with only $\approx 25\%$ as many parameters as the Ridge model. Such models hold promise for brain-computer interfaces that recover full-vocabulary semantics in aphasia. Future work could explore the potential of larger architectures to refine neural-semantic mappings with larger amounts of data, advancing the field toward real-time continuous semantic decoding.

A5 - Simultaneous representation of multiple object-states in language is supported by left temporal theta-gamma phase-amplitude coupling

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[Introduction] What do we represent in our minds when processing events in language? Consider the sentence: "The chef will chop the onion". The same onion token exists in both its intact and chopped states within the event. Subsequently cueing the object for retrieval (e.g. "and then he will smell it") elicits an effect of competition in the brain (Hindy et al., 2012; Solomon et al., 2015). This finding has been interpreted to reflect the difficulty of selecting among distinct states, bound to the same object token, for integration into the sentence. Prior to retrieval, however, these multiple object-states must be simultaneously maintained in the mind. What are the neural dynamics by which we do this? Here, we test the hypothesis that the brain recruits the same process it uses to hold objects in visual working memory: theta-gamma phase-amplitude coupling (henceforth PAC). PAC strength has been shown to increase with visual working memory load (e.g. Canolty et al., 2006; Axmacher et al., 2010; Heusser et al., 2016) and performance (e.g. Sauseng et al., 2009; Reinhart & Nguyen, 2019), and is thus a strong candidate mechanism for how the brain represents distinct object states. Across two EEG experiments, we show increased PAC for sentences with substantial change to the object (e.g. "the chef will chop the onion") over those with minimal change (e.g. "the chef will weigh the onion"). We also show that this PAC mirrors that elicited by a visual working memory task (Experiment 2). [Methods] Experiment 1 (N=79) aggregated EEG data from 3 prior studies. Participants read sentences on a screen (one word every 600ms). Stimuli consisted of 2 sentences each: The object underwent either substantial or minimal change in the first, and then was cued for retrieval in the second (e.g. "The chef will chop the onion. And then, he will smell it."). EEG signal was epoched from the onset of the first verb ("chop") to the end of the sentence, and PAC was calculated using a Driven Auto-Regressive (DAR) model (Dupré la Tour et al., 2017) and subject to a cluster-based permutation analysis (Maris and Oostenveld, 2007). In Experiment 2 (N=40), participants also performed a visual working memory task – the PAC cluster obtained from this task was used as a localizer to improve sensitivity for the sentence comprehension task. [Results] In Experiment 1, we identified a left temporal cluster showing increased PAC in the theta-gamma range for substantial change sentences. This cluster was not statistically significant per a cluster-based permutation test. In Experiment 2, we generated an ROI based on the cluster identified in the visual working memory task. Within this ROI,

substantial change sentences showed greater PAC than minimal change sentences ($W = 421$, $p < 0.001$). A simple linear regression showed that PAC increased with degree of change to the object, irrespective of substantial/minimal change labels ($\beta = 0.15$, $p < 0.01$). [Summary] Maintaining multiple object-states online appears to share a neural process with holding objects in visual working memory: left temporal theta-gamma phase-amplitude coupling.

A6 - The role of attention in verbal short-term memory

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Attention is intimately linked with verbal short-term memory (STM) in temporarily maintaining information either by selecting and prioritizing linguistic representations in the long-term memory itself, or within specialized buffers. However, the precise role of attention in supporting verbal STM, particularly auditory-verbal STM, remains unclear. Auditory-verbal STM—the ability to maintain spoken information over a brief period—is frequently impaired in stroke survivors with aphasia (SWA). Cognitive-linguistic aphasia treatments often target auditory-verbal STM to strengthen both retrieval and maintenance of linguistic representations. In this study, we examined the role of attention in maintaining speech sounds over a short delay in 18 chronic SWA and 13 age-matched healthy individuals using a dual-task paradigm. The overarching goal of this work is to inform treatment development targeting maintenance of speech sounds at a single word level, and within phrases, sentences and dialogues. We investigated attention as a limited-capacity resource supporting both phonological maintenance and concurrent cognitive operations. Our framework builds on prior work suggesting that: (1) attention is a domain-general resource, insensitive to its content (e.g., visual-spatial, linguistic); (2) STM traces decay in the absence of attention; (3) the proportion of time that attention is occupied by a concurrent distractor task is the proportion of time during which memory traces decay without being refreshed, as described by the time-based resource sharing model. Our dual-task paradigm consisted of a maintenance task with consonant-vowel (CV) syllable strings and a visual distractor task involving shape judgments. Maintenance load was manipulated by varying CV set sizes (1-5), and cognitive load by varying the distractor shape judgment difficulty (hard, easy). We expected responses to hard shape trials to take longer than those to easy trials, thereby modulating cognitive load. Maintenance performance was assessed using a probe span recognition task after an 8-second maintenance period. We hypothesized that increased cognitive load would impair phonological maintenance. A hard distractor condition would create a bottleneck by limiting the time devoted to maintenance of phonological traces, resulting in their decay and ultimately poorer recognition performance. Data were analyzed using signal detection theory and linear mixed effects modeling. In both SWA and healthy individuals, cognitive load affected probe recognition sensitivity (d') for set sizes 4 and 5, with poorer recognition after hard vs. easy distractor trials ($p=0.032$). No effects were found for set sizes 1 or 2. Unexpectedly, for set size 3, recognition sensitivity was better after hard than easy trials ($p=0.017$). While recognition performance declined from set sizes 1 to 3 during easy trials, no such decline occurred during hard trials, resulting in relatively

better performance at set size 3. We interpret this paradoxical finding as a switch to a more efficient maintenance mechanism under dual-task timing constraints. Overall, results suggest a bottleneck in attentional resource sharing, which affects higher maintenance loads, underscoring the role of attention in phonological STM. Intermediate maintenance loads may benefit from attentional mechanisms in SWA, providing compelling preliminary support for testing the use of dual-task paradigms as a treatment strategy to improve auditory-verbal STM.

A7 - Does Integrity of the Phonological and Semantic Brain Networks Predict Response to Phonological and Semantic Aphasia Treatment?

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Introduction Treatment-induced language reorganization in aphasia is a function of lesion and integrity of the residual language network.^{1,2} However, the differential effect of treatment focused on restoring impaired functional networks or strengthening preserved networks remains unclear.³ Here, we examined the extent to which integrity of brain networks predominantly involved in phonological vs. semantic processing predicts response to phonologically- and semantically-focused aphasia treatment, respectively. **Method** A total of 93 participants with chronic aphasia (>12 months post-stroke) after left-hemisphere stroke underwent language assessments and neuroimaging prior to receiving 15 hours of phonological and semantic treatment in a cross-over design.⁴ Naming performance was assessed with the Philadelphia Naming Test (PNT)⁵ before and after each treatment. Lesions were manually demarcated on T2-weighted structural images⁴ and functional naming-specific activity was obtained by contrasting naming-related activity and activity elicited by abstract image viewing acquired with task-based functional MRI.⁶ Lesion and activation maps were parcellated using the Johns Hopkins University atlas⁷ to define the regional distribution of each network. With reference to prior literature⁸⁻¹³, the phonological network was defined as the inferior frontal gyrus (IFG) pars opercularis, supramarginal gyrus, anterior insula, superior temporal gyrus (STG), and posterior STG, and the semantic network was defined as the IFG pars triangularis, angular gyrus, superior and middle temporal gyri poles, and middle temporal gyrus. Proportional lesion load and functional activity were averaged across areas in both networks, resulting in four values reflecting residual neural integrity for each participant: lesion load and residual activity in the phonological and semantic networks. Linear mixed-effects models (LMMs) were used to test the main effect of lesion load and functional activity in each network as well as their interaction with lesion volume on pre- and post-treatment PNT scores. All LMMs were fit with subject-specific intercepts and adjusted for lesion volume, aphasia severity, age, and time post-onset. **Results** A significant main effect of lesion load in the phonological network on naming was revealed for both treatment phases (phonological: unstandardized $\beta=43.5$, $p=.028$; semantic: $\beta=39.0$, $p=.034$), but no effect of lesion load

in the semantic network. No main effect of activity in either network on treated naming was observed (all $p>.200$). After adjusting for lesion volume interactions, activity in the phonological ($\beta=-11.3$, $p=.034$) and semantic ($\beta=-19.7$, $p=.008$) network was significantly associated with post-treatment relative to pre-treatment naming after semantic treatment only, and activity in the semantic network only was significantly influenced by lesion volume ($\beta=0.01$, $p=.046$). **Discussion** Our results demonstrate that integrity of the phonological network is associated with naming performance irrespective of treatment focus, whereas integrity of the semantic network is selectively associated with semantic treatment effect. Moreover, the association between activity in the semantic network and semantic treatment effect is partially dependent on lesion volume, with greater activity predicting better recovery in larger relative to smaller lesions. These findings suggest that language reorganization following different aphasia treatments depends on the integrity of dissociable functional networks as well as overall lesion size, emphasizing the need for further research on restorative vs. preservative treatment foci.

A8 - Acoustic markers of non-fluent and logopenic primary progressive aphasia through automated speech analysis of picture descriptions

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Introduction Connected speech tasks are widely used by trained professionals in the clinical assessment of primary progressive aphasia (PPA), as they provide insight into the integrity of linguistic representations and motor speech function in this language-based dementia. While recent efforts have begun to use automated speech analysis to objectively quantify connected speech profiles in PPA, acoustic features related to voice quality, intonation, and phonation remain relatively understudied—despite often being disrupted and potentially informative of underlying neural dysfunction. This study aimed to identify a subset of acoustic features able to differentiate between healthy controls (HC), individuals with logopenic variant PPA (lvPPA), and non-fluent variant PPA (nfvPPA), two PPA syndromes associated with distinct patterns of neurodegeneration and speech-language impairment. **Methods** We analyzed speech recordings from 12 lvPPA, 27 nfvPPA, and 30 HC participants describing the Western Aphasia Battery (WAB) Picnic Scene task. Using the Python OPENSIMILE-EGE library, we extracted 38 acoustic features, and grouped them into four categories based on commonly observed deficits: voice quality, volume, spectral richness, and amount of produced speech. We hypothesized that reduced spectral richness would characterize lvPPA (e.g., flattened intonation due to syllable-by-syllable production), while nfvPPA would be marked by impaired voice quality, reduced volume, and limited speech output (e.g., slurred, breathy, or creaky voice with fragmented sentences and overall reduced output). To select features, we used machine learning gradient boost models per category to estimate feature importance in PPA group discrimination and retained the 2-3 highest-ranked, minimally intercorrelated features ($r=-0.16-0.3$) resulting in a set of 10 features. **Results** A multinomial logistic

regression model using the selected features predicted diagnosis with good fit ($R^2=0.693$) and prediction accuracy=84.0%. Receiver operating characteristic (ROC) curve analysis showed that both PPA groups could be discriminated from HC (AUCHC-lvPPA=92.5%, AUCHC-nfvPPA=96.9%), and from each other (AUClvPPA-nfvPPA=78.1%). In combination, the most informative features for classifying lvPPA among the three groups included mean zero crossing rate ($p<.0001$, $z=-37.37$), mean spectral slope between 0-500Hz ($p<.0001$, $z=5.87$), mean length of unvoiced segments ($p<.0001$, $z=-25.55$), and local shimmer ($p=0.05$, $z=1.96$). The set of most informative predictors of nfvPPA included mean number of loudness peaks per second ($p=0.0001$, $z=-3.73$), mean alpha ratio of unvoiced segments ($p=0.007$, $z=-2.68$), and mean spectral slope between 0-500Hz ($p=0.041$, $z=2.03$). Conclusion Speech in lvPPA was characterized by low spectral variability, shorter pauses, and unstable timbre, while speech in nfvPPA was marked by sparse output, high spectral variability, and creaky non-silent pauses. These findings highlight the potential of targeted acoustic features in connected speech to refine phenotypic characterization of PPA variants and offer insight into how distinct neurodegenerative processes disrupt speech motor control and prosody. Ongoing work will validate this set of acoustic features in a larger sample and investigate relationships of acoustic features with neuropsychological performance, brain atrophy, and brain connectivity patterns to contribute to a better understanding of the neural bases of speech and language impairments in PPA.

A9 - Dual-Stream Language Network Mapping in People with Post-Stroke Aphasia and Age-Matched Controls Using Functional Near Infrared Spectroscopy

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Introduction: There are comparatively few functional neuroimaging studies focused on early aphasia recovery, likely due in part to the logistical difficulties of using fMRI with this population. While functional Near-Infrared Spectroscopy (fNIRS) is more cost-effective than fMRI and can be administered across diverse settings, its utility for language mapping in people with aphasia (PWA) remains underexplored. To assess the potential use of fNIRS to index neurological recovery from aphasia, we aimed 1) to determine whether fNIRS activation patterns from semantic and phonological tasks map onto ventral and dorsal perisylvian brain regions, respectively[1,2], and 2) to evaluate how brain activity in PWA varies by lesion location and task performance. **Method:** Thirteen PWA (2 women, 11 men; mean age: 65.8 +/- 6.7 years) and 15 neurologically healthy adults (6 women, 9 men; mean age: 62.5 +/- 11.4 years) completed one run of the Adaptive Language Mapping Semantic Matching[3] and Rhyme Judgment[4] tasks. Both tasks followed an AB design with alternating 20s blocks of experimental (semantic or rhyme judgment) and control (letter string matching) trials. fNIRS data were acquired with two connected 8x8 NIRx NIRSport2s, resulting in 44 long and 8 short channels symmetrically positioned over bilateral perisylvian language areas. fNIRS data preprocessing was completed in Homer3[5] using standard steps. For each task, changes in oxygenated hemoglobin (HbO)

for experimental>control were modeled within a GLM ($t=-2$ to 25s). **Results:** For Semantic Matching, controls significantly activated left inferior frontal gyrus pars opercularis (LIFGop) and triangularis (LIFGtri) and left mid to posterior superior (LSTG), middle (LMTG), and inferior temporal (LITG) gyri. As a group, PWA significantly activated mid LMTG only for Semantic Matching. For Rhyme Judgment, controls significantly activated LIFGtri, left supramarginal gyrus (LSMG), and left angular gyrus (LAG) whereas PWA significantly recruited LSMG only. A significant group x task effect on experimental trial accuracy was observed ($F(1, 52)=4.46$, $p=0.040$) with PWA exhibiting significantly lower accuracy on Rhyme Judgment experimental trials than controls ($t=4.52$, $p<0.001$) with no between-group differences in Semantic Matching accuracy ($t=1.53$, $p=0.132$). No significant relationships between task accuracy and activation were found using LASSO regression. Across PWA, greater damage to LIFGtri ($r=0.68$) and LSTG ($r=0.66$) was associated with increased activity within LMFG for Semantic Matching. For Rhyme Judgment, greater damage to LIFGtri and LIFGop was associated with widespread reductions in activation, whereas greater damage to LSMG coincided with increased activation across most right hemisphere regions. **Discussion:** In controls, activation was primarily observed in ventral stream regions for Semantic Matching and dorsal stream regions for Rhyme Judgment, as predicted according to the dual-route model of language processing[1,2]. As expected, substantial intersubject variability in activation was seen across PWA, yet peak areas of activity for each task still aligned with the dual-route model. The lack of significant brain-behavior relationships were likely in part due to the adaptive nature of the tasks, which reduced the variance in task accuracy. Our results suggest that when critical nodes network nodes are damaged, PWA resort to recruiting ipsilesional regions typically associated with domain-general processing[6] or right hemisphere areas.

A10 - Aphasia, Agraphia and Apraxia of Speech Following Right Hemisphere Basal Ganglia Lesion: Implications for Language Laterality

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Introduction. In recent decades, a detailed picture of language lateralization has emerged: Language Laterality (LL) can differ across the sub-processes (speech production, perception, and reading) and across individuals (Haegen & Cai, 2019). This view, known as the gradient view of LL, is currently gaining ground while the dogma of non-dominant hemispheric role in language is less preferred. For instance, recent brain stimulation research highlighted the functional role of cortico-subcortical structures of the right hemisphere for LL (Vilasboas, Verber, & Duffau, 2017). Greater role for RH in language functions came to be recognized in recent studies of variability in LL (Knecht et al, 2000., Labache et al, 2023). In the backdrop of the recent developments in LL research, the current study discusses a case with crossed aphasia. **Objectives:** To present a case of non-fluent aphasia with apraxia of speech and central agraphia following a right hemisphere basal ganglia lesion, and to discuss the implications of the constellation of language-related symptoms for the evolving theories and models of language laterality. **Method.** A retrospective single case study. **Subject.** SE, a 69-year -old female had a sudden onset of aphasia and

left hemiplegia. Neuroimaging studies of her brain revealed a hemorrhagic lesion in the right head of the caudate and putamen (See Figure 1.). Her language was categorized as global aphasia in the first week after onset. Seven weeks post-onset, her aphasia syndrome evolved into agrammatic Broca's aphasia. At this stage, symptoms of apraxia of speech (AOS) and limb apraxia have persisted. Her LVF neglect also persisted. Clinical observation revealed difficulties in writing/spelling to dictation. Experimental Tests. The following tests were performed to obtain comprehensive information on her aphasia, apraxia of speech and dysgraphia: Boston Diagnostic Aphasia Examination (BDAAE), Apraxia Battery for Adults (ABA), and Psycholinguistic Assessment of Language Performance in Aphasics (PALPA). Additionally, a review of research on nonfluent aphasia following left versus right hemisphere lesion, a review of apraxia of speech causing lesions, and a review of lesions causing central agraphia were completed. Results from these reviews will be used in discussing the right hemisphere's role in language and speech production, and graphic performance of SE. Results. On BDAAE, SE's performance profile was indicative of agrammatic Broca's aphasia. The ABA test results revealed the presence of moderately severe AOS. On PALPA test, SE's writing performance was indicative of the presence of central (phonological) agraphia. Conclusions. The current study supports the view that the BG of the RH plays an important role in language production. Results of lesion studies reviewed indicated that the lesions in BG were almost equally distributed between the two hemispheres. Recent brain stimulation research also offers support to this conclusion. Regarding AOS, no agreement exists among researchers regarding a common site of lesion. However, BG lesions were reported in numerous cases of the acquired neurogenic stuttering (ANS). Dysgraphia as well as aphasia and AOS in SE indicate that the crossover of LL was a global shift in cortical organization, probably due to genetic factors (Labache et al, 2023).

A11 - Altered semantic representations in the cerebellum and cerebrum of autistic individuals

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Individuals with autism spectrum disorder (ASD) process lexical semantic information differently than neurotypical people. However, the brain representations associated with lexical-semantic processing in ASD remains unclear. Previous work has shown that crus I/II of the cerebellum is one of the most common brain regions to show atypical structural development in ASD populations and that these structural abnormalities are correlated with early language delays. Further, neuroimaging studies have shown that crus I/II of the cerebellum represent social semantic information in neurotypical populations. These two lines of evidence suggest that structural and functional differences in crus I/II of the cerebellum may account for behavioral language differences in ASD. Previous studies of lexical semantic representation in ASD have been limited in two important ways. The first is that conventional approaches have often under-sampled the semantic space by comparing how autistic participants differ from neurotypicals on only a limited

number of words or categories. Second, traditional approaches have often failed to consider alternate brain regions besides the neocortex such as the cerebellum. The exclusion of the cerebellum biases our understanding of representational changes in ASD towards the neocortex. To address the limitations in previous studies, we combined natural language stimuli with encoding modeling techniques to precisely map the semantic system in the cortex and cerebellum. To map the semantic system, BOLD fMRI data was collected while participants (ASD = 12; neurotypical = 12) listened to naturalistic language stories. Each participant listened to 11 different ~10-minute stories, with a total of 2 hours of fMRI data per participant. To model language representations in each participant, we extracted a series of feature spaces from the narrative stories to capture different types of language information across the language processing hierarchy. These feature spaces captured information that ranged from low-level auditory information to high level semantic and pragmatic information. We used regularized regression to model the relationship between the feature spaces and the BOLD response for each voxel and evaluated the model on a held out test set. We compared model weights between ASD participants and neurotypicals to understand differences in language representations between the two groups. Low-level language representations associated with auditory and phonological processing were similar between ASD and neurotypical participants in the cortex and cerebellum. In contrast, we observed large differences in semantic representation between the ASD group compared to the neurotypical group. Semantic representations were much more sparse in ASD participants than in neurotypical participants. This effect was strongest in crus I/II of the cerebellum, although differences are also evident in the frontal lobe of the neocortex. Representations related to social processing and theory of mind were significantly underrepresented in both the cerebellum and cortex in ASD participants compared to neurotypical participants. These findings show that the semantic representations are altered in ASD particularly in the cerebellum and frontal lobe of the neocortex. This underscores the potential importance of the cerebellum for studies of ASD.

A12 Sandbox Series - The relation of language and attention skills to brain functional activity in children with ASD and ADHD.

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Up to 15% children are identified as having one or more neurodevelopmental disorders (NDDs; Gidziela et al., 2023), such as autism spectrum disorder (ASD) and attention deficit hyperactivity disorder (ADHD). ASD and ADHD display overlapping symptomatology, especially in areas of social communication, cognitive functions and attention. These shared traits often blur diagnostic boundaries and complicate efforts to understand underlying mechanisms. Moreover, language development in NDDs and its associations with attention is still poorly understood. To address this gap, the current project aims at investigating the relationship between language skills, brain activity and attention in 5-to-7 year-old children with ASD, ADHD, and typically developing (TD; all native Polish speakers,

IQ within age norms). Data collection is ongoing and will be completed by June 2025. Currently the sample includes 45 children with ASD (18 girls), 41 children with ADHD (18 girls), and 36 typically developing children (20 girls). Children completed a battery of behavioral tests including standardized Language Development Test (Smoczynska et al., 2015), a child-friendly version of a go/no-go task and the Attention Network Task (ANT; Rueda et al., 2004). During the functional magnetic resonance (fMRI) session children performed an auditory localizer task of their native language, based on Malik-Moraleda et al. (2022). They listened to short passages from Alice in Wonderland (intact condition) along with an acoustically distorted control condition. Each of 2 runs consisted of 6 intact passages 6 degraded passages (18 s each), presented in pseudo randomised order. Preprocessing of fMRI data will be performed using the fMRIPrep pipeline (Esteban et al., 2019). First-level models and group-level analyses will be run using Statistical Parametric Mapping (SPM12). At the 1st level, a localizer contrast intact condition > distorted condition will be computed. At the 2nd level, a series of one-sample t-tests will be computed to investigate whole-brain activations for the localizer task for each group, along with a one-way ANOVA analysis testing between-group differences. Beta values will be extracted from independent regions of interest of the left inferior frontal gyrus (IFG) and the left superior temporal gyrus (STG) from Fedorenko et al. (2010), for the localizer contrast (intact > distorted). Obtained beta values will be correlated with language test scores (word- and sentence comprehension subtests), go/no-go and ANT scores. Previous fMRI research using the Alice in Wonderland localizer paradigm with children (Tang, 2024; Hiersche, 2024) revealed functional activity in the left IFG and the left STG during language processing. To our knowledge there is no research using this localizer in groups of young children with NDDs. We predict that the language localizer will activate language-related regions including the left IFG and STG in all groups. However, we expect that the extent of the language-related activity would differ between groups and will be positively correlated to language and attention abilities. This study has the potential to expand our knowledge of typical and atypical development, highlighting complex associations between language and attention which could pave the way for early interventions guidelines in the future.

A13 - Pupillometry as a Window into Attention and Reading in ADHD: Insights from a Go/No Go Task

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Introduction: Attention-deficit/hyperactivity disorder (ADHD) is a common developmental condition in childhood, marked by hyperactivity, impulsivity, and inattention. These symptoms impact cognitive, executive, perceptual-motor, emotional, and social functioning. One proposed mechanism underlying ADHD involves dysfunction in the locus coeruleus–norepinephrine (LC-NE) system, which regulates alertness. Higher baseline LC activity in ADHD may cause excessive exploratory-mode behavior and reduced ability to filter irrelevant information. Since pupil diameter reflects LC activity in real-time, pupillometry offers a non-invasive method to investigate this neuromodulatory dysfunction. Pupillometry, which measures pupil dilation in response to stimuli, has been increasingly used

in ADHD research. Studies using working memory tasks, such as the N-back, have found reduced phasic pupil dilation in children with ADHD, as well as correlations between pupil size and task performance. However, no studies have examined pupil responses during an attention and inhibition task, such as the Go/No Go task, or how such responses relate to reading skills, which also require inhibitory control. This study addresses that gap by investigating the relationship between pupil size, inhibitory control, and word reading in children with ADHD. **Methods:** Eleven neurotypical children (age = 11.49 ± 3.30 years) and 11 children with ADHD (age = 10.40 ± 3.0 years) completed a Go/No Go task while eye movements were recorded using an EyeLink Portable Duo (500 Hz sampling rate). In the Go task, participants pressed a button for rare targets (lion; 20% probability) randomized amid frequent non-targets (tiger; 80%). In the No Go task, they responded to frequent stimuli (tiger) and withheld responses to rare targets (lion). A fixed task order was used to build a prepotent response. Each task included 20 practice trials and two blocks of 125 experimental trials. Stimuli were presented for 200 ms with a 1,500 ms intertrial interval. Accuracy, reaction times, and reaction time variability were recorded. Reading skills were assessed using four subtests from the Woodcock-Johnson IV: Letter-Word Identification, Word Attack, Reading Fluency, and Passage Comprehension. Linear regression models were used to predict each reading outcome from pupil size (diameter) during No Go trials and diagnostic group (ADHD vs. neurotypical), including their interaction. Data collection is ongoing, with preliminary results based on 22 participants. **Results:** For Letter-Word identification, larger pupil size is positively associated with better scores for the ADHD group. The effect of pupil size on performance is weaker for neurotypical children. The model explains 48.88% of the variance, suggesting a strong fit ($F(3,10) = 5.144, p = .02$). For Passage Comprehension, larger pupil size during non-target trials is positively linked to better scores for the ADHD group. The relationship between pupil size and comprehension is weaker for neurotypical children, indicating a differential effect by diagnosis. The regression model explains 36.69% of the variance ($F(3,10) = 3.512, p = .05$). Models for word attack and reading fluency were not statistically significant. **Conclusion:** Preliminary results suggest that pupil size during inhibitory control tasks is related to specific reading skills, particularly letter-word identification and passage comprehension, for children with ADHD.

A14 - Structure–Function Coupling in Adults Who Stutter: Evidence from Multimodal Connectivity Modeling

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Introduction: Altered brain structure and function have been independently reported in adults who stutter (AWS), particularly in motor cortical and subcortical circuits, suggesting widespread disruptions in speech-related brain connectivity. However, the relationship between structural and functional connectivity—quantified as structure–function coupling (SFC)—has not been explored in this population. SFC reflects how well structural connections (SC) predict functional interactions (FC), and

reduced SFC has been linked to symptom severity in conditions such as ADHD (Hearne et al 2019), Schizophrenia (Jiang et al 2021), traumatic brain injury (Wang et al 2021), and Alzheimer's disease (Cao et al 2020). These findings suggest that studying SFC may reveal subtle neural abnormalities in stuttering more effectively than unimodal approaches. Prior research shows reduced structural integrity in left hemisphere speech-motor networks and increased functional activity in right hemisphere homologues in AWS (Matsuhashi et al., 2023). This has been interpreted as compensatory right hemisphere recruitment in response to persistent left-hemispheric deficits. Based on this, we hypothesized that AWS would show reduced SFC in left hemisphere speech-motor areas and enhanced SFC in the right hemisphere, reflecting compensatory mechanisms. Methodology: We retrospectively analyzed multimodal MRI data from 65 adults (33 AWS, 26 AWNS), including resting-state fMRI and diffusion-weighted imaging. Functional connectivity was computed using the CONN toolbox (Whitfield-Gabrieli & Nieto-Castanon, 2012) from time series in regions defined by the Speech Lab atlas (Rowe et al 2024). Structural connectivity was estimated using constrained spherical deconvolution implemented in MRtrix3 (Tournier et al., 2019) and quantified as normalized streamline counts between regions. For each participant, we modeled FC as a function of SC using subject-level linear regression, controlling for age, sex, and group. The absolute difference between predicted and observed FC yielded a subject-level error matrix, representing regional SFC decoupling. Group-level comparisons were performed on these error matrices to identify regional differences in SFC. Results: Preliminary analyses from 30 participants (15 AWS, 15 AWNS) revealed no significant group differences in subject-specific SC beta coefficients of the linear regressions ($t = -0.937$, $p = .357$), though there was a trend towards reduced SFC in AWS. Regionally, AWS showed greater coupling between left-right subcortical regions (thalamus, caudate, pallidum), but more decoupling between cortical-subcortical connections (e.g., left somatomotor cortex-thalamus, dorsal inferior frontal gyrus-putamen). Moreover, AWS exhibited stronger interhemispheric coupling in motor areas but reduced intra-hemispheric coupling between sensory and motor regions. Conclusion: This study is the first to investigate structure-function coupling in developmental stuttering. Although group-level differences were not significant in this preliminary sample, regional SFC patterns suggest altered brain integration in AWS, particularly involving cortical-subcortical and sensorimotor pathways. Understanding these structure-function dynamics may offer insights into the neurobiology of stuttering and inform future interventions targeting specific neural networks.

A15 - THE CROSS-LANGUAGE ACTIVATION OF FIRST LANGUAGE (L1) HOMONYMS IN SECOND LANGUAGE (L2) PROCESSING AN INVESTIGATION OF WHETHER L1 HOMONYMS ARE ACTIVATED IN L2 SENTENCE CONTEXT

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The present study aimed to investigate the role of a first language (L1) translation on a second language (L2) word processing in a sentential context by relatively advanced Arabic learners of English. The focus is on cases where a homonymous word in the L1 is realized by independent words in the L2, e.g. Arabic قرش realized by English shark and coin. Using the visual-world paradigm, Arabic-English bilinguals and English native

participants were auditorily presented with English sentences that are predictive of a specific target word (e.g., "shark" in Scuba divers saw the sharp teeth of a giant shark yesterday) while looking at a visual screen. The screen will contain one of the three critical objects: a target object whose English name corresponded to the target word (shark; Arabic: قرش) in the target condition, an Arabic competitor object whose Arabic name shared the same Arabic translation of the target word (coin; Arabic: قرش) in the Arabic condition, or an object that was unrelated to the target word (drums; Arabic: طبول) in the unrelated condition. Compared to native speakers of English, relatively advanced Saudi learners of English made more fixations on the critical objects in the Arabic condition compared to the unrelated condition. This study supports the potential automatic activation of L1 translations when processing sentences in L2, even in relatively highly proficient learners and suggests evidence for the verification model in L2 word recognition

A16 - Congenitally blind participants show enhanced prosody sensitivity in garden path sentences.

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The study of language processing in blind individuals provides insight into the interface between sensory experience and language. Prior studies find that people born blind recruit "visual" cortices for language and outperform sighted peers on some tasks (e.g., Röder et al., 2002; Bedny et al., 2011). Blind adults are resilient to garden path ambiguities in spoken sentences (Loiotile et al., 2020). One hypothesis is that congenitally blind individuals have superior sentence processing abilities, potentially due to greater cortical resources devoted to language. Another, not mutually exclusive possibility, is that they rely more on prosodic cues to avoid garden-paths. The prior study used human-recorded sentences with subtle, but measurable, prosodic cues to sentence structure and could not distinguish between these alternatives. 23 congenitally blind and 22 sighted age-and-education matched adults performed a self-paced listening task (Speech Experiment) and a self-paced reading task (tactile for blind, visual for sighted; Reading Experiment). In the Speech Experiment, the sentence were constructed from words recorded in isolation and therefore had disrupted prosody. In the Reading Experiment, explicit prosody is unavailable. Participants heard/read sentences segment-by-segment and advanced to the next segment by pressing a button; half were syntactically ambiguous (garden path - GP), half were controls (NGP). Fillers were added to minimize strategic adaptation. Participants answered a yes/no comprehension question after each sentence. Offline accuracy and reaction times (RTs) and online RTs were analyzed using mixed-effects models. Speech Experiment: When prosody was disrupted, blind participants exhibited greater GP costs in offline comprehension accuracy (complexity $\times$ group interaction: $B = -1.11$, $SE = 0.44$, $p = .01$; main GP effect, $p < 0.001$; main group effect: $B = -0.05$, $SE = 0.55$, $p = 0.9$) and a marginally larger RTs (group $\times$ complexity interaction: $B = 0.07$, $SE = 0.04$, $p = .09$; main group effect: $B = -0.05$, $SE = 0.06$, $p = 0.3$, main GP effect $B = -0.14$, $SE = 0.02$, $p < 0.001$). These results suggest that distorted prosody has a larger effect on blind listeners, who are sensitive to prosodic cues. Both groups also showed a significant GP effect at the critical segment in the online measure ($B = -0.01$, $SE = 0.008$, $p = 0.04$). Blind participants overall listened faster

than sighted participants ($p < 0.001$). Thus, blind participants performed similarly on comprehension questions despite listening nearly twice as fast, possibly due to experience with rapid screen-reader speech, an assistive technology. Reading Experiment: GP ambiguity was associated with reduced accuracy across groups (main GP effect: $B = 1.28$, $SE = 0.32$, $p < 0.001$). Blind participants performed similarly to sighted in offline comprehension accuracy (main group effect: $B = -0.26$, $SE = 0.42$, $p = 0.5$) and showed a marginally smaller GP cost (group $\times$ complexity interaction: $B = -0.49$, $SE = 0.26$, $p = 0.06$) but were somewhat slower to answer the comprehension questions (main group effect $B = -0.1$, $SE = 0.05$, $p = 0.01$). Both groups showed a significant GP effect on critical segment in the online reading-time measure ($B = -0.08$, $SE = 0.01$, $p < 0.001$). Together, these findings suggest that when prosodic cues are available, blind individuals outperform sighted listeners, but blind people are also more negatively affected by disrupted prosody. We hypothesize that blind individuals rely heavily on prosodic information during sentence parsing, likely due to habitual reduced access to visual referential context.

A17 - Mapping Language-Related Brain Regions in Early Development via Integration of fMRI and fNIRS

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Introduction: The neural mechanisms supporting language learning in early development remain poorly understood, partly due to the challenges of imaging the developing brain with functional magnetic resonance imaging (fMRI)—the gold-standard technique for studying adult neurobiology. To bridge this gap, we have developed a multi-modal imaging protocol that integrates fMRI and functional near-infrared spectroscopy (fNIRS). fNIRS is a more versatile tool to study brain function in young children due to its portability, ease of implementation in naturalistic settings and robustness to motion relative to fMRI. Our approach, combined with a child-friendly localizer, enables mapping of language-related brain regions in early development. **Methods:** Study 1 (data collection complete): We collected simultaneous fMRI (Siemens 3T PRISMA) and fNIRS signals in 40 young adults (18- to 35-year-olds) using a previously validated language localizer task. Study 2 (ongoing): fMRI-fNIRS signals (either simultaneous or concurrent) are currently being collected from toddlers and pre-school-age children ($n = 10$, target $n = 25$) using a naturalistic language localizer task. This naturalistic paradigm consists of 20-sec child-friendly video clips that contrast speech and nonspeech conditions. **Data preprocessing:** The fNIRS data are preprocessed using NeuroDOT (Eggebrecht & Culver, 2019) to create anatomically registered maps of cerebral hemodynamics. Image reconstruction steps include mapping fNIRS optode locations to the individual anatomical MR images, implementing the light model, and running 3D image reconstruction on CIFTI surface maps. In addition, we used eight short-separation fNIRS channels to measure and remove extracerebral signals. The fMRI data are preprocessed via Human Connectome Project (HCP) pipelines (Glasser et al., 2013). For scalp-to-anatomy co-registration of the fNIRS signal, we use a direct mapping of optode locations to the T1w image via vitamin E capsules on the fNIRS caps at each optode location. A key innovation is co-registration of fNIRS channels to each individual's cortical

surface (i.e., a CIFTI surface map), and co-registration of fMRI voxels using the HCP MMP 1.0 atlas (Glasser et al., 2016) and subsequent cortical parcellation, which consists of 180 cortical areas per hemisphere. **Results:** Results from the adult sample (Study 1) show two main findings: 1) similar to fMRI, fNIRS signals recruit canonical language regions in fronto-temporal cortices with lateralization to the left hemisphere; and 2) Optode-to-anatomy co-registration highlights the importance of precise optode localization (e.g., head shape, head circumference). Ongoing quantitative analyses of the two signals consist of assessing the timeseries temporal correlation across fMRI and fNIRS as a function of cortical region, location of the fNIRS probes, and implementation of different smoothing parameters during fMRI data preprocessing. Preliminary data from Study 2 shows bilateral engagement of language areas and modulation by the level of language knowledge. **Conclusion:** Our study provides a comparison of fMRI and fNIRS signals collected simultaneously from the same subjects and shows that fNIRS can be used to investigate cortical activations underlying speech processing during a traditional language localizer task. Preliminary data using a child-friendly, naturalistic paradigm supports the feasibility of fNIRS for mapping language areas in early development.

A18 - Developmental changes in neural states during speech planning for simple phrases in school-age children and adults

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While previous behavioral studies indicate similar speech planning processes for language production in children and adults, neuroimaging studies have identified age-related differences in the neural mechanisms underlying speech planning during single-word production. However, less is known about how children and adults plan longer utterances, such as simple phrases. To address this, we used a picture naming task with magnetoencephalography (MEG) to investigate the speech planning of simple phrases in school-age children and adults. This study aimed to examine: (1) whether there are age-related changes in the neural mechanisms underlying speech planning during phrase production, and (2) when children begin to exhibit adult-like patterns of speech planning for phrases. Eighteen school-age children (9 females; mean age 9.7 ± 2.5 years) and 20 adults (13 females; mean age 26.7 ± 11.3 years), all native English speakers, participated in this study. During a picture naming task, participants described a picture using either an adjective-noun phrase (e.g., "green house") for phrase naming or a noun (e.g., "house") for word naming, while their brain activity was simultaneously recorded using MEG. For data analysis, we applied a hidden semi-Markov model (HsMM) to identify sub-states during speech planning by detecting state transitions through fitting a half-sine impulse model. Source activity per state was then estimated for subsequent comparisons. Behaviorally, both groups had lower accuracy and slower response times ($ps < .001$) during phrase naming

compared to word naming. Across conditions, children showed lower accuracy and slower response times than adults ($p < .001$). Sensor-level MEG results using the HsMM approach indicated that, during speech planning, the optimal number of events was three (yielding four states) for adults and four (yielding five states) for children. Source-level spatial clustering permutation tests revealed that, when contrasting phrase and word naming, adults showed greater activation in the right temporoparietal and posterior medial regions during state 2 ($p = .008$; 310 vertices; approximate 170-410 ms), followed by increased activation in the left insula and anterior temporal lobe (ATL) during state 3 ($p = .035$; 373 vertices; approximate 360-660 ms). Under the same contrast, children exhibited greater activation in the left parietal regions during the first two states, with a spatial shift from parietal to temporal areas between state 1 ($p = .046$; 181 vertices; approximate 0-240 ms) and state 2 ($p = .031$; 202 vertices; approximate 200-450 ms). Correlational analyses further showed that, in state 5 (approximate 750-1080 ms), an adult-like activation pattern in the left ATL during phrase naming gradually emerged with increasing age in children (Spearman's $\rho = 0.62$, $p = .006$). In sum, our study demonstrated distinct speech planning processes between children and adults during picture naming. Specifically, adults recruited bilateral regions related to feature binding and compositional process, with distinct temporal profiles, when planning simple phrases. In contrast, children engaged more attention- or lexico-semantic related left temporoparietal regions during the early stages of phrase naming. Furthermore, age correlations in children indicated a prolonged development of the left ATL to specialize in semantic composition for phrase production.

A19 - New Language Training Promotes Neurocognitive Resilience in Healthy Aging

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Bilingualism i.e., the long-term experience of speaking two or more languages has been shown to promote neuroplasticity by engaging memory, attention, and inhibitory control and boost neurocognitive reserves (Stern et al., 2019; Paulavicius, et al. 2020; Anderson, Hawrylewicz & Grundy, 2020; Deluca et al. 2019). However, little is known about the effectiveness of novel, short-term language learning as a tool for promoting healthy neurocognitive resilience in older adults. This study tests the effectiveness of short-term new language training as a linguistic and cognitive neuromodulator in healthy older adults. The goal of this study is therefore to test the effects of a relatively short novel language training (i.e., 36 days) both as a means to track early brain markers of new language learning using electroencephalography (EEG), and to test whether the effects of the language training generalize to other cognitive functions, such as working memory that are known to be vulnerable in aging. Research design. In this longitudinal study 20 English monolingual older adults, aged 60-85 completed first a pre-test that included several neurocognitive, and linguistic tasks including: Resting-State EEG, an EEG-based N-Back task to measure working memory, a verbal fluency task in English and in Spanish, and a personal social network questionnaire. After pre-test, participants were randomly assigned to either a Spanish Language Training condition or an Active Control

condition. The Language Training group ($n = 10$) completed a Spanish training for ~36 days, using Rosetta Stone in Spanish from home. Each day, participants completed a module that lasted between 30 and 40 minutes. Individuals assigned to the Active Control group ($n = 10$) watched scientific videos from home and answered a few questions for a comparable duration of days and time. After the end of the training (Language Training or Active Control), participants came back for the post-test. During post-test participants completed again verbal fluency tasks in English and Spanish, an EEG-based picture naming task (only for the individuals who completed the Spanish Rosetta Stone Training), and the EEG-based N-Back task. Results: Data for the ERP-based picture naming task at post-test was analyzed for the 10 older adults who completed the Spanish training. Averaged ERP amplitudes in response to pictures that were learned during the training were compared to the ERP amplitude of items that participants were not exposed to during the training. The preliminary results confirm our hypothesis that encoding and memory consolidation of new Spanish vocabulary induces a reduction in the N400 for studied words relative to non-studied words. Working memory was measured through the EEG N-Back task at pre- and post-test. In addition, working memory was measured through the EEG N-Back task at pre- and post-test (Kok, 2001; Finnigan et al., 2011). Our results show an enhanced P200 and P300 at post-test for the older adults who completed the Spanish language training compared to the control group. Conclusions: Overall, these results point toward a positive neuromodulator effect of novel language training in healthy older adults both for language and generalizes to memory functions.

A20 - Neural indices of asymmetries in processing stop consonant place distinctions: replication and extension

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Several studies have suggested that the nature of linguistic-phonological representations accounts for asymmetries in the neural mismatch negativity (MMN) measure to speech sounds which contrast by one phonological feature (e.g., "anterior" versus "coronal" place of articulation). Specifically, the claim is that some features are not specified in neural representations (e.g., "coronal"), and thus, result in a less robust MMN when serving as the central sound representation in an MMN oddball protocol. The current study employed event-related potentials (ERPs) to /b/ and /d/-onset stimuli to attempt to replicate the finding that the MMN is larger when the underspecified coronal (/d/) is the deviant, using three stimulus pairs: "ba" vs. "da" (Experiment 1), "baz" vs. "daz" (Experiment 2) and "bad" vs. "dad" (Experiment 3). Method: Twenty participants listened to the stimuli while the electroencephalogram (EEG) was recorded from 32 scalp sites, time-locked to the stimuli, flipping which stimulus served as the standard and deviant in each experiment. Data were cleaned and the normalized difference between each stimulus as the deviant and standard were subjected to a principal components analysis (PCA) followed by k-Means cluster analysis of the site factor scores. Two clusters reflected the MMN negativity over left versus right frontal region and two clusters reflected the MMN inversion over left and right inferior posterior sites. The data at the sites in a cluster were averaged

and the four models (Right Fronto-Central (FC) Model: Fz, Cz, F4, FC1, FC2, C4, CP1, CP2; Left Frontal Model: F7, F3, FC5, T7, C3, CP5; Right Inferior model: RM, P8, CP6; Left Inferior Model: LM, P7) were subjected to statistical analyses. Results: In Experiment 1, a significantly larger MMN was observed to /dæ/ deviant compared to /bæ/ deviant, peaking at 200 ms. In Experiment 2, however, /dæz/ as the deviant did not show a larger negativity than /bæz/ as the deviant. In fact, frontal negativity was only robust between 350 and 400 ms. In Experiment 3, /dæd/ as the deviant elicited a larger MMN than /bæd/ as the deviant, peaking around 200 ms. The stimulus /dæd/ as a deviant also elicited an enhanced N1 pattern peaking at 88 ms at frontal sites and inverting at the mastoids. The other stimulus conditions also show an increase in N1 for the FC model, but the response did not invert at the inferior sites. Not observing an MMN at 200 ms for the /dæz/ deviant was unexpected because the /b/ vs /d/ difference was identical to the onsets used for /bæd/ and /dæd/. Discussion: These findings suggest a more complex explanation of asymmetries of the MMN, where acoustic-phonetic properties (e.g., formant frequencies of [z]) and/or lexical properties of the stimuli modulate neural discrimination. Future studies will need to systematically explore how phonetic features and lexical information modulate neural discrimination before concluding that asymmetries in MMN to various phonological feature contrasts support a model of phonological underspecification.

A21 Sandbox Series - Does parent talk influence child exploration? Comparison of signing and non-signing parents' guidance during shared exploration with their children

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Background: Developmental theorists emphasize the importance of caregiver talk during children's exploration in shaping their language learning. Parental guidance through talk -- such as scaffolding, encouragement or direction -- may influence children's tactile exploration. Research has primarily focused on monolingual English-speaking parents with typically-hearing children, leaving significant gaps in understanding how diverse language experiences shape learning through tactile exploration. Children who are deaf or have deaf parents experience varied home language environments -- some using visual-manual languages like American Sign Language (ASL) at home, others using spoken language. For signing children, hands serve dual purposes: language expression and tactile manipulation, potentially impacting their cognitive strategies during exploration. Rationale: Our ongoing study measures tactile exploration in 2-to-6-year-old children with their caregiver whose primary home language is either spoken English or ASL. Parent utterances are classified as falling in guidance types following methods of Fender and Crowley (2007). We address two research questions: 1) Do speaking vs. signing parents differ in their guidance type? 2) Does parent guidance type influence the depth of children's exploration? Method: Data so far includes 10 signing parent-child dyads and 22 speaking parent-child dyads. Parents complete home language history surveys in RedCap. Dyads are filmed at a local children's play-based museum in a mock grocery store exhibit for 10 minutes. Parents wear chest-mounted GoPro harnesses, with an RA filming from 5-8 feet away. Videos are coded using

an adapted Exploratory Behavior Scale (EBS), scoring children from 0-3 (minimal to deep exploration) in 30-second intervals over 10 minutes (Van Schijndel et al, 2010). Parent utterances are transcribed and classified as: scaffolding, encouragement, directing, or other/unrelated. Preliminary Results: To address our first research question, our planned analysis model will predict average utterance frequency from parent language modality (signing, speaking) and guidance type (scaffolding, encouragement, directing) as primary predictors. Child age, child gender, caregiver gender and caregiver education are covariates. For our second research question, we will examine whether average EBS scores across children are predicted by parent language modality and guidance type. Conclusion: While exploratory play clearly benefits language learning, few studies examine how exploratory play behaviors vary based on home language modality and experience. Our research examines how language modality influences parent-child interactions during exploration. Recognizing the factors that shape children's exploratory behavior is important because different language experiences may provide children with varying tools for tactile exploration and thus their understanding of the environment. Furthermore, comparing signing and speaking parents' strategies helps us understand how diverse language experiences shape children's exploratory behavior. The EBS shows promise as a quantitative measure for assessing preschoolers' tactile exploration, contributing to our understanding of relationships between linguistic input, modality, and active learning.

A22 - Cross-language transfer of morphological processing in Chinese-English bilingual preschoolers

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Morphological awareness, or the ability to understand and use units of words (morphemes), is an essential language skill for reading development. Languages differ in morphological rules. For example, Chinese makes up words mainly through compounding (i.e., snow-man), while English is more characterized by affixes (i.e., read-er, fly-ing). It was found that Chinese-English bilingual young readers show different brain mechanisms than English monolingual readers when processing morphological units. Yet, what remains unknown is if these differences are early emerged. Indeed, behavioral evidence showed that children begin to show morphological awareness from as early as 4 years. Using fNIRS, the current study aimed to measure functional brain activities during morphological word processing among preliterate children. Bilingual Chinese-English and English monolingual children (N=162) completed a lexical morphology task in which they heard three words and picked out the one that "goes with" the target word (e.g., runner, water, dancer). Results showed cross-language transfer that, bilingual experience with compound-heavy Chinese leads to more specialized brain activities during English compound processing by engaging stronger left middle temporal regions and less strong left inferior frontal regions in the Chinese bilinguals than English monolinguals. Moreover, English monolinguals showed more specialized brain basis during the affix processing with a stronger left superior temporal activation. These findings reflect differences in the strategies for breaking words into parts and accessing meanings for each part. This research will further our understanding of how the brain adapts to different types of language input to support

language acquisition and emerging literacy in children from linguistically diverse backgrounds.

A23 Sandbox Series - The Role of the Mentalizing System in Novel Word Memory Across Neurotypical and Autistic Adults: a Functional Connectivity Approach

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Mentalizing skills – computing others' perspectives – are a gatekeeper for word learning in typically-developing (TD) individuals and a central aspect of autism (Tomasello, 2003; Kuhl, 2011; Baron-Cohen et al, 1985; Rosenthal et al, 2019). Behavioral work has showed that the mentalizing system can be leveraged for word retention in typical development – children and adults remember more words learned in situations requiring mentalizing than one-to-one meaning-mapping situations (Trice et al, 2023, 2025). Importantly, mentalizing skills predict better retention – not immediate mapping – suggesting that there may be a privileging of words learned via mentalizing in memory. This is supported by emerging behavioral and neuroimaging work in non-linguistic domains, which suggest the privileging of scenarios evoking mentalizing and similar socio-cognitive processes in memory consolidation and retention (Lin et al, 2019; Jimenez and Meyer 2024). However, this behavioral link for word retention has not been found in autistic individuals (Trice et al, in prep). With 60% of autistic children demonstrating language difficulties, including vocabulary, which don't resolve with age, understanding if mentalizing in autism is a barrier or support for vocabulary growth is critical (Durrleman et al, 2015; Tager-Flusberg, 2011). But current neuroimaging work is limited on the role of the mentalizing system in word learning even in TD individuals, and the relationship between this and memory system is largely unexplored. Here, we aim to characterize the neural connection between mentalizing and memory in word learning and retention in autistic and TD adults. 20 TD and 20 autistic adults (currently, 8 and 12) will complete a word learning task in a MRI scanner. Novel words will be learned in three conditions – a direct mapping condition, in which there are only identical novel objects present and thus there is a clear one-to-one mapping between word and object; a lexical inference condition, in which two novel object of contrasting sizes are a present and the initial ambiguity of the intended referent can be resolved by the contrast of the object's named size; a pragmatic inference condition, in which two identical and one unique novel objects are present and the intended referent can be resolved by correctly computing the speaker's underlying beliefs and intent. Retention of all novel words will be tested 18 minutes later. A mentalizing localizer will identify group-constrained mentalizing parcels, from which subject-specific sub-parcels of the greatest activation will be extracted (Richardson et al, 2018). Subject-specific memory regions will be extracted based on greatest activation for known over forgotten words in the medial prefrontal cortex, the prefrontal lobe, and hippocampus during retention. Task-based functional connectivity between mentalizing and memory region sub-parcels will be calculated for each condition and analyzed for relation to group, condition, and individual memory outcomes. Here, we hypothesize that the functional connectivity between the mentalizing and memory systems during word learning will be reduced in autistic adults, particularly when mentalizing is needed. Furthermore, in both groups, greater functional connectivity between mentalizing and

memory will correlate with a memory advantage for words mapped via mentalizing.

A24 - Cortical sites critical to speech and language function have distinct static and dynamic network profiles

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Prior to surgery for epilepsy or brain tumors, focal brain areas that are "critical" for speech and language have long been identified using electrocortical stimulation (ECS), which perturbs function. However, the precise mechanisms of ECS are poorly understood, despite its established utility in the clinic. For example: speech/language circuits in the brain are recognized to span multiple cortical areas, but it remains unclear whether ECS affects only the local cortex, or if network-level processing is disrupted. To investigate this question, we recorded electrocorticography (ECoG) from sixteen participants while they performed a single-word reading aloud task. We extracted high-gamma (70-200 Hz) activity from ECoG recordings from frontal, temporal, and parietal electrodes, and quantified the properties of cortical networks as they relate to both criticality and behavior. To do this, we first computed pairwise correlations between electrodes over different timescales—static (several minutes) and dynamic (750-ms windows sliding by 100-ms increments) to examine changes in network properties during behavior. We quantified network properties using graph theory metrics computed from the correlations. As noted, we were particularly interested in the static and dynamic properties of critical sites for speech and language (those producing speech arrests and language errors such as anomias and paraphasias, respectively) compared to other (non-critical) cortical sites. Static analysis showed that critical sites could be distinguished by their profile of network properties. This profile included lower global and local connectivity (clustering coefficient, eigenvector centrality) for both speech arrest and language error sites than for non-critical sites. Notably, language error sites served as connectors between modules (subnetworks) in the language network (i.e., had high participation coefficients). Additionally, cortical networks reconfigured dynamically during oral word-reading. Transitions between behavioral states—for example, among rest, task engagement, and speech onset—changed the relationships between measures of local connectivity and connectivity across subnetworks. In particular, there was a change in the correlation between participation coefficient ("connectorness") and within-module degree (local connectivity) for critical sites, but not for non-critical sites. These patterns of change meant that, broadly, cortical network connectivity during the behavior could deviate substantially from its profile as calculated with a static analysis. These results suggest that a site's pattern of connections within the language network helps determine its importance to language function. Further, language networks' properties change dynamically and heterogeneously with behavior. This highlights the importance of examining brain activity during active behavior, at the resolution of the behavior itself, in addition to static resting state analysis. It also suggests that sites critical for language and speech function can be defined by dynamic, quickly changing connectivity profiles.

A25 - Lexical stress precedes syllable structure during speech planning – evidence from EEG-MVPA

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To produce a word, speakers need to decide which concept to express, select an appropriate item from the mental lexicon, and spell out its phonological form. The temporal dynamics of these processes remain a subject of debate. Concerning the phonological phase, (psycho)linguistic theories have long argued whether a word's stress pattern is retrieved independently, or whether this information is derived from a word's syllable structure. To address this issue, we investigated the time course of lexical access in picture naming with electroencephalography (EEG). Native speakers of Dutch (N=30; 23 female; age 23.4 ± 4.2 years) named 48 pictures using simple nouns. The picture names varied in semantic category (animate or inanimate), stress pattern (first or second syllable), and the structure of the first syllable (open or closed). We analysed the EEG data using time-resolved multivariate pattern analysis (MVPA), which quantifies the extent and time course in which neural representations support the discrimination of relevant stimuli dimensions. Using time-resolved MVPA, we decoded the availability of semantic category, stress pattern, and syllable structure during speech preparation. An additional, exploratory analysis was performed on the availability of the word-initial phoneme (plosive vs. fricative). The results demonstrated above-chance decoding of semantic category within 100 ms after picture onset, confirming early access to semantic information. This was followed by stress pattern and syllable structure, at around 150 and 250 ms after picture onset, respectively. These results suggest that a word's stress pattern can be retrieved before syllable structure information becomes available. The exploratory analysis demonstrated the availability of the word-initial phoneme within 100 ms after picture onset. This result, while not part of the a-priori analysis plan, tentatively supports the view that during picture naming semantic and phonological information are accessed rapidly and in parallel. In sum, our results offer novel insights for theories of language production, suggesting that the retrieval of lexical stress is independent from syllable structure. Importantly, this study demonstrates the successful application of MVPA on pre-articulation data from EEG, a widely available method, offering an accessible approach to address novel questions in speech production research.

A26 - The Relationship between Glymphatic Function (DTI-ALPS), Executive Function, and Language Production in Healthy Aging

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The glymphatic (glial-lymphatic) system is a fluid-clearance pathway that clears cerebral waste products within the central nervous system. Animal studies suggest that better glymphatic clearance enhances cognitive abilities. Diffusion Tensor Imaging Analysis along the Perivascular Space (DTI-ALPS) is a recently proposed method to measure glymphatic function in the human brain (Taoka et al., 2017). The DTI-ALPS index accounts for age-related variability in structure and function (Taoka et al.,

2022), where lower ALPS index correlates with smaller cerebral cortical volume and worse cognitive performance (Siow et al., 2022; Zhao et al., 2024). For example, among individuals with dementia, a lower ALPS index was correlated with worse picture naming performance (Zhao et al., 2024). Among healthy adults, the DTI-ALPS index was negatively correlated with age, and positively correlated with executive function performance in manipulation and working memory tasks (Hsiao et al., 2023). However, the relationship between DTI-ALPS and age-related differences in language production has not been examined. We examined age-related differences in the glymphatic system and its role in executive function and language production among 91 neurotypical adults (20–81 years old). We used an automated ALPS calculation (Li et al., 2024) to identify the perivascular regions of interest required to calculate the ALPS index for the left and right hemisphere. Using the mean ALPS value, we found a significant negative correlation between ALPS index and age ($b = -0.002$, $p < .001$), indicating worse glymphatic function with increasing age. To examine executive function, we used the color-word Stroop effect as a measure of inhibition ability, and the Reading Span task as a measure of working memory. To examine language production, we examined accuracy (ACC) and reaction time (RT) to a picture naming task. There was a negative correlation between the ALPS index and the Stroop interference effect ($b = -163.97$, $p < .05$), linking better glymphatic functioning with better inhibitory control (i.e., less interference). There was also a main effect of age on Stroop performance, however the ALPS index did not mediate this relationship. There was no significant relationship between the ALPS index and reading span. For performance on the picture naming task, older ages were associated with slower and less accurate picture naming (p 's $< .001$) and a higher ALPS index was related to faster picture naming times ($b = -.0017$, $p < .005$). Additionally, we found significant interactions between Age and ALPS index on picture naming ACC ($b = 0.039$, $p = .001$) and RT ($b = -.0078$, $p < .001$) where among older adults a higher ALPS index was associated with faster and more accurate responses, and the opposite was found among younger adults. Moreover, mediation analyses indicated that the ALPS index mediated the relationship between age and picture naming RT (ALPS $R^2 = 17.4\%$, $p < .001$). Overall, our findings highlight the utility of the ALPS index for evaluating the relationship between cognition and healthy aging especially for inhibition and word retrieval among older adults.

A27 - Individual rhythms in solo and joint speech

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INTRODUCTION: Individuals exhibit stable rate preferences for motor activity, like finger tapping or music performance, and these preferences also impact auditory-motor synchronization (Scheurich, Zamm, & Palmer, 2018). We extend consideration to speech production, a highly adaptable task with layered rhythmic structure: pulse (syllabic timing) and meter (prosodic phrasing) (Fitch, 2013). To balance between these two rhythms, speakers may modulate syllabic rate to preserve prosodic timing across longer phrases (Jun 2003). **METHODS:** We use a self-paced and joint-reading paradigm to examine: 1. Whether individuals show stable self-paced speech rate preferences and whether prosodic structure affects these rates; 2. Whether individual rate preferences influence synchronization in joint

speech. Ninety participants first completed a self-paced reading task. Based on their average syllable inter-onset interval (IOI), we invited a subset of 32 to perform synchronized joint reading. Each participant read with one rate-matched and one rate-mismatched partner. Stimuli were short sentences of varying lengths (4–6 syllables), and were read in blocks of 10 sentences to promote rhythmic entrainment. We measured speech rhythm via syllable IOIs (including lengthening and pauses) and synchronization via onset asynchrony. The difference in solo IOI rate preferences within each pair was used to predict joint asynchrony. **RESULTS:** Self-paced IOIs ranged from 188 to 388 ms ($M = 288$, $SD = 50$), showing substantial inter-individual variation. IOIs decreased as sequence length increased (~30 ms from 4 to 6 syllables), consistent with metrical pacing. IOIs at sentence-final positions were about twice as long as in other positions, indicating the prominence of phrase-final lengthening and pause. In joint reading, rate differences between partners did not significantly predict onset asynchrony, though pairs with closer solo rates showed a small numerical trend toward better synchronization. Regardless of initial preference, pairs tended to converge toward an intermediate rate, with one speaker leading by ~30–40 ms. Asynchrony peaked at sentence onsets and decreased over the course of the sentence, suggesting participants used both sentence-initial and sentence-final boundaries as synchronization cues. **CONCLUSION:** These findings suggest that while individuals have preferred speech rates, they flexibly adapt in social contexts. The weak predictive power of solo speech rate for joint synchronization highlights the flexibility of entrainment mechanisms. Compared to music, speech's faster tempos and greater variability may make temporal alignment less reliant on individual rhythmic defaults and more dependent on adaptive cueing at prosodic boundaries.

A28 - Semantic Priming Effects of Highly Typical and Atypical Category Exemplars on Visual Word Recognition in Spanish

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The current study aims to evaluate the effect of lexical typicality (e.g. how popular a word is in its lexical category based on existing normative studies) on visual word recognition in Spanish. Previous research demonstrated the effect of different semantic characteristics of a word, such as familiarity, relatedness and translation equivalence in visual recognition and memorization tasks (Grainger & Frenck-Mestre, 1998; Leroy & Kauchack, 2014). The effect of lexical typicality has mostly been studied in English and in tasks without direct word recognition (e.g. picture naming, relatedness judging) (Crowe & Markschark, 2019). This study intends to fill the gap left by the absence of previous research in Spanish in this area. 38 undergraduate students from Bogotá and Cali, Colombia, participated in an experiment consisting of a semantic categorization task using masked priming. Subjects saw a fixation “####” for 500msec, followed by a prime for 67msec, in lowercase, and finally a target, in uppercase, which only disappeared once they pressed a button. They were asked to decide if the target was a member of a semantic category. All experimental targets belonged to the group tested (e.g. “FRESA” (STRAWBERRY) – frutas (fruits), and primes were organized in 3 conditions: 1) highly typical member of the category (e.g. prime: “manzana” (apple), target: “FRESA”

(STRAWBERRY)), 2) atypical member of the category (e.g. prime: “tomate” (tomato), target: “FRESA” (STRAWBERRY)) and 3) unrelated (e.g. prime: “ventana” (window), target: “FRESA” (STRAWBERRY)). Results show statistically significant priming effects of approximately 18 msec in the highly-typical condition, $F(1,37)=45.816$, $p<0.001$; and 9 msec in the atypical condition against controls, $F(1,37)=7.483$, $p=0.010$. Statistically significant differences were also found between highly typical and atypical primes, $F(1,37)=11.172$, $p=0.002$. These results indicate that highly typical members of a semantic category cause a stronger activation of related terms than atypical ones. These findings help elucidate one of the aspects that contributes to the word recall processes in real time, support the idea that the mental lexicon groups semantically related items together as discussed in previous research and theoretical models (i.e. Lakoff (1987)) and converge with the findings from previous experiments (e.g. Jergen and Damian (2005); De Deyne et al. (2016)), which supported the idea that highly typical items are more strongly associated in their semantic networks with their respective categories in comparison to atypical ones.

A29 - The N400: A comprehensive neurocognitive synthesis and new explanatory framework unifying processing and learning within neocortical-medial temporal-lobe circuitry

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The N400 is a widely-studied brain response elicited by both language and non-language stimuli. N400s have generally been taken to reflect aspects of lexical and/or semantic processing. Building on previous work, we propose that N400s reflect both the processing and learning of lexical/semantic knowledge. Specifically, we suggest that the N400 is rooted in a processing-and-learning “what” circuit that links the temporal-lobe ventral stream with anterior portions of medial-temporal-lobe-based declarative memory, in particular in (peri)rhinal cortex and the anterior hippocampus. In this circuit, the ventral stream hierarchically processes (visual and/or auditory) inputs, posteriorly to anteriorly. The resulting representation is then passed to perirhinal cortex, which evaluates to what extent it matches already-existing representations, by retrieving that information from (mainly temporal) cortex. A mismatch (in content or strength) warrants updating/strengthening the existing representations, in which case perirhinal cortex passes the incoming representation downstream via (anterior) entorhinal cortex to the (anterior) hippocampus. The hippocampus then binds together novel and existing aspects of the relevant representations upstream in (mainly temporal) neocortex, particularly in the ventral stream(s) and middle/anterior temporal cortex. We posited that N400s are generated by various portions of this circuit. To test this framework and more generally to comprehensively examine the neurocognitive bases of N400s, we examined multiple lines of evidence. First of all, as expected by the framework, N400s are indeed found largely for stimuli that involve the “what” circuit and are potentially meaningful (related to already-learned representations, thus warranting their retrieval), especially when such stimuli are unfamiliar or unexpected (and thus they are likely to engage perirhinal cortex and lead to hippocampal learning). Conversely, N400s are typically not found when the

input does not involve the “what” circuit, for example when the stimuli engage procedural memory (e.g., in Serial Reaction Time tasks, or for grammatical anomalies in native languages), or when they involve the “what” circuit but are not potentially meaningful (e.g., consonant strings like ‘qxmz’) or are more expected (e.g., semantically congruous) or familiar (e.g., high-frequency/real items). To directly examine the neuroanatomical substrates of the N400, we performed two meta-analyses, each based on systematic searches of the relevant literatures. First, to help identify which brain structures are involved in generating N400s, we performed a quantitative synthesis of structures (throughout the brain) implicated in generating N400s in direct (intracranial) brain recording. Second, to help reveal which brain structures are necessary for generating N400s, we performed a quantitative synthesis examining lesion-symptom (structure-N400) mappings; that is, we examined the degree to which damage in neuroanatomical structures (throughout the brain) across a range of disorders predicts N400 amplitude reductions in those disorders in comparisons with healthy controls. Both of these meta-analyses particularly implicated both middle/anterior temporal neocortex and the anterior medial temporal lobe, especially (peri)rhinal cortex. Overall, converging evidence supports the proposed framework positing that N400s are generated by the neocortical-medial temporal-lobe “what” circuit. Further, the evidence identifies exactly which structures within the circuit play crucial roles in generating N400s. We conclude by discussing basic research and translational implications.

A30 - Our difficulty remembering new words as we get older may be driven by hippocampal atrophy

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Although word learning is important during childhood, it continues throughout our lives (sudoku, Wegovy, your new neighbor's name). However, it remains unclear just how aging affects learning and remembering new words and how this is impacted by age-related neural declines. We examined these issues in a cross-sectional continuous-age study (N=191) of participants aged 18-85. Participants saw and heard new words (concrete nouns) together with picture referents, and were then tested on recall (name a word from its picture) and comprehension (match one of two pictures with a word). Gray matter volumes were segmented from whole-brain and high-resolution-hippocampal MRI scans. Given the striking hippocampal atrophy in aging, and evidence implicating the hippocampus in learning and recalling (“recollecting”) associations, we hypothesized that hippocampal atrophy may contribute to age-related declines of word learning, perhaps especially at then recalling these words. Preliminary analyses revealed the following. First, the recall but not comprehension (which does not require recollection) of newly-learned words showed significant age-related declines. Second, the recall declines were (marginally significantly) mediated by volumes of the hippocampus but not of frontal- or temporal-lobe control structures. Third, within the hippocampus, several hippocampal subfields appear to play a role in the declines, including the dentate gyrus, CA1, and CA3, all of which have been implicated in learning or recall. In summary, as one ages it appears that one's ability to learn new words and then understand them does not clearly decline. However, recalling newly-learned words

does decline with age. These declines may be driven by the hippocampus, a structure not traditionally tied to language. The study further reveals that particular hippocampal subfields contribute to these declines, potentially advancing our understanding of the fine-grained neural bases of language. The study suggests that word-learning declines in aging may benefit from interventions targeting the hippocampus (e.g., exercise, pharmacological agents).

A31 Sandbox Series - Influence of sentence information load on predictive processing: An ERP study

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Listeners make predictions about upcoming content using previous information in the sentence, which contributes to language processing efficiency (Ryskin & Nieuwland, 2023). Capacity limitations on human cognitive resources mean that we may not always be able to keep all of the information in mind that might be relevant to making predictions. The goal of the current study is to examine the impact of information load on sentence final prediction. Consider these two sentences: (a) “I wanted to give him a phone call, but I could not remember his number.” (b) “I wanted to give him a phone call when I was at work yesterday, but I could not remember his number.” Based on the cloze task, we know that both sentences lead to the prediction of “number,” given the context of giving a phone call, but not when that context is missing, as the most common completion of the final clause is “I could not remember his name.” Sentence (b) involves an intervening middle clause, which increases the information load and cognitive demand involved in maintaining that critical initial context that drives prediction of “number”. The hypothesis being tested here is that with the intervening clause the listener is more likely to fail to maintain the key contextual information in the first clause in a working memory (WM) system, and is therefore more likely to generate a prediction based on adjacent context. Comparing predictive processing following sentence contexts constructed like (a) versus (b) allows us to examine whether the sentence information load and WM demand involved in processing the context impact prediction. The experiment uses EEG recording during a sentence comprehension task, and the key measure is the N400 event-related potential (ERP) as a measure of prediction. Participants read sentences structured as (a) and (b), and the sentences are followed by an expected word (number), a word predicted by adjacent context (name), or an unexpected word (jacket). The N400 has a strong linear relation with the word's predictability and is sensitive to the degree of semantic prediction violation (Federmeier et al., 2007; Federmeier & Kutas, 1999). Thus, for (a) and (b) sentences, one should expect a small N400 following the expected word, a medium N400 following the word predicted only by the adjacent context, and a large N400 following the unexpected word. However, the key question is whether the presence of the intervening clause in (b) sentences impacts the sentence-final prediction relative to sentence (a). We hypothesized that if the intervening clause in type (b) sentences leads to higher WM demand and biases the comprehender towards a prediction biased by the adjacent information, then one should also expect a bigger N400 following the expected word “number” and a smaller N400 following the less expected word “name” for sentence (b) than for sentence (a). By designing sentences with varying information load and examining the impact on sentence-final

prediction-related effect, the current experiment aims to enrich our understanding of the cognitive mechanisms of predictive processing in language.

A32 - Neural Decoding of Autobiographical Visual Imagery cued by Text

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The human brain's ability to mentally visualize autobiographical experiences has been linked to the Medial Temporal subsystem of the Default Mode Network (MT-DMN). In contrast, Frontotemporal-DMN has been proposed to support more abstract verbal, semantic and social cognition, and Core-DMN has been associated with self-referential cognition. Whilst broad patterns of activation and deactivation within DMN subsystems have been thoroughly investigated by contrasting brain responses to different neurocognitive tasks, and MT-DMN has been observed to activate during visuospatial imagery and pictorial semantic tasks, the representational codes underlying the mental visualization of autobiographical scenes have been understudied. This is in large part because deriving computational models to use to identify idiosyncratic visual components of self-generated mental images in functional brain scans is challenging. To target this question, we scanned fifty peoples' brain activity with fMRI as they imagined their personal experience of twenty natural scenarios when presented with generic written scenario cues (e.g. wedding/funeral/driving). Visual imagery was modeled using: (1) Image-generation AI models to depict participants' verbal descriptions of their mental images made outside the scanner, and (2) Image-recognition models to re-represent synthetic images as abstract visual representations, that have been applied to model neural responses in high-level visual perception and the imagination of visual objects. Non-visual autobiographical semantics associated with participants' mental image descriptions was modeled using the large language model GPT-2. A Representational Similarity Analysis revealed that MT-DMN reflected participant-specific visual model structure when controlling for GPT-2 features, and this effect was not present in FT-DMN or Core-DMN. MT-DMN also reflected GPT-2 information structure when controlling for the visual model, however greater/equivalent effects were observed in Core- and FT-DMN respectively. To further evaluate whether MT-DMN visual correlates were a product of active autobiographical imagery, the same the same modeling and RSA approaches were deployed to test a separate fMRI activation dataset scanned as fourteen different participants read imageable third person sentences in absence of an active mental imagery task. In absence of active imagery, the visual effect in MT-DMN was also absent, however MT-, FT- and Core-DMN all reflected GPT-2 relatively strongly. This finding helps to characterize the neural bases of autobiographical mental imagery, and sentence reading and identifies image AI models as valuable tools for exposing the neural correlates of autobiographical visual imagery.

A33 - The neural basis of language about animates

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Starting early in life, humans are highly motivated to think and talk about animate entities (i.e., people, animals). Infants attend to faces from birth (Maurer, 1985; Johnson & Morton, 1991), and nouns referring to people and animals are among their first words (Nelson, 1973; Gentner & Boroditsky, 2008). Throughout life, we use language to acquire culturally-accumulated knowledge about animates from other people, such as how plants grow and why people get sick (Harris & Koenig, 2006; Legare et al., 2012). Here we applied univariate and multivariate fMRI approaches to investigate the neural mechanisms that support thinking about animates during language comprehension. To provide broad insight into this question, we combine data across three fMRI experiments (total n=75) with stimuli ranging from single words (e.g., 'sparrow', 'giraffe'), to two-word phrases (e.g., 'princesses want') and short stories (e.g., 'Sam sunbathed on a sunny beach...'). Across conditions, linguistic stimuli were matched in word frequency, length, and grammatical complexity. Stories elicited causal inferences across sentences without adding explicit mention of people or animals, allowing us to disentangle conceptual retrieval from surface form. Some stories encouraged thinking about minds, and others about bodies (i.e., illness). A subset of the participants (n=32) additionally completed a language localizer task that identified language-responsive regions in individual brains (Fedorenko et al., 2010). Analyses used both univariate (whole-cortex, individual-subject fROI) and multivariate (MVPA, RSA) approaches. Across all experiments, understanding language about people and animals recruited a consistent temporoparietal 'animacy network,' including specific portions of the temporoparietal junction and precuneus. This network exhibits several signatures of sensitivity to animacy. First, it responds more to single words describing animates (animals) than inanimates (places). Elevated responses to the mention of animates are also observed in story contexts, whereby the network's activity scales with the number of animates (people) mentioned. Multivariate patterns within the animacy network distinguish between people types (e.g., princesses vs. cowboys) described in two-word phrases (e.g., 'cowboys believe'), regardless of the actions the agents are engaged in (e.g., wanting vs. believing). Finally, the same temporoparietal animacy network shows an elevated response to causal inferences about animates (e.g., sneezing transmits illness) compared to causal inferences about inanimate objects (e.g., earthquakes damage buildings) as well as causally unconnected stories. Neighboring regions within this network are sensitive to causal inferences about bodies (illness) and minds (beliefs). In contrast to the temporoparietal animacy network, visual areas associated with face processing (i.e., fusiform face area) did not respond to language about animates. Individually-localized frontotemporal language regions also did not respond to the number of animates in stories or prefer causal stories over non-causal stories, animate or otherwise. However, multivariate patterns in language regions did distinguish between animate from inanimate causal stories. Together, our findings suggest that understanding language about animates depends on an amodal semantic network. We hypothesize that this network interacts with frontotemporal language regions during comprehension. More broadly, our results support the hypothesis that the frontotemporal language network interacts with a distributed collection of semantic systems that represent different types of abstract conceptual knowledge.

A34 - Characterizing the contributions of anterior temporal lobe areas to semantic language processing

Leonardo Fernandino¹, Jia-Qing Tong¹; ¹Medical College of Wisconsin

While the anterior temporal lobe (ATL) has been known to contribute to semantic language processing, the precise nature of these contributions remains controversial. Does the ATL constitute/contain a single high-level semantic hub where all concepts are represented, or do different regions of the ATL represent different kinds of concepts? Taking advantage of recent advances in fMRI acquisition and analyses techniques, we investigated these questions using representational similarity analysis (RSA) and multiparametric univariate analyses across 3 independent data sets with high spatial resolution. The results provide novel insights into the functional neuroanatomy of language processing and highlight the differential contributions of distinct ATL regions to semantic cognition. Methods: We analyzed fMRI data from 3 independent experiments. In all experiments, participants performed semantic judgments on individual lexical concepts, which were visually presented as written English nouns. All data sets were acquired with 2 x 2 x 2 mm voxels (gradient-echo EPI). Study 3 used multiband multi-echo EPI acquisition designed to minimize signal drop-out in the anterior temporal lobes. Data were preprocessed with fMRIPrep and analyzed with AFNI. Study 1 (n = 39) consisted of 320 unique nouns and Study 2 (n = 40) consisted of 300 unique nouns, each presented 6 times over 3 scanning sessions (Fernandino et al., 2022; Tong et al., 2022). Study 3 (n = 8, data collection still ongoing) consisted of 600 unique nouns, each presented 3 times over 3 scanning sessions. Regions encoding lexical semantic information were identified via multivoxel RSA searchlight (5-mm radius) using a model of word semantics based on experiential feature ratings, controlling for orthographic and phonological similarity. Additionally, a whole-brain general linear model (GLM) analysis including word concreteness, number of phonemes, word frequency, phonological Levenshtein distance (PLD), and response time as predictors was conducted to identify regions where neural activity varied parametrically according to each predictor. Results: At the group level, Studies 1 and 2 converged in revealing four distinct RSA searchlight clusters in the ATL, namely, in the anterior superior temporal sulcus (STSva/STSda), anterior STG (STGa), temporal pole (TGd/TGv), and perirhinal cortex (PeEc). The GLM analysis revealed similar clusters, such that the STSva/STSda, STGa, and TGd/TGv were more strongly activated by abstract than by concrete concepts, while the PeEc was more strongly activated by concrete concepts. Word frequency correlated positively with activation in STSva/STSda and temporal pole, and negatively with activity in PeEc. While activation in the STS cluster was also correlated with the number of phonemes, this was not the case for the other ATL clusters. PLD predicted activation along most of the STG as well as in other areas associated with ortho-phonological processing, but not in area STGa or any of the other ATL clusters. In Study 3, this pattern of results was observed in each individual participant, ruling out potential artifacts of spatial blurring due to cross-participant normalization. Conclusion: The results indicate that different portions of the ATL represent distinct aspects of word meaning, differentially contributing to the processing of concrete and abstract concepts.

A35 - Replicability of semantic network analysis for younger and older adults

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Older adults have a continually growing vocabulary (Burke and Peters, 1986; Park et al., 2002; Salthouse, 2019) and experience more contexts and environments for semantic concepts (Federmeier and Kutas, 2005; Hoffman, 2018). However, with this greater semantic richness comes a larger set of words to choose from which can influence age-related processing deficits (Hoffman, 2019; Hills et al., 2013). Network science provides an objective and analytic approach to study semantic memory (Wulff et al., 2019; Siew et al., 2019). Semantic memory network analyses have the capability to measure the interaction between the information stored in semantic memory and the ability to navigate and retrieve relevant information (Kenett et al., 2025). Many semantic tasks can be utilized to construct networks including semantic relatedness judgements (Cosgrove et al., 2023), free association responses (Dubossarsky et al., 2017), and verbal fluency data (Cosgrove et al., 2021). Across these tasks, there have been relatively consistent age effects where older adults demonstrate less efficient, less connected, and more modular semantic memory networks (Cosgrove et al., 2021, 2023; Dubossarsky et al., 2017; Wulff et al., 2019). While several studies have shown consistent findings regarding age-related differences in semantic memory networks, there remain several ongoing questions that will push the aging mental lexicon field forward. One of the next steps in semantic network research is to determine the replicability of results. This methodological question remains especially pertinent for aging populations where differences in environment, life experiences, and cognitive abilities are more variable across the cohort (Wulff et al., 2019). In this current study we have several datasets of verbal fluency responses to multiple semantic categories including Animals, Supermarket, Courthouse, and Fruits/Vegetables. Each verbal fluency dataset contains a balanced younger and older adult sample who are cognitively healthy, English-speaking monolingual adults. Replicating the same pipeline as previous work (see Cosgrove et al., 2021), our findings show consistent results across most datasets. Specifically, both Animals and Supermarket categories revealed significant differences in network properties between older and younger adults, with younger adults exhibiting higher clustering, shorter average path lengths, and less modular network structures. However, there were some differences between categories across datasets, which may be attributed to variations in data collection modality or the type of semantic information selected. Overall, these findings suggest, that with increased age, semantic memory becomes less efficient, less organized, and more sparsely connected (consistent with prior work Cosgrove et al., 2021, 2023; Dubossarsky et al., 2017; Wulff et al., 2019, 2022). Moreover, through percolation analyses, which determine semantic network stability under simulated targeted attacks, our results reliably showed that older adults semantic memory networks break down faster than younger adults. These analyses shed light on the replicability of network science approaches to study the aging mental lexicon. Critically, this objective analytic approach could consistently capture a snapshot of a cognitive system as adaptable as semantic memory.

A36 Sandbox Series - Using Conversational AI to Elicit Linguistic Variation in Written Language Production: A Useful Neurolinguistic Tool?

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Linguistic variation—the ways language use shifts across speakers, contexts, and structures—offers insight into how humans produce and comprehend language. Studying variation reveals the cognitive, social, and grammatical processes underlying communication, yet capturing naturalistic variation within an experimentally controlled framework remains a longstanding challenge. Traditional approaches rely either on controlled elicitation tasks or naturalistic language corpora. While elicitation tasks offer experimental precision, they often sacrifice ecological validity, producing language that may not reflect everyday use. In contrast, corpus studies provide rich, authentic data but are time-intensive to collect and analyze. These methodological differences often result in inconsistent estimates of variation rates. Therefore, we introduce a novel paradigm that uses conversational AI to elicit linguistic variation in a naturalistic but structured setting. We present two parallel studies using this paradigm in English and Spanish. Each study includes approximately 50 monolingual speakers engaging in a written brainstorming dialogue with GPT-4o, a conversational large language model. Rather than instructing participants to use targeted linguistic forms, the AI is prompt-engineered to ask leading questions about the creative prompts to encourage variation—without producing the target forms itself. From the participant's perspective, the AI acts as a co-author; from the researcher's perspective, it functions as a confederate encouraging natural language variation. We hypothesize that this method will elicit usage patterns more closely aligned with corpus distributions than traditional elicited production tasks. Study 1 focuses on past participle variation in English. Participants respond to creative prompts (e.g., encountering a mysterious traveler) that encourages usage of the modals with past participles. We analyze whether participants produce either standard (He could've written, he should've eaten) or non-standard forms (He could've wrote, he should've ate). Study 2 examines variable clitic placement (VCP) in Spanish. Spanish permits clitics before or after non-finite verbs (e.g., *lo quiero pintar* '(it) I want to paint' / *quiero pintarlo* 'I want to paint (it)'). The AI encourages repeated referents and target constructions known to condition clitic variation, allowing us to study spontaneous usage patterns. Data from both studies will be compared to corpus-based and elicited production data to assess ecological validity. We seek to establish conversational AI as a confederate-like elicitation tool that preserves the spontaneity and variability of natural language, offering a promising middle ground between elicitation tasks and corpora. Because morphosyntactic variation engages memory, attention, and syntactic planning, this paradigm offers a novel behavioral tool for studying language control, morphosyntactic retrieval, and monitoring processes in neurocognitive research. Additionally, since prior research shows that monolinguals and bilinguals differentially represent language in the brain, this approach could be extended to probe how language experience and proficiency shape grammatical processing. Overall, this approach could open up new methods using conversational AI for behavioral and neurocognitive research or as a therapy tool for clinical patients.

A37 - Comparing Indirect Tract-Based Disconnection Metrics for Post-Stroke Language Deficits: A Methodological Evaluation of LQT and BCBToolkit

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Understanding the extent of white matter tract damage is critical for predicting post-stroke language deficits. Indirect structural disconnection-symptom mapping methods—using structural lesion data and probabilistic white matter atlases—have become increasingly popular as practical alternatives to direct methods such as diffusion imaging. Previous studies using different indirect metrics have reported mixed findings regarding the association between tract damage and language deficits, suggesting that the predictive power of these metrics may vary across linguistic domains. Variability in algorithmic implementations across studies introduces further discrepancies, potentially contributing to inconsistent results. The present study aims to directly compare three widely used indirect disconnection metrics—tract lesion load (percent of the tract covered by the lesion), binary disconnection (whether the tract is disconnected or not), and severity of disconnection (percent of streamlines damaged by the lesion)—as implemented in two popular toolkits: the Lesion Quantification Toolkit (LQT; Griffis et al., 2021) and the Brain Connectivity and Behavior Toolkit (BCBToolkit; Foulon et al., 2018), providing systematic methodological guidance for future research. We analyzed data from 113 individuals with aphasia resulting from left hemisphere stroke and examined the relationship between white matter tract damage and post-stroke language deficits. Language performance was assessed using the five subtest scores from the Western Aphasia Battery–Revised (WAB-R; Kertesz, 2007). Indirect disconnection metrics were derived from LQT and BCBToolkit for six language-relevant tracts: the arcuate fasciculus (AF), superior longitudinal fasciculus (SLF), inferior longitudinal fasciculus (ILF), inferior fronto-occipital fasciculus (IFOF), frontal aslant tract (FAT), and uncinate fasciculus (UF). In a subset of 32 participants with available diffusion-weighted imaging (DWI), we additionally extracted direct metrics of tract integrity—volume, normalized volume, and hindrance modulated orientational anisotropy (HMOA)—to assess their correspondence with the indirect estimates. The three indirect disconnection metrics yielded significantly different estimates of tract damage across all tracts, underscoring substantial methodological variability in disconnection quantification across toolkits. In relation to behavior, both severity of disconnection and tract lesion load explained unique variance in WAB-R scores beyond lesion volume for the ILF and IFOF. For the SLF, only severity of disconnection showed a significant association, while tract lesion load emerged as the sole predictor for the AF and FAT. In the DWI subsample, only HMOA was significantly associated with language outcomes after controlling for lesion volume. Among the indirect measures, tract lesion load demonstrated the strongest consistency with HMOA, suggesting greater alignment with diffusion-based indices of tract integrity. These findings demonstrate that methodological choices—such as the selection of disconnection metric and analysis toolkit—as well as the tract under investigation, can substantially influence the strength and specificity of structure–function relationships in post-stroke aphasia. While tract lesion load aligned more closely with DTI-derived measures of tract integrity and showed more

consistent associations with language outcomes than the other metrics, its predictive power varied depending on the tract and the linguistic domain assessed. By comparing multiple metrics across toolkits and tracts, our study provides practical guidance for applying indirect disconnection methods and underscores the need to match measurement strategies to research aims and neuroanatomical targets.

A38 Sandbox Series - Skill Acquisition of Lesion Segmentation in Novice Tracers

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Introduction: Lesion segmentation is an essential prerequisite to lesion-symptom mapping (LSM), a method that investigates the relationship between the location of brain damage and cognitive function. Lesion segmentation involves hand-tracing the outline of a brain lesion onto a three-dimensional magnetic resonance image (MRI). We have set up an independent working group to allow individuals to develop lesion segmentation skills using freely available software, without reliance on expert neuroradiologists or specialized trainers. To our knowledge, lesion segmentation is not included in the standard curriculum of any graduate programs or medical schools, making it an uncommon yet valuable skill. Despite its absence, there is high demand for accurate lesion segmentation, specifically within studies that include hundreds of subjects. Our aim here is to establish and identify the best practices for lesion segmentation training. **Methods:** Over 22 weeks, participants were assigned 11 lesion tracings. We pre-selected the 11 lesions from the openly-available USC ATLAS dataset, focusing on lesions in the left hemisphere, within the frontal and parietal lobes. We began with an initial training period in which members received a lesion-tracing guide and four MRI scans with corresponding gold-standard segmentation to familiarize themselves with the software and understand lesion delineation. Our group met after completing each segmentation to receive feedback with slice-by-slice visual comparisons of their tracings against the gold standard and their peers, which they could also access independently. We measured participants' accuracy by calculating the Dice coefficient (DC) to capture the degree of similarity between participants' tracings and the gold-standard segmentation. **Results:** Participants (N = 13) included a range of social science undergraduates, graduate students, and one individual with prior MRI experience. They had an average DC with the gold-standard segmentation of .60 (range: 0.48-0.71) across the first five scans. By Scan 4, the average DC rose to 0.71, indicating growth and improvement in segmentation skill. Notably, one participant exemplified the greatest improvement, with an initial 0.43 in Scan 1 to 0.79 in Scan 4. Participants completed a brief survey after each scan. They reported consistently finding ventricles and sulcal structures difficult to trace, with axial and coronal views preferred and sagittal views most difficult to interpret. Despite persistent challenges with cortical structures, most participants showed increased efficiency and improved confidence by Week 5. **Conclusion:** At the end of the training period, we will conduct a reliability test of trainees by having them segment lesions on 3 new samples, which will be compared against gold-standard tracings. By evaluating participants' performance using voxel overlap metrics (Dice coefficient), we expect training and feedback to improve lesion tracing accuracy over time and reduce variability both

against the gold standard and among tracers. It is worth noting that we intentionally selected scans to increase in difficulty, which may artificially hide progress despite participant improvement. Our findings will support the development of standardized and accessible training resources for lesion tracing and pave the way to enhanced diagnostic precision to create targeted treatment interventions in both research and clinical settings for neurological conditions.

A39 - A meta-analysis on the effectiveness of transcranial direct current stimulation (tDCS) on the processing of implicit associations (IATs) in men and women

The Implicit Association Test (IAT) is a widely used language-based paradigm that measures implicit social biases by assessing the speed of participants categorizing word-based stimuli representing social stereotypes (Greenwald et al. 1998). For example, reflecting common gender biases or stereotypes, participants taking a gender-based IAT are generally faster at associating "men" with "boxing" than "Pilates," and similarly, generally faster at associating "women" with "Pilates" than "boxing" (Proverbio et al. 2017). The difference in response times (RTs) during IATs is more extreme for participants with stronger biases and reflected in more extreme difference (D) scores. The IAT measures implicit rather than explicit social cognition in the sense that social biases or stereotypes are measured with implicit response times rather than explicit verbal reports, which can be useful in cases where people may not accurately report (or even be aware of) their own social biases. The IAT is frequently used in social psychology to measure implicit social biases as well as in cognitive neuroscience to measure the neural networks involved in semantic processing and social categorization. Since the IAT is widely used to measure implicit social biases, recent research has investigated whether brain stimulation techniques, such as transcranial direct current stimulation (tDCS), can be used as an effective intervention for reducing implicit social biases as measured with IAT scores. To determine the general effectiveness of tDCS on implicit bias across studies, a meta-analysis of all relevant studies involving tDCS and IATs was therefore conducted. Using a random-effects model, this meta-analysis found no significant effect for tDCS versus sham on implicit bias scores among all participants ($k = 39$, $SMD = -0.063$, $p = 0.311$). Further subgroup analyses also found no significant effect for tDCS versus sham on implicit bias scores in men ($k = 14$, $SMD = -0.236$, $p = 0.107$) or women ($k = 14$, $SMD = 0.054$, $p = 0.470$). Results also showed no significant effect for tDCS versus sham on response times among all participants ($k = 78$, $SMD = -0.043$, $p = 0.472$). However, further subgroup analyses revealed a small yet significant effect for tDCS versus sham on increasing response times in men ($k = 28$, $SMD = 0.252$, $p = 0.012$) and a very small yet significant effect for tDCS versus sham on decreasing response times in women ($k = 28$, $SMD = -0.140$, $p = 0.026$). A between-group heterogeneity test further indicated that sex significantly moderated the effect of tDCS on response times across groups ($Q\text{-between} = 14.828$, $df = 2$, $p < 0.001$). The results from this meta-analysis therefore reveals that tDCS significantly modulates IAT response times, degrading processing speed in men but improving processing speed in women, without affecting implicit bias scores, highlighting sex-specific effects on the general neurobiological mechanisms of language-mediated cognitive processing. Potential factors for sex differences in the response times of men and women

discussed here include differences in anatomy (skull thickness), hormone regulation (testosterone and estrogen), neurotransmitter dynamics (GABA modulation), and neural network organization (baseline connectivity and flexibility).

A40 - Brain mechanisms of affective word processing in bilingual speakers

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Previous research has reported a reduced emotional resonance when bilinguals process linguistic information in their second language (L2). This is possibly because native languages (L1) have a distinctive emotional feel as a result of being learned or used in a specific emotional context. There are, however, other studies that report an effect of emotional content of the same magnitude in both languages, or even a larger emotional effect in L2 than in L1. Such inconsistencies may be attributable to methodological differences between studies (e.g., introspective vs. behavioral vs. psychophysiological approaches), or to the variable characteristics of the tested samples (e.g., early vs. late bilinguals; balanced vs. dominant bilinguals). We conducted a functional magnetic resonance imaging (fMRI) study to shed light on the neural correlates of bilinguals' emotional processing in L1 and L2 during an emotional interference task (i.e., the Emotional Stroop Task – EST). Our sample (n = 36) comprised Italian-English bilinguals who were proficient in their L2, displayed a relatively balanced use of the two languages at time of testing, and learnt English mainly in instructional or mixed contexts (rather than via immersion). Stronger activations were observed for processing L1 versus L2 emotional words in sectors of the posteromedial cortex involved in attention modulation, memory retrieval, and affective processing. This finding is consistent with the hypothesis of a stronger emotional resonance when processing words in a L1. Moreover, in line with previous behavioral and psychophysiological evidence, it also suggests that L2 proficiency – more than other speaker-related variables – may modulate the extent to which emotional resonance is dampened in a L2. Overall, the present results offer new insights into the brain mechanisms of affective word processing in bilingual speakers, and – more broadly – on the interplay between language and affective processing.

A41 - Foreign language modulates neural responses to instructed fear: an fMRI study in bilinguals

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Introduction The use of a non-native language (L2) has been associated with reduced emotional resonance, particularly for negative emotions such as fear. While previous studies explored how using L2 affects the processing and regulation of negative emotions (Dang et al., 2023; Dylman & Bjärtå, 2019; Jończyk et al., 2016, 2024; Ortigosa et al., 2024; Ortigosa-Beltrán et al., 2023; Vives et al., 2021; Wu & Thierry, 2012), less is understood

about how L2 influences fear learning. Prior psychophysiological study of instructed fear conditioning in Spanish/English bilinguals showed reduced fear responses when participants received threat-related instructions in their L2 compared to their first language (L1) (García-Palacios et al., 2018). However, no neuroimaging studies have yet examined the neural basis underlying this effect. In this fMRI study, we investigated how language context (L1 vs. L2) and bilingualism type (unbalanced vs. balanced) modulate neural responses to instructed fear across two experiments. **Methods and Results** In Experiment 1, two groups of Spanish/English unbalanced bilinguals completed the instructed fear task in either their L1 (Native group) or L2 (Foreign group). The fMRI task consisted of a bilingual adaptation of instructed fear conditioning task (Phelps et al., 2001). ROI analyses showed significantly greater activation during the threat versus safe condition in bilateral nucleus accumbens (NAcc) in participants who completed the task in their L1 compared to L2. Whole-brain analyses showed greater activation of ventral anterior cingulate cortex (ACC) in L1. Experiment 2 included 117 Spanish/Catalan participants divided into four groups based on bilingualism type (unbalanced vs. balanced) and task language (reported L1 vs. L2). The results revealed a significant interaction between bilingualism type and task language in the dorsal ACC (dACC), pregenual ACC (pgACC), and the right NAcc. Post-hoc analyses showed that the unbalanced L1 group showed significantly greater activity to threat appraisal compared to the balanced L1 group in all three regions, and greater activity in the pgACC and right NAcc compared to the unbalanced L2 group. In balanced bilinguals, the L2 group showed higher activity in the dACC. Finally, no significant differences were observed between the two L2 groups and between the unbalanced L1 and balanced L2 groups in any of the ROIs. **Conclusions** The results of this study provide the first neuroimaging evidence that instructed fear learning is modulated by language context and bilingualism type. The higher activation in the ACC and NAcc during threat appraisal in unbalanced bilinguals' L1 suggests greater emotional resonance of fear instructions when they are received in the native or dominant language compared to L2. On the other hand, attenuated fear response in balanced bilinguals compared to unbalanced bilinguals when both groups performed the task in their L1 suggests that language exposure and use may play a modulatory role on fear learning even in the first language. These results have important implications for bilingual emotional processing and potential clinical applications in fear processing and regulation.

A42 Sandbox Series - Beyond speech: Exploring the cognitive advantages of bimodal bilingualism

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Bilingualism fosters communication, cognitive development, and neurological resilience. In the U.S., 68 million people speak more than one language. Beyond cultural significance, bilingualism enhances attention, problem-solving, and delays dementia onset, while increasing neuroplasticity, cognitive flexibility, and executive functioning. Neuroimaging shows that bilingualism enhances brain structure and protects against cognitive decline, with early bilinguals showing increased gray

matter density. Research suggests that bilingualism contributes to the development of cognitive reserve, enabling individuals to maintain higher levels of brain function in the face of neurodegeneration, thereby supporting memory and learning. Bilingualism encompasses signed languages such as American Sign Language (ASL), a fully developed linguistic system. Bimodal bilingualism, where individuals use both a spoken and a signed language, is a legitimate and robust form of bilingualism. Bimodal bilingualism is distinct from oral bilingualism in that it involves two different sensory modalities: the auditory-oral and the visual-gestural. Whereas oral bilinguals typically alternate between languages through code-switching, bimodal bilinguals can engage in code-blending, simultaneously producing elements of both a spoken and a signed language. Due to these differences, some researchers have argued that bimodal bilingualism may not confer the same cognitive benefits as unimodal bilingualism, where one language must be consistently inhibited while the other is in use. Although ASL was historically marginalized, research has refuted the belief that ASL use interferes with speech development. In fact, ASL-English bilingual children often exhibit English language skills that are equal to or stronger than those of monolingual peers. Additionally, early exposure to ASL has been shown to support the development of vocal communication in hearing infants. To further explore the potential cognitive advantages of bimodal bilingualism 38 English monolinguals and 29 bimodal bilinguals (proficient in ASL and English) have been recruited so far to complete a series of cognitive and linguistic tasks. An adapted Language Experience and Proficiency Questionnaire (LEAP-Q) is being used to gather self-reported ASL and English proficiency. Participants complete a Flanker, switching, digit span, nonword repetition, and hand movement tasks. The preliminary analysis comparing group performance across tasks show that bimodal bilinguals on average outperform monolinguals on working memory tasks, while monolinguals show greater accuracy in the Flanker task. No significant differences have emerged on the switching task thus far, but a trend of better performance from the bilingual group is emerging. These preliminary results align with previous research showing bilinguals' strengths in executive function, specifically working memory and potentially mental flexibility. Results with a total sample of 80 participants (40 in each group) will be presented. These findings underscore that bilingualism, spoken or signed, supports cognitive and communicative advantages. Clinicians should actively promote bimodal bilingual therapeutic approaches, collaborate effectively with interpreters, and embrace the cultural and linguistic richness of Deaf communities. Understanding the cognitive impact of bimodal bilingualism, reinforces the importance of multilingual education and fosters lifelong brain health.

A43 - Brain connectivity and maturation of the T-complex to lexical tone in bilingual Mandarin-English children

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Individuals with various developmental disorders, including auditory processing disorders, frequently exhibit abnormalities in their cortical auditory evoked potentials (CAEPs) at temporal sites. Temporal CAEPs, also known as the T-complex, have been studied in monolingual and bilingual children with non-

tonal language backgrounds. However, the developmental trajectories of the T-complex in bilingual children with tonal language backgrounds—such as those who speak both Mandarin and English—remain largely unknown. This study aims to investigate neurodevelopmental changes in Mandarin lexical tone processing, as reflected by the T-complex, in Mandarin-English bilinguals. We employed a multiple oddball paradigm and recorded event-related potentials using 65 sensors from bilingual adults and children aged 5 to 10. Tone 1 (high level) and Tone 2 (low rising) were used as deviant tones, while Tone 3 (low dipping) served as the standard. The analysis included data from 17 adults and 35 children, comprising 18 children aged 5–7 years and 17 children aged 8–10 years. We observed that the three subcomponents of the T-complex (Na, Ta, and Tb) were less well-formed in children compared to adults. Both groups of children showed significantly larger Na amplitudes than the adult group. Furthermore, the Ta and Tb components were difficult to identify in the left hemisphere in children across both age groups. These results suggest that the T-complex involved in lexical tone processing is not fully developed in bilingual children before the age of 10, and that the right hemisphere plays a more prominent role in lexical tone processing in bilingual children between 5 and 10 years of age. Results from source localization and brain connectivity analyses further advanced our understanding of the developmental trajectories of lexical tone processing in this bilingual population.

A44 - Effects of bilingualism on brain reserve in clinical AD variants

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Bilingualism, defined as speaking two or more languages, may contribute to cognitive reserve and serve as a protective factor against neurodegeneration. However, studies are mixed. One potential explanation for previous mixed findings is that bilingualism has network-specific effects (e.g., more protective effects on language networks compared to memory networks). For example, De Leon et al. (2020) reported a later age of symptom onset in bilingual speakers with logopenic variant primary progressive aphasia (lvPPA) compared to monolingual speakers with lvPPA. Conversely, there was no difference in age of symptom onset between monolingual and bilingual speakers with amnesic Alzheimer's disease (AD), therefore supporting network-specific effects of bilingualism in cognitive reserve. In the current study, we aim to assess the effect of bilingualism on brain reserve. In particular, we evaluated network-specific effects of bilingualism on brain volume in monolingual and bilingual speakers with lvPPA and amnesic AD. To compare brain volume in monolingual (lvPPA: n = 67; AD: n = 119) and bilingual (lvPPA: n = 21; AD: n = 17) speakers, we preprocessed T1-weighted structural MRI data in CAT12 within SPM12 using standard procedures. From the segmented, normalized, and modulated images, we extracted cortical volumes using the Brainnetome atlas. For each participant, we then obtained ROI values of cortical volume across the entire brain. These values were harmonized by scanner, age, and total intracranial volume using ComBat tools. We employed linear mixed-effects models (LMEMs) to analyze harmonized cortical volumes in individuals with lvPPA and AD, separately. The fixed effects included bilingualism, region of interest (ROI), and their

interaction. To account for subject-specific variability, random intercepts for subjects were included in the model. Sex and MMSE total scores were included as covariates. Results were FDR-corrected for multiple comparisons. Results on left-hemisphere volumes showed that bilingual lvPPA speakers had significantly larger inferior parietal lobule (IPL) volumes compared to monolingual lvPPA speakers. Conversely, among individuals with amnesic AD, no regions showed larger volumes in bilinguals compared to monolinguals. We also found larger volumes in monolingual speakers compared to bilingual speakers in certain brain regions. Monolingual lvPPA speakers had larger volumes in the middle temporal gyrus (MTG), superior temporal gyrus (STG), and medial ventral occipital cortex (MVOcC) compared to bilingual lvPPA speakers. Monolingual AD speakers, compared to bilingual AD speakers, showed significantly larger volumes across multiple memory-related and occipital regions, including the fusiform gyrus (FuG), hippocampus (Hipp), and lateral occipital cortex (LOcC). Interestingly, adding years of education—a factor that is often related to cognitive reserve—as a predictor in the LMEMs analysis significantly improved the fit of the model for the AD group, but not the model for the lvPPA group. Our findings suggest that bilingualism may contribute to network-specific cognitive and brain reserve, particularly in language-related regions. Other factors related to cognitive reserve (e.g., years of education) might affect different groups and networks in a distinct way.

A45 Sandbox Series - Accounting for variability in event-related potentials reflecting second language processing: A role for memory?

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Substantial variability among individuals has been evidenced in second/additional language (L2/A) neurocognitive processing as evidenced by electrophysiology (Luque & Covey, 2023). We have a limited understanding of the various factors that account for this variability, although recent evidence suggests a role for cognitive factors, such as working memory (Gabriele et al., 2021). Indeed, individual differences in both working memory and long-memory systems, such as declarative and procedural memory, have been shown to play significant roles in the development of L2/A knowledge (Linck, 2014, Morgan-Short et al., 2021). Yet, little research has examined their role in neurocognitive L2/A processing. Thus, the current study examines whether individual differences in working memory, declarative memory, and procedural memory can account for variability in the electrophysiological processing signatures in L2/A learners. The current study employs an event-related potential methodology to examine this question in regard to the P600 ERP effect, which associated with grammatical processing in first and L2/A languages. We tested 37 L2/A learners of Spanish, who were enrolled in intermediate to advanced Spanish college courses at a large midwestern University. Participants completed two tasks to assess their Spanish proficiency level (a written vocabulary/grammar test and an oral elicited imitation task). They also completed tasks that measured working memory capacity (shortened complex span tasks, Oswald et al., 2015) and declarative and procedural memory learning ability (an encoding and recognition task, Hedenius et al., 2013, and a serial reaction time task, Nissen &

Bullemer, 1987, respectively). Finally, electrophysiological data was recorded (ANT Neuro) as participants judged the grammaticality of 244 Spanish sentences (half correct and half violation sentences, including phrase structure (PS), subject-verb agreement (SV), noun-phrase number and gender agreement (NPn, NPg) conditions. EEG was processed following standard lab procedures (Morgan-Short et al., 2022) and averaged for the P600 time window (600-1000 ms). Participants demonstrated intermediate levels of proficiency and reasonable levels of accuracy on the judgment task, with accuracy ranging from 61% to 82% across the four conditions. ERP analyses demonstrated small positivities for all conditions, although the only clear P600 effect was found for the NPn condition. Correlational analysis found that (a) working memory was positively correlated with the P600 effect for PS ($r=.37$, $p=.03$), but was not associated with the P600 for the other conditions; (b) declarative memory was not associated with the P600 for any condition; and (c) procedural memory was positively correlated with NPg ($r=.37$, $p=.04$), negatively correlated with NPn ($r=-.35$, $p=.05$), and not associated with the other conditions. Overall, these preliminary results do not yet show a clear pattern between the development of the P600 effect and cognitive abilities within these memory systems. Although two positive associations were found between the P600 effect and working memory and procedural memory, other correlations were not statistically significant, and perhaps somewhat surprisingly, we found a significant negative correlation between the P600 and procedural memory for the NPn condition. With data collection ongoing, we consider potential interpretations of the associations found in this preliminary analysis in light of participants' L2/A proficiency level.

A46 Sandbox Series - Die verwante woord projek: Using HD-tDCS to investigate acquisition of second language Afrikaans

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Introduction High-definition transcranial direct current stimulation (HD-tDCS) is a non-invasive brain stimulation technique that modulates cortical excitability through low-intensity electrical currents delivered with high spatial precision. HD-tDCS has been used primarily in clinical research, where stimulation to language-relevant areas has shown promise. However, its potential in second language acquisition (L2A) remains underexplored. This sandbox project investigates whether HD-tDCS applied to the left posterior temporal lobe can enhance learning of lexical and grammatical features in a new language. We examine the potential benefits on two central aspects of language learning: (i) implicit versus explicit L2 learning, and (ii) similarity of structures in the L2 to a known language. L2A research distinguishes between explicit grammar learning, involving conscious understanding and application of rules, and implicit learning, where learners acquire grammatical structures incidentally through repeated exposure without formal instruction. While explicit learning tends to benefit rule-based elements, particularly in adult learners, implicit learning is thought to more closely mirror natural language acquisition and

is essential for the internalization of complex morphosyntactic patterns. Relatedly, evidence suggests that learners more easily acquire structures that overlap with their first language. Here, we investigate learning generalization of vocabulary and morphosyntax. We teach Afrikaans cognate (i.e., words with similar meaning and form cross-linguistically) and non-cognate vocabulary, along with morphosyntax (i.e., pronouns and plural endings, which each have some similarity to English). Afrikaans pronoun forms differ from English but match in procedure, whereas Afrikaans plural morphosyntax has one overlapping form and one dissimilar form to English, but with lexical phonology determining plural form. **Methods** Participants are fluent English-speakers with no knowledge of Afrikaans. In the pilot phase, participants learned Afrikaans vocabulary through picture, text, and audio input delivered via an automated program developed in E-Prime software. In the expanded version of the study, participants will be exposed to both lexical and syntactic input, with vocabulary then sentence training. Participants are pseudorandomly assigned to either an active HD-tDCS stimulation group or a sham control group. HD-tDCS is delivered using a 4x1 ring configuration targeting the left posterior temporal lobe, a region linked to lexical-semantic processing. Approximately 30 minutes after the learning phase, participants complete two post-tests: a grammaticality judgment task (which tests (a) subject-pronoun to predicate-number agreement and (b) vocabulary to plural pattern) and a vocabulary recognition task (which tests non-trained cognates). Follow-up testing occurs again at about 2- and 6-weeks post-training. Measures include accuracy and reaction time on within- and between-group factors. **Results** Preliminary pilot data from 20 participants revealed a significant interaction between cognate status and stimulation ($p < .001$). Specifically, participants who received HD-tDCS showed greater accuracy and faster reaction times when learning cognates compared to non-cognates, and outperformed the sham group overall. **Conclusion** Initial results support the effectiveness of HD-tDCS in enhancing second language vocabulary learning, especially for cognates. This ongoing study expands on those findings to investigate long-term effects and grammar acquisition. By integrating HD-tDCS with explicit and implicit learning mechanisms, this work may inform future neurolinguistic approaches to adult language learning and rehabilitation.

A47 Sandbox Series - Modality Dominance and Integration in L2 Comprehension: An fMRI Study of Speech Rate Effects

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[Introduction] In second language (L2) comprehension, integrating multiple modalities—such as audio and text—has been shown to enhance understanding compared to relying on a single modality (Shaojie et al., 2022). However, some studies report that the simultaneous processing of auditory and visual inputs may lead to cognitive interference due to the limited capacity of attentional resources. The listening-dominance hypothesis (Robinson et al., 2018) suggests that, under time constraints, auditory input tends to be prioritized over visual input, even when the auditory signal is difficult to comprehend. This prioritization may delay or diminish the processing of

concurrently presented visual information. Conversely, other research indicates that when auditory input becomes less reliable—such as in time-compressed or degraded speech—attention may shift toward the more stable visual modality (Seijdel, 2024). These contrasting findings imply that the effectiveness of multimodal input may vary depending on cognitive demands and input characteristics, including speech rate. The present study investigates whether L2 learners integrate auditory and visual information simultaneously, or whether they selectively prioritize one modality depending on the rate of auditory input. **[Method]** To examine this, we employed functional magnetic resonance imaging (fMRI) under two conditions: (1) simultaneous presentation of standard-speed English audio (easier to comprehend) and written text, and (2) simultaneous presentation of time-compressed (2× speed) audio (more difficult to comprehend) and text. Twenty-four Japanese university and graduate students learning English as a foreign language performed a semantic judgment task in both conditions. Behavioral measures included response accuracy and reaction times. Brain activity was analyzed across two key time windows: the audio presentation phase and the post-audio phase (from audio offset to participant response), during which only the visual text remained available. **[Data Analysis]** Behavioral performance was compared between conditions to evaluate comprehension. Whole-brain analyses identified brain regions exhibiting differential activation based on speech rate and processing phase. Repeated-measures ANOVAs were conducted to examine interaction effects between condition (standard vs. fast) and phase (during vs. after audio). Region-of-interest (ROI) analyses targeted areas involved in auditory processing (anterior superior temporal gyrus [STG]), multimodal integration (inferior frontal gyrus [IFG], angular gyrus [AG]), and executive function (dorsolateral prefrontal cortex [DLPFC]). **[Expected Results]** We hypothesize that under the standard-speed condition, learners will integrate auditory and visual inputs in real time, as reflected by concurrent activation of STG, IFG, and AG. In contrast, under the 2× speed condition, auditory input may initially dominate, with visual information being integrated later during the post-audio phase. This pattern may be reflected in delayed activation of IFG and AG, along with increased recruitment of DLPFC, which supports top-down control and working memory. These findings will contribute to a better understanding of how input rate and cognitive demands influence modality processing in L2 learners and offer insights for designing effective multimodal instructional materials.

A48 - Rethinking ERPs: Does sensory and linguistic experience shape ERP signatures in deaf signers?

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To what extent is visual and cognitive processing shaped by the languages we use and the modality through which those languages are experienced? Deaf signers offer a valuable test case for this question. Research has shown that deaf individuals exhibit distinct visual attention allocation, enhanced peripheral motion detection, and modified face processing strategies compared to hearing individuals (Allencar, Butler, & Lomber, 2019; Bavelier, Dye, & Hauser, 2006; Bottari et al., 2010). These differences suggest that core visual and cognitive processes may be fundamentally reorganized through experience with a

visual-manual language and in the absence of auditory input. Canonical event-related potential (ERP) components, such as the P1, N170, N2pc, N400, P3, LRP, and ERN, have been extensively used to index key aspects of cognition, including early sensory encoding, attentional selection, semantic integration, and performance monitoring (e.g., Olivares et al., 2015; Kutas & Federmeier, 2011). However, little is known about how these components manifest in deaf signers, whose neural architecture is shaped by both deafness and lifelong use of American Sign Language (ASL). This study investigates whether the temporal dynamics and scalp distributions of these components are modulated by sensory and language experience. In a pre-registered, ongoing study, we employ the ERP CORE battery (Kappenman et al., 2021), a standardized set of paradigms designed to elicit well-validated ERP components with high signal quality. Participants complete six core tasks: face perception (N170), visual search (N2pc), visual oddball detection (P3), semantic word pair judgment (N400), simple response selection (LRP), and flanker-induced error monitoring (ERN). We supplement the battery with a novel ASL sign pair semantic judgment task, designed to elicit the N400 response to semantically related and unrelated ASL signs. By comparing semantic processing across English and ASL within the same bimodal bilingual individuals, we examine how language modality shapes the neural correlates of meaning. Participants to date include 5 adult deaf signers and 13 hearing non-signers, with a target sample size of 40 per group. All participants completed standardized written language and cognitive measures, and deaf participants additionally completed ASL proficiency measures, to identify effects of group, language proficiency, or age of language exposure on the ERP signatures. Preliminary data reveal subtle but theoretically meaningful group differences. Deaf participants show a more bilaterally distributed N170 response to visual objects such as faces, in contrast to the right-lateralized N170 observed in hearing participants at parietal-occipital sites. For the N400, both groups demonstrate robust effects of semantic relatedness to written words; however, deaf participants exhibit a slightly delayed and more posteriorly distributed N400 compared to their hearing peers. These emerging patterns suggest that sensory and language experience shape the timing and topography of core ERP components, raising critical questions about the modality neutrality of neural markers commonly used to index basic visual and cognitive processes.

A49 - Using electroencephalography to investigate the neural mechanisms responsible for processing self versus externally generated sounds

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When we produce sounds ourselves, the brain typically attenuates the neural response through a corollary discharge mechanism (Crapse & Sommer, 2008), allowing us to distinguish between self and external auditory inputs. Prior research has demonstrated clear evidence of suppression at the cortical level, particularly in the auditory cortex as measured by components like the N1 event-related potential (Ford et al., 2013; Sitek et al., 2013). However, it remains unclear whether earlier subcortical processing stages also implement these attenuative mechanisms. One method that has been used to

study the early auditory system is the frequency-following response (FFR), an evoked electrophysiological potential that reflects the synchronized neural activity of populations of neurons throughout the auditory pathway in response to periodic acoustic stimuli. While the FFR has multiple neural generators, including auditory cortex, single-electrode scalp-recorded FFRs reflect primarily subcortical sources (Coffey et al., 2016; 2019). This measure has emerged as a powerful tool for understanding the neural encoding of sound with a non-invasive means to assess the fidelity of sound encoding in the early auditory system (Skoe & Kraus, 2010). While most FFRs are collected during passive sound presentation, it is unclear how motor-related signals during active button-pressing affect FFR fidelity. To investigate potential auditory-motor interactions early in the auditory pathway, we recorded FFRs from 32 normal-hearing adults during active (self-initiated) and passive (externally presented) listening conditions using a 170 ms 'da' speech syllable presented in positive and negative polarities. FFRs were recorded on a BioSemi ActiveTwo EEG system with a sampling rate 16384 Hz. Stimulus onsets were identified in the stimulus track that was recorded as a separate EEG channel. The electrode placed at Cz was referenced to linked mastoid electrodes and filtered between 65–2000 Hz. After outlier removal ($> 75 \mu V$), we averaged responses across positive and negative stimulus polarities within the active (self-initiated) and passive (externally presented) listening conditions. To compare potential differences between active and passive conditions, we conducted analyses in both the time and frequency domains. For the time domain analysis, we computed root mean square (RMS) signal-to-noise ratios (SNR) for each participant's responses. For the frequency domain analysis, we extracted spectral power in the fundamental frequency range of the stimulus (90–110 Hz). Statistical analyses revealed no significant differences between active and passive conditions in RMS SNR ($t = 0.232$, $p = 0.817$) or spectral power ($t = -1.468$, $p = 0.147$). These findings suggest that motor-induced suppression of self-generated sounds may primarily affect later stages of auditory processing rather than the early subcortical encoding reflected in the FFR. Additionally, the lack of difference between conditions demonstrates that active button pressing does not affect FFR fidelity. This has important implications for understanding auditory-motor integration in speech self-monitoring and could inform future research on clinical populations with altered auditory feedback processing.

A50 - Reduction of the late N1/N250 component after valid parafoveal previews as a robust indicator of visual-orthographic facilitation that depends on experience

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Previous research demonstrated functional divergence between early and late parts of the N1 ERP component in response to visual words. Here we show a similar divergence in fixation-related potentials (FRP) across three studies in Chinese. Consistently, the late (but not early) N1/N250 component was reduced after valid previews (also termed "preview positivity"). Experiment 1 showed the late N1/N250 effect occurred similarly for magnocellular and parvocellular stimuli. Experiment 2 showed the late N1/N250 effect in FRPs was similar in timing

and distribution but more pronounced compared to masked priming effects in ERPs. Experiment 3 showed the late N1/N250 facilitation depended on experience with the direction of a writing system, as Mainland Chinese and Taiwanese participants showed an opposite pattern, consistent with their different exposure to horizontal vs. vertical writing. The results suggest that the late N1/N250 effect is a robust indicator of facilitation in visual-orthographic processing that is mediated through experience.

A51 - The Neurophysiology of Visual Rhyme Data in Deaf Undergraduate Readers

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This study investigated the neural time-course and distribution of neural activation during a rhyming task in pre-lingually deaf undergraduate students. Participants were deaf individuals with moderate-to-profound hearing loss, and the majority of the participants reported using American Sign Language (ASL) as their primary mode of communication. On average, students had completed 3.1 years of college, and approximately half of the participants were born to hearing parents. A comprehensive battery of neuropsychological measures was administered to gain a better understanding of the cognitive, linguistic, and reading profiles of these deaf students. The battery included: the Wechsler Abbreviated Scale of Intelligence (WASI; Perceptual Reasoning and Vocabulary subtests), the Peabody Individual Achievement Test-Revised (PIAT-R), the Woodcock Reading Mastery Test (WRMT), the Wechsler Memory Scale-Fourth Edition (WMS-IV), the Psychology Reading Test (PDT), American College Testing (ACT) scores, and cumulative Grade Point Average (GPA). In the experimental task, participants judged whether two visually (printed) words rhymed (e.g., chair-pear), with all stimuli deemed appropriate for a Second-grade reading level. Of the 48 participants, 22 demonstrated behavioral performance at or above chance level on the rhyme judgment task and were included in the ERP analysis. We looked at three ERP components in these 22 participants: (1) Contingent Negative Variation (CNV), a sustained negative response following the priming stimulus reflecting rehearsal and working memory; (2) Rhyming Effect (RE), characterized by enhanced negativity (N450) to non-rhyming second stimulus words compared to rhyming second stimulus words (targets); and (3) Late Negativity (LN), possibly reflecting working memory load or cognitive effort. Results show a CNV that was observed between 400ms -800 ms following the prime stimulus. CNV was significantly greater over the right hemisphere compared to the left hemisphere ($p=.02$). This negativity was prominent over the central sites. These sites are not similar to what is reported in the literature. The RE did not reach significance ($p=.06$) across the group for the 22 participants. However, individual analyses revealed that 10 of the 22 had discernable RE, primarily in the right frontal-central and left parietal electrode sites. The RE occurred around 350-600 ms. A LN was not observed for this participant pool. The absence of group-level RE and LN suggests that many deaf undergraduate readers may not fully utilize phonology during a visual rhyme judgment task. Instead, participants may rely more heavily on whole word recognition strategy for this reading task. Correlations between ERP effects and neuropsychological measures were weak ($r=+.3$ to $-.3$), indicating that ERP rhyme effects were only modestly

associated with individual differences in language and reading skills. Participants generally demonstrated weaker performance on linguistic measures strongly linked to reading success, particularly in vocabulary, phonology, and comprehension of sentences and passages. Overall, these findings provide new insight into the cognitive and neural mechanisms underlying reading in deaf individuals, highlighting a potential reliance on non-phonological processing strategies during the word recognition task.

A52 - Reading efficiency after stroke relates to lesions, structural disconnections, and activation in spared language and cognitive nodes

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The neural systems that underlie reading are frequently damaged in left hemisphere stroke, leading to alexia. Alexia is thought to result not only from direct anatomical damage to the language/reading network, but also dysfunction of unlesioned network nodes. However, few studies of alexia combine both measures of residual function and anatomical lesion damage. Here, we leverage a large sample of left-hemisphere stroke survivors and controls to identify 1) the necessary neural structures for oral reading via lesion-symptom mapping and 2) where residual fMRI reading/language activation supports oral reading. Controls ($N=52$) and stroke survivors ($N=87$) read aloud 200 single-syllable words, crossed on regularity, imageability, and frequency. Reading efficiency (mean accuracy/median RT) was calculated for each participant. Stroke survivors also performed behavioral tasks assessing semantic and phonological processing. fMRI activation was measured during an adaptive written semantic relatedness task in all participants. A reading/language network, consisting of eight left-hemisphere frontal and temporal ROIs, and a right cerebellar ROI, were identified from a sample of 15 held-out controls. We used support-vector regression voxelwise lesion-symptom mapping (SVR-VLSM) and connectome lesion-symptom mapping (SVR-CLSM) to identify lesions and structural disconnections associated with reduced reading efficiency, covarying for demographics and lesion size. Separately in controls and stroke survivors, used partial Spearman correlations between ROI-wise fMRI activation and reading efficiency to identify regions where activation supports reading ability, controlling for demographics. For stroke survivors, lesion volume, chronicity, motor speech impairment, and ROI-wise lesion load were also covaried. Exploratory correlations examined the relationship between activation and efficiency on eight categories of words (high/low frequency, imageability, regularity; 100 words/cell). Finally, within the stroke survivors, we correlated semantic and phonological processing measures with nodewise fMRI activation. SVR-VLSM identified a left posterior superior temporal gyrus lesion location, extending into the angular and middle and inferior temporal gyri, that reduced reading efficiency ($p=0.03$). SVR-CLSM identified disconnections within a network spanning left anterior and middle temporal gyrus, fusiform gyrus, angular gyrus, and supramarginal gyrus (edgewise $p's < 0.001$). Controls outperformed stroke survivors in semantic decision ($t(126.5)=7.7$, $p<0.0001$) and reading ($t(119.2)=10.5$, $p<0.001$).

Anterior inferior temporal gyrus (aITG) activity correlated with reading efficiency in both groups (controls: $r=0.45$, $p=0.013$, stroke: $r=0.385$, $p=0.019$), and with semantic processing in stroke survivors ($r=0.32$, $p=0.017$). Exploratory Spearman correlations found that dorsomedial prefrontal (dmPFC) activation was related to low-frequency word efficiency, regardless of regularity or imageability (all r 's >0.29 , p 's <0.05) in stroke survivors only. The left posterior temporal cortex is a critical lexical convergence zone for reading, where damage or disconnections impair reading efficiency. Separately, activation of the aITG is associated with better reading in typical readers and stroke survivors and better semantic performance after stroke, supporting previous findings linking this region to semantics. In stroke survivors only, dmPFC activation was specifically related to low-frequency word efficiency, suggesting additional cognitive resources may be needed to retrieve infrequent lexical representations after stroke. Together, these results suggest that reading is served by a critical network of temporoparietal regions, supported by task-sensitive activation in semantic and, for stroke survivors, prefrontal cognitive control regions.

A53 - The role of anterior temporal lobe in reading: an HD-tDCS study

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Introduction. The anterior temporal lobe (ATL) is involved in lexicosemantic processes and in the reading of low-frequency inconsistent words, which are words that do not follow standard grapheme-to-phoneme conversion rules (e.g., pint). Pseudowords are read via sub-lexical processes, while inconsistent words require whole-word or semantic processing. Alexia is an acquired reading impairment following brain lesions. Surface alexia is characterized by difficulty in reading inconsistent words. Surface alexia often co-occurs with the semantic variant of Primary Progressive Aphasia (PPA), with atrophy typically starting in the left ATL. Since the ATL is suggested as a semantic hub, it may support reading inconsistent words via semantic access. However, this association is challenged by cases of post-stroke alexia without semantic impairments and semantic impairments in PPA without surface alexia. Moreover, the ATL's role as a semantic hub remains debated. **Methods.** Seventy-seven neurotypical participants underwent two High-Definition Transcranial Direct Current Stimulation, corresponding to real and sham stimulation, with the order of stimulation counterbalanced across participants. In the first experiment, we targeted the left ATL while participants performed a Word Naming task involving consistent words, inconsistent words and pseudowords. In a second experiment, participants completed a Picture Plausibility task, making semantic judgments about pictures following the same ATL stimulation. Some pictures represented plausible objects or events, while others depicted implausible objects (e.g., a parrot with duck feet) or events (e.g., an elephant riding a bicycle). In a third experiment, we stimulated the left temporo-occipital cortex (TOC) while participants performed the same

Picture Plausibility task. This served as a control experiment, as TOC is hypothesized to be involved in visual-semantic processing and was expected to affect nonverbal semantic processing. We applied linear mixed-effects regression models on Reaction Time, including participant as a random factor, and controlling for variables of no interest (i.e., number of letters, Orthographic neighborhood, frequency, concreteness and valence) as regressors. **Results.** We conducted a median split to divide words as high-frequency or low-frequency for both consistent and inconsistent categories. In the sham condition, low-frequency inconsistent words were read more slowly than high-frequency inconsistent words. This effect disappeared with ATL stimulation. Furthermore, we found an interaction between consistency and stimulation in the low-frequency subset, but not in the high-frequency subset. More specifically, low-frequency inconsistent words were read more quickly after stimulation, whereas consistent words showed the opposite pattern being read more slowly after stimulation. In the Picture Plausibility task, ATL stimulation showed no effect on the reaction time of nonverbal semantic processing, whereas TOC stimulation significantly increased reaction time. **Discussion.** These findings support the role of the left ATL in reading inconsistent words, aligning with the presence of surface alexia in the semantic variant of PPA. However, the lack of effect on the non-lexical semantic task suggests that the ATL is likely to be involved in lexical processes rather than purely amodal semantic representation. This is consistent with lesion studies showing dissociation between semantic impairments and surface alexia. These findings clarify previously conflicting result in the literature and elucidate the role of ATL in reading.

A54 - Reading proficiency is associated with the precision of high-level visual processing across domains in children with and without dyslexia

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Learning to read constitutes a milestone in children's development, leading to profound changes in language processing and beyond. Illiterate adults notably differ from literates in visual processing across object categories, with reduced neural repetition suppression (i.e., a smaller activation decrease between the first and second occurrence of a repeated image, suggesting worse exemplar discrimination, Pegado et al., 2014) and less clearly defined category-selective regions in ventral occipito-temporal cortex (vOTC, Dehaene et al., 2010). Interestingly, adults with dyslexia also show difficulties in fine-grained visual tasks (Kristjánsson & Sigurdardottir, 2023) and reduced repetition suppression across categories (Perrachione et al., 2016). While these differences have been proposed as causes of dyslexia, parallels with illiteracy question the directionality of associations between reading proficiency and visual processing. Here, we investigated how reading proficiency relates to high-level visual processing in a developmental sample of 41 children with dyslexia and 36

without, aged 7 to 17. Children performed a standard repetition detection (one-back) localizer task in the fMRI, within blocks of words, numbers, limbs, faces, objects and places. Absolute reading proficiency was indexed by the principal component in children's raw scores in word and pseudoword reading on the Test Of Word Reading Efficiency (TOWRE-2), reflecting overall differences in grade level on top of relative differences in achievement (including those due to dyslexia). We tested whether dyslexia group membership and absolute reading proficiency relate to the precision of visual processing across categories, both in brain and behavior, controlling for age, ADHD status and other confounding variables. We also explored whether such effects were shared, or more attributable to dyslexia diagnosis vs. raw reading skills. Repetition detection hit rates were lower in children with dyslexia across visual categories and negatively correlated with absolute reading proficiency. These shared behavioral differences suggest challenges in representing stimulus identity across domains, and were accompanied by neural differences in repetition effects. We also investigated the uniqueness of categorical representations by estimating the difference in multivariate similarity within vs. across categories in the left and right vOTC. We observed that both absolute reading proficiency and dyslexia impacted categorical distinctiveness for words and other categories across hemispheres, in different but complementary ways. Word distinctiveness positively correlated with absolute reading scores, especially in the left hemisphere, but did not differ between dyslexia groups overall. Absolute reading proficiency was also positively associated with the distinctiveness of limbs, and marginally for faces and places, while a specific increase in face distinctiveness was seen in dyslexia. Higher distinctiveness was further associated with higher repetition detection rates, demonstrating its behavioral relevance. Overall, lower reading proficiency and dyslexia both relate to poorer visual processing and noisier cognitive representations of stimulus identity and category across visual domains. Reading scores showed stronger effects on categorical representations, although children with dyslexia additionally showed a unique strength for faces. These findings reconcile visual processing challenges reported in dyslexia and illiteracy, altogether reinforcing the view that learning to read refines high-level visual processing across domains.

A55 - Theta-Burst Stimulation to Left SMG Slows Pseudoword Processing in Young Adults

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Introduction: Theta-burst stimulation has significant potential for improving outcomes after intervention across disordered populations. By upregulating or downregulating regions with atypical activity or connectivity, we may be able to induce plasticity to encourage more typical neural patterns which can improve behavioral outcomes. Previous data from our lab has shown that the mechanisms of theta-burst stimulation in complex cognitive networks differs from the mechanisms in the motor system, from which we primarily derive stimulation protocols and interpretation. Specifically, we have shown an inconsistent facilitative effect from continuous theta-burst stimulation (cTBS) which is often described as inhibitory (Harrington et al. 2023). In this study, we examine the effects of cTBS versus sham stimulation to left supramarginal gyrus

(SMG) on a lexical decision and phonological decoding task. We hypothesized that cTBS stimulation of SMG would inhibit accuracy and reaction time on pseudoword decisions during forced-choice computerized reading tasks as compared to sham stimulation. **Methods:** Eleven participants were included in this analysis (21.5 +/- 2.1; 7 females, 4 males; Woodcock-Johnson IV Broad: 104.7 +/- 14.5 (77-127); WASI FSIQ-2: 103.1 +/- 13.5 (85-121). Participants were pseudorandomized into stimulation order for active or sham stimulation. cTBS was delivered via standardized paradigm (Huang et al., 2025) with a Magventure Magpro MCF-B65 coil and Neurolite Neuronavigation software using individual neuroanatomical landmarks. Sham stimulation was delivered with the MCF-P-B65 coil. Post stimulation, participants performed two computerized forced-choice reading tasks. The phonological decoding task required participants to determine if a pseudohomophone (target) or pseudoword (foil) could be pronounced like a real word (i.e. "roze" vs "filk"). The lexical decision task required participants to determine if a word (target) or pseudoword (foil) is a real word ("rose" vs "filk"). Reaction time and accuracy data for each task were collected via E-Prime. Paired t-tests of accurate responses for the whole task, target words, and foil words were computed using R with the t.test function. **Results:** No significant differences were found for accuracy in either condition. Reaction time was slower after stimulation in all conditions involving pseudowords (foils in the lexical decision task, foils and targets in the phonological decoding tasks). Slower reaction time reached significance for the pseudowords in the phonological decoding task ($t(6) = 2.74$, $p = 0.03$) with all participants decreasing reaction time from the sham to the active condition. Surprisingly, while the pseudowords in the lexical decision task trended toward significance ($t(10) = 1.25$, $p = 0.2$), there was not a significant trend for pseudohomophones in the phonological decoding task ($t(6) = 0.73$, $p = 0.5$). **Conclusions:** cTBS stimulation to SMG slowed pseudoword decision making processes. This effect, however, was specific to pseudowords and did not extend to pseudohomophones. Previous research from our lab has found that iTBS stimulation of SMG preferentially affects decision-making of pseudohomophones. Taken together, these findings suggest that stimulation type may differentially modulate subcomponents of phonological decoding. This dissociation underscores the need to refine stimulation protocols based on the cognitive architecture of the target task.

A56 - Neural-Differentiation Mapping Reveals Experience-Dependent Tuning of Sublexical Units

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A central question in written language processing is understanding how experience with sub-lexical units shapes the neural representations that support skilled reading. Prior studies of sub-lexical processing have primarily focused on orthographic regularities, such as letter sequences, but there has been little investigation into the role of phonologically informed units or their experience-dependent tuning in the brain. This leaves open key questions about how the frequency of graphemes and onset-rime structures influences the quality of their neural representations. One study (Purcell & Rapp, 2018) provided

initial evidence that higher-frequency words are associated with greater spatial differentiation in the neural response, particularly within the left ventral occipitotemporal cortex (vOTC). This finding suggests that increased experience leads to more efficient, well-differentiated neural coding, which is an interpretation that goes beyond earlier findings of reduced activation for high-frequency words observed in mean BOLD signal studies (e.g., Kronbichler et al., 2004). However, the Purcell & Rapp (2018) findings still await independent replication, and it remains unknown whether similar differentiation effects extend to sub-lexical units that are phonologically informed. The present study addresses both of these gaps. First, we aimed to replicate the original finding that word frequency predicts local neural differentiation in the vOTC. Second, we tested the novel hypothesis that sub-lexical frequency at both fine (i.e., grapheme) and coarse (i.e., onset-rime) levels of granularity are positively associated with the degree of neural differentiation during single word reading. Using the Sublexical Toolkit (Wiley et al., 2024; 2025), we computed experience-based frequency measures for 160 words and 40 pseudowords. Twenty-nine neurotypical, above-average literate adults performed single-word and pseudoword reading aloud during fMRI. We applied a local heterogeneity regression (Hreg) method to quantify stimulus-specific neural differentiation and conducted parametric analyses to identify voxels where differentiation varied as a function of word, grapheme, and onset-rime frequency. Two main findings emerged. First, in the left vOTC, we replicated the positive relationship between word frequency and neural differentiation such that higher frequency words are associated with greater local neural differentiation. Second, we found that in the mid-vOTC - adjacent to regions tuned to whole-word frequency - there were distinct subregions selectively associated with the frequency of graphemes and onset-rimes. This suggests that the mid-vOTC is sensitive to phonologically informed, experience-dependent features of written words. This study is the first to replicate the association between word frequency and neural differentiation and the first to show that phonologically informed sub-lexical units exhibit distinct tuning for graphemes and onset-rimes within the reading network. These findings underscore the potential of neural-differentiation mapping as a powerful tool for charting the functional architecture of reading and other experience-dependent cognitive systems.

A57 - The neural network supporting sign language comprehension: A dynamic causal modeling study

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Sign language provides a unique and natural opportunity to explore the cognitive and neural mechanisms of language processing because its linguistic structure is coded in movement and space and decoded through vision. The neural network supporting sign language processing is poorly understood compared to spoken and written language. Using dynamic causal modeling (DCM), this study investigated the neuronal network underlying Spanish Sign Language (LSE) comprehension and compared the model with two other language modalities: written and auditory words. Three groups

of hearing native Spanish-speaking participants with varying experience in LSE took part in the study: 23 proficient native signers, 20 proficient late signers, and 23 non-signers. Three modalities of stimuli were designed: sign stimuli (signs, pseudosigns, scrambled video as baseline), written stimuli (words, pseudowords, scrambled words as baseline), and audio stimuli (words, pseudowords, rotated speech as baseline). Participants viewed the stimuli while performing a simple detection task to maintain attention (i.e., indicate the direction of an arrow, presented in 10% of trials). Based on brain regions identified in the current study and previous DCM research on written and spoken language comprehension, we constructed a DCM model for each modality with six volumes of interest (VOIs) in the left hemisphere: inferior occipital gyrus (IOG), ventral occipital-temporal cortex (vOTC), inferior parietal lobule (IPL), posterior superior temporal sulcus (pSTS), anterior superior temporal sulcus (aSTS), and the pars orbitalis of inferior frontal gyrus (IFGorb). We used equivalent contrasts to determine the coordinates of the six VOIs across three modalities (signed, written, auditory): IOG was identified in the All>Null contrast (All includes words, pseudowords, and baseline); vOTC, pSTS, and IPL in the Word-like>Null contrast (Wordlike includes words and pseudowords); left aSTS and IFGorb in the Word>Baseline contrast. Similar to written and auditory words, sign language comprehension recruited multiple routes from the perceptual cortex (IOG) to higher-order semantic areas (IFGorb) such as IOG→vOTC→pSTS→IFGorb and IOG→pSTS→IFGorb. These two pathways suggest that semantic information (in the IFGorb) can be accessed from the visual cortex (in the IOG) via a route with or without vOTC region. In the sign language model, the pSTS region is the critical hub that transmits activations to other regions, reflecting crucial phonological processing involved in sign language comprehension. In contrast to a sublexical pathway (vOTC→IPL→pSTS) in written and auditory modalities, the reversed pathway (pSTS→IPL→vOTC) reflects specific roles of the left IPL (e.g., feedback activation during the precise configuration and location of hands in space that conform to phonological structure) in sign language processing. Additionally, the absence of bidirectional connectivity between the left aSTS and IFGorb suggests that sign language processing may involve alternative routes for semantic integration compared to the other two modalities. The most striking finding of this study is that the model for spoken or written language also accounts for the neural architecture underlying sign language processing, with multiple links between the processing of (visual) input with phonological or semantic processing. While the nodes are the same, the differences in connectivity provide new avenues for exploring how modality shapes language processing.

A58 - Congruent pitch gestures enhance the phonological and semantic processing of L2 Mandarin words in L1 English speakers

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Introduction. Tonal languages (e.g., Mandarin) use lexical tone to distinguish between meanings, resulting in minimal pairs that differ only in terms of their pitch contours. For speakers of atonal first languages (L1s), like English, learning to use novel suprasegmental features may present challenges over-and-above the inherent difficulty of learning novel segmental

features of second language (L2) words. These challenges may be overcome by observing gestures consistent with the vertical conceptual metaphor of pitch, in which pitch is associated with spatial height. This study uses the N400 event-related potential (ERP), which reflects processing effort, to reveal the extent to which congruency of observed gestures with the vertical conceptual metaphor of pitch affects semantic and phonological processing of newly learned L2 words differing minimally in lexical tone. We predicted that learning via gestures congruent with the vertical metaphor of pitch would generate increased N400 response differences for mismatching vs. matching stimuli following learning in the lexical tone discrimination task, which taps into phonological processing, as well as the word meaning association task, which taps into semantic processing. **Methods.** Adult L1 English speakers ($n=22$) with no tonal language experience completed a pre-test, a learning task, and a post-test. Six pairs of words differing minimally in lexical tone were presented in the pre-test, post-test, and learning tasks. In the pre-test, which consisted of a lexical tone discrimination task, pairs of Mandarin words with either matching or mismatching lexical tones were presented. In this test, the 12 words were randomly presented 12 times each (144 trials). In the learning task, pairs of Mandarin words differing minimally in lexical tone were presented in one of three learning conditions: with gestures conveying the pitch contours of lexical tones (congruent); with gestures conveying the pitch contours of other lexical tones (incongruent); or with no hand movement (no gesture). In this task, 6 word pairs were presented in 6 blocks (36 trials). The post-test consisted of the lexical tone discrimination task presented in the pre-test and a word-meaning association task in which the 12 learned Mandarin words were paired with text of their English translations or translations of the other words in minimal pairs. N400s were measured throughout. **Results.** In the post-test, learning with congruent gestures resulted in larger right posterior N400s for mismatching than matching stimuli in the lexical tone discrimination and word-meaning association tasks. In contrast, the incongruent and no gesture conditions resulted in less differentiated right posterior N400 responses in the lexical tone discrimination and word-meaning association tasks. **Discussion.** Our preliminary findings suggest the difference in right posterior N400 responses between learning conditions reflects increased sensitivity to lexical tone in both phonological and semantic processing of newly-learned L2 Mandarin words after exposure to gestures congruent with the vertical metaphor of pitch. These results demonstrate that observing gestures consistent with the vertical conceptual metaphor of pitch when learning L2 words differing in lexical tone enhances phonological and semantic differentiation between them in atonal L1 speakers.

A59 Sandbox Series - Scalar implicature processing in deaf and hearing signers of German Sign Language (DGS): Preliminary findings from some-but-not-all scalar implicatures

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Scalar implicatures (SI) are derived when statements like “some guests have arrived” are interpreted as a negation of “all guests have arrived”. Scalar implicatures are not explicitly conveyed but are conclusions based on pragmatic inferences, which by some are assumed to be rooted in communication principles such as

the ones described by Grice (1975; Spychalska et al., 2016). They have been the subject of extensive investigation in the field of experimental pragmatics (for an overview see Politzer-Ahles, 2020). However, most behavioral, and so far, all electrophysiological research on the matter has focused on spoken/written language paradigms and hearing monolinguals. Only a few studies have included hearing bilinguals (e.g., Dupuy et al., 2019) or deaf bimodal bilinguals (Davidson, 2014; Davidson & Mayberry, 2015) in their studies. Moreover, only behavioral research has been conducted on scalar implicature processing on the semantic-pragmatic interface in sign languages, focusing on deaf American Sign Language users (Davidson, 2014; Davidson & Mayberry, 2015). This ongoing study investigates how deaf and hearing users of DGS process some-but-not-all scalar implicatures triggered by the scalar quantifier *einige* (engl. *some*) in written German. So far, participants include (i) 19 deaf L1 signers of DGS & German, (ii) 18 hearing L1 signers of DGS & German, (iii) 21 hearing L2 learners of DGS, and (iv) 21 hearing non-signers (controls). A truth-value judgment task assesses accuracy and response time across 224 trials, where participants judge the truthfulness of German sentences containing *einige/alle* (engl. *some/all*; presented word-by-word with a duration of 500 ms each) in context of a preceding picture. During the behavioral task, the EEG was recorded. Preliminary findings display significant differences in response times between signers and non-signers ($p < .01$), suggesting that language experience might influence the timing of scalar inference processing. While all groups derive them from quantifier scales, rejection rates for underinformative trials vary depending on language group. Both deaf and hearing DGS users make scalar inferences, which is in accordance with Davidson (2014). This points to the assumption that their processing is shaped by both sensory and linguistic experience, supporting the universality of conversational principles across modalities. Davidson, K. (2014). Scalar implicatures in a signed language. *Sign Language & Linguistics*, 17(1), 1–19. <https://doi.org/10.1075/sll.17.1.01dav> Davidson, K., & Mayberry, R. I. (2015). Do adults show an effect of delayed first language acquisition when calculating scalar implicatures? *Language Acquisition*, 22(4), 329–354. <https://doi.org/10.1080/10489223.2014.962140> Dupuy, L., Stateva, P., Andreetta, S., Cheylus, A., Déprez, V., van der Henst, J.-B., Jayez, J., Stepanov, A., & Reboul, A. (2019). Pragmatic abilities in bilinguals. *Linguistic Approaches to Bilingualism*, 9(2), 314–340. <https://doi.org/10.1075/lab.17017.dup> Grice, H. P. (1975). Logic and Conversation. In P. Cole & J. Morgan (Eds.), *Syntax and Semantics* (pp. 41–58). Politzer-Ahles, S. (2020). What can electrophysiology tell us about the cognitive processing of scalar implicatures? *Language and Linguistics Compass*, 14(10), 1–22. <https://doi.org/10.1111/lnc3.12401> Spychalska, M., Kontinen, J., & Werning, M. (2016). Investigating scalar implicatures in a truth-value judgement task: Evidence from event-related brain potentials. *Language, Cognition and Neuroscience*, 31(6), 817–840. <https://doi.org/10.1080/23273798.2016.1161806>

A60 - Cortical Tracking of Manual and Facial Articulators in Sign Language Processing

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Cortical tracking of spoken language refers to the synchronization of brain oscillations with the speech envelope. While research has primarily focused on spoken language, some studies have begun exploring cortical tracking in sign language, which relies on the visual modality and coordinated movement of facial and body articulators. These articulators (e.g., hands, mouth) serve distinct linguistic functions and convey varying amounts of information. In previous work, our group used Kinect v2 motion tracking and found that hearing signers tracked hand and head movements more than non-signers in right parietal regions. This study extends that work by examining whether hearing signers also track the kinematics of facial articulators, which carry linguistic information but could not be reliably captured with Kinect. We used the same MEG dataset, collected from two groups of hearing Spanish speakers (14 proficient signers of Spanish Sign Language (LSE) and 14 non-signers), but extracted facial and body motion data from the video stimuli using MediaPipe (Lugaresi et al., 2019), a deep-learning-based computer vision model. The stimuli consisted of 1-minute videos showing narratives in LSE (known to signers) or Russian Sign Language (RSL, unknown to all participants), produced by two deaf native signers of each language. Brain activity was recorded with MEG while participants watched 20 videos (10 per language, 5 per model), followed by a recognition task using a five-second video probe and a foil to ensure engagement. To characterize the visual linguistic signal, we extracted the speed time series from several body articulators (hands, head, torso), along with facial features: mouth aperture (distance between upper and lower lips); mouth movement (histogram of oriented gradients, which reflects how much the lips are moving and in which directions); face orientation in terms of pitch (up and down orientation of the face) and yaw (right and left orientation of the face). The results from the body articulators confirmed the findings of the previous study, demonstrating that MediaPipe (which only requires a standard video recording) provides comparable results to the earlier method (which required specialized cameras and setups) in terms of cortical tracking. However, for facial articulators, we found no evidence of tracking nor any group differences. To assess whether our facial kinematic measures lacked sensitivity, we analyzed cortical tracking of mouth aperture during a spoken language task, where participants viewed Spanish (known) and Russian (unknown) narratives. We found that signers showed stronger tracking of mouth movements associated with spoken Spanish than non-signers in frontal areas, while both groups similarly tracked mouth movements in Russian. These findings show that speech-related mouth movements are tracked in challenging contexts, such as the unknown language condition. Hearing signers also track mouth movements in their known language, possibly due to their experience with a visual language. Importantly, these results demonstrate that our measure is sensitive enough to capture mouth movement. Taken together, the results suggest that cortical tracking of facial articulators may not occur during sign language processing and that tracking in sign language primarily relies on manual articulators.

A61 Sandbox Series - Developing an fMRI localizer for German Sign Language (DGS)

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Introduction: Functional localizers in fMRI enable the precise and participant-specific identification of voxels that respond to a particular cognitive function or task of interest (e.g., Kanwisher et al., 1997; Saxe et al., 2006) and have been increasingly popular also in the cognitive neuroscience of language (Fedorenko et al., 2010; Nieto-Castañón & Fedorenko, 2012; Fedorenko et al. 2016). Yet, there is currently no functional localizer for any sign language, presumably because existing language localizers rely on written or auditory stimuli (Fedorenko et al., 2010, 2012, 2015; Scott et al., 2017), which are not modalities used by sign languages. Moreover, pseudoword or jabberwocky conditions are often used in localizers (Fedorenko et al., 2010, 2012, 2013), but creating analogous pseudosigns is difficult due to the larger iconic potential of the visual-kinesthetic modality (Emmorey et al., 2011). Against this background, we document here our ongoing effort of developing the first language localizer for any sign language, using German Sign Language (DGS) as an example. Methods: We adapt the approach of Malik-Moraleda et al. (2022), who have used degraded versions of auditory stimuli to create a contrast between comprehensible and incomprehensible sentences when studying spoken languages that lack a written form, to the visual-kinesthetic modality of sign languages. Accordingly, we use video clips of complex sentences in DGS from Trettenbrein, Maran, et al. (2024) and determine the degree of visual degradation necessary to be able to create the desired contrast between comprehensible and incomprehensible DGS. Research on visual degradation of sign language stimuli is scarce. One exception is Pavel et al. (1987) who systematically added degrees of Gaussian noise to stimuli, however, nearly one third of their stimulus set was still intelligible to deaf participants, even at the at the highest degradation level. Here, we adopt a novel approach for degrading stimuli by increasing the size of pixels in a video clip. That is, all frames in a video are first downsampled and then upsampled by a chosen pixelation factor to create an output video with larger individual pixels than in the input. The result is a video that appears “blocky,” obscuring visual details afforded by a high pixel count such as facial expression, handshape and, to some extent, location which all carry linguistically relevant information in sign languages. To determine the appropriate degree of degradation for incomprehensibility, we are running an online gating study wherein deaf native signers of DGS view and rate the intelligibility of videos with different degrees of degradation on a 5-point Likert scale. Outlook: The validation of our materials and collection of pilot fMRI data is currently still ongoing. Also, we are working on creating and including an additional condition that uses point-light displays derived from motion-tracking of the signers in our stimulus clips to further reduce comprehensibility while still triggering a robust response of the language network. This approach should generalize to other sign languages and we intend to make all our scripts and the localizer task itself publicly available to the community.

A62 - Neural Signatures of Gesture-Speech Integration in Children with Autism Spectrum Disorder: An fNIRS Investigation

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Effective communication relies on the integration of multimodal cues such as speech and co-occurring gestures, a process supported by a distributed frontotemporal network including the inferior frontal gyrus (IFG) and posterior superior temporal sulcus (pSTS). Deficits in gesture-speech integration are well documented in Autism Spectrum Disorder (ASD), yet the neural mechanisms underlying these impairments are unclear. The present study employed functional near-infrared spectroscopy (fNIRS) to investigate the neural dynamics of gesture-speech integration in children with ASD and age-matched typically developing (TD) peers. Participants (ASD: $n=15$; TD: $n=15$; age 5–10 years) were presented with stimuli in four conditions: speech-only (S), gesture-only (G), congruent gesture-speech pairings (CG+S), and incongruent gesture-speech pairings (IG+S). Hemodynamic responses, indexed by changes in oxyhemoglobin (Oxy-Hb) and deoxyhemoglobin concentrations, were recorded from bilateral IFG and pSTS. Compared to TD children, children with ASD exhibited significantly lower increases in Oxy-Hb concentrations, reflecting reduced functional activation, in left IFG and pSTS across all conditions. Critically, TD children showed greater increases in Oxy-Hb concentrations in left IFG and pSTS, reflecting increased functional activation, for incongruent compared to congruent gesture-speech pairings, indicating sensitivity to cross-modal semantic congruency. In contrast, children with ASD displayed minimal differences in Oxy-Hb concentrations between congruent and incongruent gesture-speech pairings, indicating reduced sensitivity to cross-modal semantic congruency. These findings provide converging evidence that diminished functional activation in left IFG and pSTS contributes to atypical gesture-speech integration in ASD. By clarifying the roles of IFG and pSTS in gesture-speech integration deficits in ASD, the results highlight their potential as biomarkers for diagnosis and treatment of gesture-speech integration impairments and as neurobiological targets for intervention strategies aimed at enhancing communication in children with ASD.

A63 Sandbox Series - Language Proficiency and Directionality Preferences in ASL-English Interpreters

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Simultaneous interpreting is a complex cognitive process that requires an individual to work between two languages, comprehending an utterance in one language while at the same time reproducing the meaning in another language. For American Sign Language (ASL)-English interpreters this involves two modalities - ASL in the visual-gestural modality and English in the oral-aural modality. There is evidence that these bimodal interpreters often prefer interpreting into their second language (L2) (Nicodemus & Emmorey, 2013; Nicodemus et al., 2023), whereas spoken language (unimodal) interpreters commonly report a clear preference for interpreting into their first language (L1). This discrepancy is of practical significance because there is debate about the effects of directionality on the quality of interpretation produced. The field of spoken language interpreting has long argued that equivalent interpretations can only be produced when working from an L2 into an L1. However, several studies have demonstrated that this is not always the case (Pavlović, 2007), especially when certain situational factors such as register and subject-matter are considered (Al-Salman & Al-Khanji, 2002). Understanding the nature of this

preference is important because the field of bimodal interpreting regularly requires working in both directions. While previous studies have established this preference, we have little understanding of its cause. One hypothesis is that discrepancies in language proficiency between the L1 and L2 lead to decreased monitoring ability of output in the L2. However, language proficiency has rarely been assessed in a rigorous manner in studies of directionality preference. This research study aims to better understand the reason(s) for this directionality preference, including the impact of various situational variables, by identifying predictors of directionality preference in bimodal ASL-English interpreters. In particular, we hypothesize that language proficiency will be a key predictor and in this study we plan to use several standardized language proficiency measures in addition to survey questions that assess L1 and L2 acquisition histories, self-rated proficiency, language attitudes, and interpreting training and work contexts. In future studies we plan to use online measures of language proficiency that may reveal processing limits that govern directionality preference. Studying bimodal interpreting not only sheds new light on the human capacity for language, it also has practical implications for improving the quality of ASL-to-English interpreters.

A64 - Validating the Academic Anxiety Inventory with a Bilingual d/Deaf, DeafBlind, and Hard of Hearing Sample

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Academic anxiety refers to feelings of anxiety and negativity associated with specific domains of academic skills or knowledge, such as math anxiety, science anxiety, or writing anxiety. Not only does academic anxiety relate to negative experiences, but it also detracts from the performance of academic skills, resulting in poorer outcomes and reduced academic achievement. In the present study, we explored the psychometric properties of the Academic Anxiety Inventory (AAI), a questionnaire designed to assess math, science, writing, test, and trait (general) anxiety. In particular, we sought to validate this questionnaire with a sample of d/Deaf, DeafBlind, and hard of hearing (DDBHH) participants ($N = 145$). DDBHH individuals may face additional challenges and barriers to academic achievement created by lack of accessibility, which may put DDBHH individuals at greater risk for developing anxiety around different domains of knowledge. Many DDBHH people in the US are bilingual, gaining proficiency in both English and American Sign Language (ASL). Our research evaluates the reliability and validity of utilizing the AAI in DDBHH participants, presenting the original written English version of the AAI with accompanying videos of each item in ASL signed by a native deaf signer, making the AAI more accessible and friendly to bilingual DDBHH participants. The results of this study suggest that the AAI is a reliable and valid measure of academic anxiety among DDBHH communities. We investigated each subscale of the AAI and found that all five subscales had sufficient reliability using Cronbach's alpha. Using factor analysis and principal components analysis we also evaluated whether the fifty items in the AAI were represented by the hypothesized five subscales for math anxiety, science anxiety, writing anxiety, test anxiety, and trait (general) anxiety. We found that the vast majority of questionnaire items loaded onto factors representing each hypothesized domain of anxiety, and

that this factor structure was extremely similar to the original results reported with a hearing sample of participants ($N = 236$). We also show that each AAI subscale has a relatively low degree of intercorrelation with the other domains, indicating that these ten-item subscales measure independent domains of anxiety. In a subset of DDBHH participants, we also evaluated the test-retest reliability of all five domains. Our results show high test-retest reliability across all subscales. We collected additional information about participants' language backgrounds, giving us insight into how bilingual experiences in ASL and English were related to anxiety about writing skills in English. Our results showed that self-reported language preferences were also significantly associated with our measure of writing anxiety. An increased preference for communicating in written English was associated with decreased writing anxiety in DDBHH participants. Interestingly, increased self-reported comfort with ASL was also associated with decreased writing anxiety. These results suggest that building stronger bilingual language skills in DDBHH people was associated with decreased writing anxiety. Taken together, these results suggest that the AAI is a reliable and valid measure of academic anxiety in DDBHH individuals, and extends our knowledge about academic anxiety and bilingualism.

A65 - Inclusive neurocognition of language: a protocol for research with deaf signers

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Neurocognitive research on language involves performing studies with a variety of populations. Working with deaf participants requires specific adaptations to ensure data quality and, ultimately, safeguard participant well-being. Our research group conducts studies with deaf signers; in this presentation we lay out the issues that researchers should be aware of, and propose guidelines for working with deaf participants, particularly in the context of neuroimaging studies, which present particular challenges. The foremost issue when working with deaf signers is communicative accessibility: all information should be available in the relevant sign language as well as written text. This means translating recruitment information, safety screening, consent forms and instructions into sign. We record signed texts in video format so they can be used in on-line questionnaires or presented on-site. The research team must include a highly proficient signer; ideally, this should be a deaf signer, who will be more sensitive to cultural issues (and promotes inclusion in research: see below). The signing researcher facilitates communication with participants: for on-line studies, this may be resolving doubts and questions via video calls; for on-site studies, the signer is on hand at all times to guarantee fluid interaction. Most research paradigms require some modification for deaf participants, but neuroimaging techniques require specific adaptations because of the communication limitations imposed by the physical setup. For MRI and MEG, communication with the participant is typically by speech over microphone and earphones/speakers. With deaf

participants, we use two cameras: one connected to the presentation computer for researchers to sign to the participant; and a video feed from the scanner allows the participant to sign to the researchers. The reduced space in the MRI drastically limits what the participant can sign: for this reason, we have developed a reduced set of adapted signs that express the most relevant communicative needs ("Fine to carry on", "I need a break", "How much time left?", etc.). Since detailed exchanges are not possible during the scanning session, before entering the scanner we explain the structure of the scanning session and run through practice trials of the task to resolve any doubts or questions. Much of the adaptation involves providing the participant with clear information in advance so that communication issues do not arise during the scanning. In addition to adapting research methods to deaf participants, research practice needs to be inclusive for and of deaf individuals. This involves creating accessible outreach materials in sign language and engaging with community stakeholders. More fundamentally, including deaf people in research requires creating opportunities and environments that allow deaf individuals to train and develop as researchers. This goal requires long-term strategy planning and working with administration and funders to make research inclusive. Carrying out research on sign languages allows us to account for the full diversity of human language; making research inclusive will provide insights and perspectives that enrich our research program and will make our practice socially equitable.

A66 Sandbox Series - Leveraging Visuospatial ASL for Better Conceptual Understanding in STEM Education

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Deaf and hard-of-hearing students face various obstacles to pursuing careers in STEM fields. One commonly cited obstacle is the lack of conceptually sound, consistent STEM signs in American Sign Language (ASL). Many groups have begun developing these signs, which often leverage the visuospatial nature of ASL to support conceptual understanding. For instance, a new sign for acid is made with one hand in a fist, representing a molecule, while the other hand makes the H-handshape (Hydrogen) and moves away from the fist, showing that acids lose Hydrogen ions when mixed with water. The same handshapes can become the sign for base by reversing the direction of the movement, because bases accept Hydrogen ions when mixed with water. The development of these signs was motivated by wanting to make concepts and the connections between them more transparent by using a shared visuospatial morphology. As such, we will call them conceptually motivated (CM) signs. We propose that CM signs allow for embodied connections between action and the concept, as signers can use their bodies to create more concrete conceptual representations for abstract ideas, similar to the use of iconic gestures to support learning. Because the development of CM signs emphasized the importance of their morphological relationships, we will test their effectiveness within lectures where those connections can be more effectively leveraged for learners. We will do this by using previously validated videos on

four STEM topics, each in two signing styles. One style is more linear/English-influenced and incorporates fingerspelling and traditional signs for key vocabulary, while the other is a more visuospatial style that incorporates CM signs. This proposed study will use a within-participant, pre- and post-test design to compare differences in learning from the two signing styles. Participants will complete a pre-test before viewing our training videos. Each participant will watch four, 5-minute-long training videos on different STEM topics, two in each signing style. They will sign a 1 to 2-minute summary after each video. After watching all four videos, they will complete a post-test and a cognitive matching task where they will see words and images related to the topics they learned about and judge if they match or not. During this task, we will measure electroencephalography (EEG) signal, focusing on mu-rhythm desynchronization, a common measure of embodiment in which increased desynchronization in alpha-range frequencies near the sensorimotor cortex is related to mirror neuron system activation. Finally, participants will complete post-tests one day and one week after training. We predict that for concepts learned with the more spatial, CM signs, participants will rely more on the signs for those concepts and thus exhibit higher levels of desynchronization when participants view the related English words as compared to concepts they learned with the more English-influenced signs. Further, we predict that this heightened embodiment will be linked to more improvement from pre-test to post-test for content learned in the more spatial, CM style. These results will provide insights into the potential for using CM, visuospatial language to support STEM learning.

A67 - Sign perceivers allocate gaze based on contextual cues during ASL sentence comprehension

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Sign languages such as American Sign Language (ASL) unfold dynamically over time, requiring perceivers to make real-time decisions about where to direct their gaze to capture linguistic information as it occurs and before it disappears. Skilled deaf signers look mostly at the face during sign perception (e.g., Emmorey et al., 2009), but occasionally direct gaze to the hands when perceiving fingerspelling (Gappmayr & Lieberman, 2024). However, signers cannot always predict when in the linguistic signal fingerspelling will occur, and their need to attend to the hands likely varies as a function of their ability to anticipate which word will be fingerspelled. We sought to investigate allocation and timing of gaze patterns to the hands and the face when perceiving signed input. We asked whether signers allocate gaze to the hands longer in conditions where they expect fingerspelling, such as when the sentence context suggests a name is upcoming (e.g., C-H-R-I-S) compared to when they expect a sign (e.g. sentence context suggests the next word would be the sign APPLE) but they were instead provided with the word in fingerspelled form (A-P-P-L-E). We also provided conditions where ability to predict the identity of the fingerspelled word is low (e.g. they do not know what name will be produced), compared to conditions where the sentence context suggests a commonly fingerspelled word (such as B-A-K-E-R-Y). Eleven Deaf adults who were exposed to ASL before the age of five completed the eye-tracking experiment (data collection ongoing). Participants' eye movements were recorded as they watched 40 pre-recorded sentences in ASL and responded to occasional comprehension questions to maintain

attention. Stimuli sentences were constructed to manipulate fingerspelling expectation and target word predictability. An additional 20 control sentences were included that had no fingerspelling. We calculated whether signers gazed at interest areas over the face or the hands (static area below the shoulders) throughout each sentence, and performed a divergence point analysis using 50 ms binned eye-tracking data focused on the proportion of looks to the hands vs. face. For each trial, timing was transformed relative to the onset of the fingerspelled word. We ran independent t-tests at each time bin to compare the effects of fingerspelling expectation and target word predictability on the mean proportion of looks to the hands. In the expected vs. unexpected fingerspelling pair (e.g. B-A-K-E-R-Y vs. A-P-P-L-E), divergence occurred 500 ms after onset with the effect lasting for 250 ms ($p < .001$). In the predictable vs. unpredictable word pair (e.g. B-A-K-E-R-Y vs. C-H-R-I-S), divergence occurred 300 ms after onset and persisted for 400 ms ($p < .001$). In the control trials with no fingerspelling (e.g. sign APPLE), gaze remained on the face throughout the sentence. Results suggest that signers look longer at the hands when fingerspelling occurs unexpectedly or when they are unable to predict the word that will be produced. The unique visual modality of sign languages paired with overt behavioral data from eye-tracking allows for inferences about real-time language processing and prediction.

A68 - Prosodic and Phonetic Coordination of Speech: fMRI Evidence for Parallel Circuits

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Human speech production is hypothesized to rely on two parallel hierarchical cortical motor pathways: one for laryngeal control of vocal pitch/prosody and another for supralaryngeal control of phonetic and syllabic sequences. Here, we test this hypothesis using functional magnetic resonance imaging (fMRI). Fifteen adult participants ($N = 15$; to date) completed two task-based fMRI paradigms. The first aims to differentiate the sub-circuits responsible for pitch modulation and supralaryngeal articulation within the speech production networks, where we compare neural activations during speech repetition tasks (Hickok et al. 2009, J. Neurophysiol.; Rong et al. 2018, PLoS ONE) across stimuli composed of four CV syllables that varied independently along prosodic (pitch) and segmental (non-pitch) dimensions. The second experiment aims to isolate pitch-specific and (non-pitch) segment-specific pathways from broader speech coordination networks by examining neural responses during speech production tasks under Altered Auditory Feedback (AAF; Tourville et al. 2008, Neuroimage; Niziolek & Guenther 2013, J. Neurosci.) that selectively perturbed either pitch or vowel formant frequencies. In both experiments, we aim to delineate the distinct neural circuits involved in coordinating pitch modulation versus segmental (phonetic) articulation. Preliminary analyses reveal a consistent neural association (i) between pitch/prosodic variation and specific regions of the left premotor cortex, particularly area 55b (Glasser et al., 2016), and (ii) between segmental/phonetic variation and classical Broca's area. These findings support proposed roles of the dorsal region of the premotor cortex in pitch-related processing (Silva et al.

2022, J. Neurosci.; Hickok et al. 2022, Brain) and the ventral region of the premotor cortex in supralaryngeal articulatory control. This work not only deepens the understanding of the neural basis of vocal pitch/prosody and phonetic/syllabic ability but also holds potential implications for clinical interventions in speech and language disorders.

A69 - Cerebellar involvement in speech production

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Producing speech is a multifaceted process that involves lexical selection, phonological planning, and articulatory execution. This ability depends on both language proficiency and complex motor functioning, utilizing a large network of brain regions. Clinical evidence indicates that both the cerebellum and the neocortex are critical nodes in this network. Ataxic dysarthria, a speech disorder primarily characterized by slowed and distorted articulation, is the hallmark of cerebellar damage. However, similar articulatory distortions have also been observed in patients with neocortical lesions. Likewise, while impaired verbal fluency (i.e., the ability to generate words under specific task demands) is typically associated with frontal lobe dysfunction, it has also been documented in cerebellar patients, even when controlling for their dysarthria severity. Therefore, the question of the distinct contribution of the cerebellum and neocortex to speech production remains unknown. To address this question, we use functional magnetic resonance imaging (fMRI) to measure the whole brain response during overt production of nine-syllable utterances. We vary multiple factors of these syllable strings that may characterize cerebellar contribution. First, we test three speeds of production to test the idea that the cerebellum especially contributes to fast speech production. Secondly, we vary the complexity of the syllabic sequence, using either the same syllable three times (simple sequence; e.g. 'ta-ta-ta') or a string of three unique syllables (complex sequence; e.g. 'ta-bo-go'). Third, we will examine lexical familiarity, utterances will either form trained real words (e.g., "bo-go-ta"), or novel, untrained pseudowords (e.g., "ta-bo-go"). Finally, to disentangle lexical effects from motor training, participants will be extensively trained on the overt production of certain pseudowords. We will use the selective recruitment analysis approach to evaluate the unique contribution of the cerebellum to speech articulation. This method uses the prediction from a task-invariant cortical-cerebellar connectivity model as baseline. If the cerebellum is specialized for a specific aspect of speech production, distinct from the neocortex, it should show higher-than-expected activity in a designated task compared to the baseline connectivity. We hypothesize that the cerebellum will be selectively recruited at production rates higher than 3Hz, as cerebellar patients show a reduced articulation rate that reaches a plateau at ~2.5-3 Hz. Furthermore, given the cerebellum's role in sequence learning, we expect enhanced cerebellar activity during the production of novel, complex pseudoword sequences. In contrast, we do not anticipate cerebellar selectivity during the production of real words, regardless of their complexity. Similarly, we predict equivalent cerebellar activation for trained syllabic sequences, whether they constitute real words or pseudowords. The results of this investigation will provide novel insights into the cerebellum's role in speech production. Pinpointing the specific aspects of speech production governed by the cerebellum

paves the way for developing rehabilitation programs for patients with ataxic dysarthria.

A70 - Dorsolateral vs Ventrolateral Precentral Gyrus Atrophy in Primary Progressive Aphasia Linked to Distinct Networks and Motor Speech Patterns

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Background: The precentral gyrus has been implicated in motor speech disorders including apraxia of speech (AOS). Recently, it has been proposed that the lateral precentral gyrus contains two parallel systems, dorsal precentral speech area (dPCSA) involved in prosodic coordination and ventral precentral speech area (vPCSA) involved in phonetic coordination, paralleling the prosodic and phonetic subtypes of AOS. In this study, leveraging a cohort of individuals with primary progressive aphasia (PPA), we aimed to test two hypotheses: (i) the dPCSA and vPCSA are part of distinguishable neural circuits, as revealed by different patterns of associated atrophy, and (ii) differential disruption to the two PCSAs is associated with distinct clinical presentations. Methods: T1-weighted MRI from 104 individuals with non-fluent PPA were processed with SPM12 to obtain voxel-wise grey and white matter W-scores indexing deviation from an age-matched control cohort. Mean W-scores were extracted from two 5 mm spheres centered on vPCSA (x=-56, y=8, z=20) and dPCSA (x=-50, y=-4, z=46). Subjects with significantly greater atrophy ($W < -1.65$) in one region than the other were designated vPCSA-predominant (n=16) or dPCSA-predominant (n=9). Group-level frequency maps summarized atrophy patterns. Auditory-perceptual ratings of specific features of apraxia of speech (AOS), dysarthria, and dysphonia were conducted by three trained speech-language pathologists, and group differences were evaluated using chi-squared tests. Results: The groups did not differ in age or general disease severity. The vPCSA group exhibited extensive bilateral grey- and white-matter loss encompassing left inferior frontal, inferior parietal and supplementary motor cortices; perisylvian white matter; thalamus; insula; hippocampus; and middle cingulum. Conversely, the dPCSA group showed focal bilateral atrophy along the precentral gyrus with left-lateralized involvement of supplementary motor area, superior and middle temporal gyri, insula and thalamus. No brainstem or midbrain atrophy was detected. Speech evaluation was not performed on four subjects due to severe motor impairment. AOS was present in both groups (11 out of 13 subjects tested in the ventral group, 7/8 in the dorsal) with largely overlapping feature profiles. Chi-squared tests showed that initiation impairment was significantly more prevalent in the vPCSA group ($\chi^2 = 7.14$, $p = 0.008$). Dysarthria was more frequent in vPCSA-predominant patients (11/13 vs 3/8; $\chi^2 = 4.95$, $p = 0.026$), whereas a trend toward harsher vocal quality characterized the dPCSA group ($\chi^2 = 3.34$, $p = 0.067$).

Dysphonia occurred more frequently in vPCSA (11/13, 84.6% vs 4/7, 57.1%), without reaching significance. Discussion: Both vPCSA and dPCSA non-fluent PPA groups presented with motor speech disorders, including AOS. While several speech features were equally distributed in our small sample, some features differed between groups, suggesting that the two areas contribute differently to motor speech deficits. Additionally, the underlying neural circuits—demonstrated by patterns of correlated atrophy throughout the brain—differed between groups, consistent with the hypothesis of distinguishable circuits. One notable difference is the implication of the dPCSA in auditory-related regions, consistent with previous results in healthy individuals. Future directions include validating these results in independent cohorts and expanding the imaging and clinical features explored.

A71 - From Compensation to Inefficiency: Rethinking Age-Related Prefrontal Involvement in Speech-in-Noise Comprehension

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Understanding speech in noisy environments becomes increasingly difficult with age, even for individuals without clinically significant hearing loss. Older adults often show increased activation in prefrontal cortical (PFC) regions during speech processing under adverse listening conditions. However, the functional significance of this activation remains controversial: it may represent compensatory support for degraded auditory input or an inefficient allocation of cognitive resources that fails to improve comprehension. In this study, we used functional near-infrared spectroscopy (fNIRS) to examine age-related differences in PFC activation during sentence-level speech comprehension in noise. In addition, we examined whether individual differences in hearing sensitivity and cognitive ability predicted these neural activation patterns. Twenty-one young adults and thirty-five older adults listened to sentences presented in moderate or high noise and repeated the last word of each sentence. The sentences varied in contextual predictability, with the last words either highly predictable or less predictable. Throughout the task, fNIRS measured changes in oxygenated hemoglobin concentration in the PFC while behavioral speech comprehension accuracy was recorded. Older adults showed increased PFC activation specifically in high-noise conditions, whereas younger adults showed no significant neural modulation across noise levels. In older adults, greater right lateralized activation was associated with poorer comprehension accuracy. Mediation analyses revealed that bilateral PFC overactivation partially explained age-related declines in comprehension performance, suggesting that such activation represents maladaptive rather than compensatory processing. Although hearing thresholds and general cognitive ability did not predict overall PFC activation levels, both factors influenced neural modulation across noise conditions. Older adults with greater hearing loss or lower cognitive scores showed less differentiation in PFC activation across noise levels, indicating inefficient neural processing regardless of task difficulty. Conversely, those with better hearing sensitivity and cognitive performance showed maladaptive neural responses only in the most challenging listening conditions. Taken together, these results provide novel

evidence that increased PFC activation during speech-in-noise comprehension in older adults reflects neural inefficiency, particularly when activation is right-lateralized and unresponsive to task demands. Importantly, this study highlights the potential of fNIRS to explore the neural mechanisms underlying communication difficulties in aging, and underscores the importance of developing targeted, evidence-based interventions to mitigate maladaptive PFC overactivation to promote more effective communication in older adults.

A72 - Adaptation to fast speech is sensitive to hearing and hearing-aid use

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Even brief exposure to degraded speech can yield rapid improvements in recognition accuracy in listeners with typical hearing. Despite substantial research, the mechanisms underlying this adaptation remain unclear. For time-compressed speech, adaptation-induced gains in speech recognition were shown to persist over time, suggesting involvement of perceptual learning processes. We investigated adaptation to time-compressed speech in relation to age, hearing status, and hearing aid experience. In this presentation we will focus on three key patterns: (1) Older adults with even mild hearing loss exhibit poorer recognition of time-compressed speech and slower adaptation compared to young adults with typical hearing. This difference persists despite testing older adults with properly fitted hearing aids and using slower speech rates to match baseline recognition. (2) In new hearing aid users, amplification provides minimal benefit for adaptation processes. (3) After six months of hearing aid use, however, these same listeners demonstrate enhanced adaptation during aided versus unaided testing, though neither adaptation rate nor overall recognition reached the level of younger adults with typical hearing. Similar patterns were observed for natural-fast speech, although with greater variability. Together, these findings suggest that speech adaptation mechanisms are influenced by long-term auditory experience and hearing status, beyond their known sensitivity to acoustic properties of speech.

A73 Sandbox Series - Pre-processing of speech in the brain

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Spontaneous speech presents unique challenges that are often absent from the carefully controlled linguistic stimuli typically used in laboratory settings. Produced "on the fly," unscripted and unedited, spontaneous speech is marked by pauses, fillers, and incomplete syntactic structures. Traditionally, such features have been dismissed as performance errors and largely overlooked in the study of linguistic competence. Yet disfluencies are not rare exceptions – they are a pervasive characteristic of everyday language use, highlighting the dramatic gap between idealized models of linguistic competence and the realities of natural speech. Despite the apparent "messiness" of spontaneous speech, everyday auditory communication occurs with remarkable ease, raising a fundamental question in the neuroscience of language: How does the brain overcome disfluent input? The brain must actively

contend with these disfluencies during real-time processing – but how? In this “sandbox presentation”, I propose the framework of “speech pre-processing,” which suggests that auditory brain regions help organize the disfluent input into a cleaner, more structured version – removing disfluencies and segmenting speech into sentences – before higher-level linguistic analysis takes place. I will present two projects: One that has been published (Agmon et al., 2023), and another that is currently an ongoing long-term project in my lab. In Agmon et al. (2023), we used EEG to analyze temporal response functions (TRFs) to spontaneous speech in Hebrew. Assessing separate TRFs for disfluent and fluent segments, we found reduced TRF responses to disfluencies, possibly reflecting early suppression of disfluent input within auditory regions. We also observed that sentence boundaries increased the latency of the speech TRF. Taken together, a possible explanation is that disfluencies and sentence boundaries have a unique prosodic profile. Indeed, prosodic cues such as pauses and lengthening can disambiguate syntactic structures or convey hesitation. However, it remains unclear whether the observed effects are purely a bottom-up response to low-level acoustic cues, or whether they reflect top-down direction of auditory attention guided by lexical and syntactic information. To better interpret the findings of Agmon et al. (2023), we aim to identify the role of prosody versus syntax in the processing of spontaneous speech, which is the goal of the second project in progress. In my lab, we are currently annotating corpora of spontaneous speech, marking disfluencies and sentence boundaries to advance two lines of research. First, using fMRI, we aim to localize brain responses to disfluencies, predicting reduced activation in language-related regions, possibly already in auditory regions. Second, leveraging large language models (LLMs), we are training two separate models to predict sentence boundaries based on either lexico-syntactic input or prosodic input alone. By generating regressors from these predictions, we will disentangle the contributions of acoustic versus lexico-syntactic cues to speech segmentation. Finally, looking ahead, I will present evidence of critical gaps in current LLMs’ handling of spontaneous speech, and advocate for the development of NLP tools that explicitly account for speech pre-processing during training, enabling more reliable modeling of real-world language use.

A74 Sandbox Series - Prototypicality effects of allophonic variants on Mismatch Negativity (MMN)

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[Introduction] Mismatch Negativity (MMN) has been found to reflect the discriminability of speech sounds (Dehaene-Lambertz, 1997; Näätänen et al., 1997; Winkler et al., 1999). However, MMN amplitude does not always correlate with discriminability—for example when allophonic variants are presented (Shinohara et al., 2022). We propose that MMN also reflects the prototypicality (i.e., familiarity) of the standard and deviant stimuli. When a more familiar allophonic variant is presented as the standard stimulus, the brain can more efficiently form a short-term memory trace, leading to a larger prediction error in response to the deviant stimulus—and thus a greater MMN amplitude—compared to the reverse order (i.e., an unfamiliar standard followed by a familiar deviant).

Additionally, we hypothesize that allophonic variants are stored in long-term memory. Therefore, even under an adapted oddball paradigm in which MMN is not typically observed (Phillips et al., 2000), we expect MMN to be elicited. When various examples of a familiar allophone are used as standard stimuli, the brain can still categorize them as the same allophone and generate a prediction to hear another example of the same allophone. If the deviant stimulus is an unfamiliar token from the same phonological category but not perceived as the same allophone, a prediction error may still occur, eliciting MMN. We predict a larger MMN when an unfamiliar deviant is presented in a series of familiar, varying standards, compared to the reverse. [Method] [Participants] Twenty General American English and 20 Southern British English speakers will participate in both behavioral perception and EEG recording sessions. [Stimuli] A ‘fleeing’–‘fleeting’ stimulus continuum was created in Praat using a recording from a Southern British English speaker. The /t/ duration was manipulated from 0 ms to 145 ms in 5 ms increments. Shorter durations resembled the General American English flap, while longer durations resembled the Southern British English plosive. [Procedure] Participants will behaviorally judge whether each stimulus matches their native accent. Based on these responses, 11 stimuli will be selected: one ‘fleeing’, five American-accented ‘fleeting’, and five British-accented ‘fleeting’ stimuli. EEG recordings will be conducted under four experimental conditions. [Expected Results] We predict a larger MMN in American English speakers under Condition A, in which five varying flap-like /t/ sounds are used as standards and one plosive /t/ as the deviant in the word ‘fleeting’, compared to Condition B—the reverse of A, where five varying plosive /t/ sounds serve as standards and one flap-like /t/ as the deviant. For British English speakers, a larger MMN is expected in Condition B than in Condition A. In Condition C, where a single flap-like /t/ is used as the standard and a single plosive /t/ as the deviant, American English speakers are expected to show a larger MMN than in Condition D—the reverse of C (i.e., a single plosive /t/ as the standard and a flap-like /t/ as the deviant). Conversely, British English speakers are expected to show a larger MMN in Condition D than in Condition C. We make similar predictions for the cross-boundary conditions (i.e., ‘fleeting’ vs. ‘fleeing’).

A75 - ERP P300 as an Indicator of Phonological Working Memory Abilities: A Study of Neurotypical and ADHD Children

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Phonological working memory (PWM)—the temporary storage and manipulation of phonological information—is a critical component of reading acquisition (Baddeley, 2003). The P300 event-related potential (ERP) has been identified as a neural index of PWM (Bonala & Jensen, 2012; Harwood et al., 2021). This preliminary study examines the P300 ERP as a measure of PWM and its association with reading behaviors in children with Attention-Deficit/Hyperactivity Disorder (ADHD) and neurotypical (NT) controls. Prior research indicates that children with ADHD experience specific PWM deficits (Raiker et al., 2019; Roberts et al., 2023), potentially impacting language and literacy development. Investigating the neural mechanisms underlying PWM may help reveal nuanced differences in

reading profiles among children with ADHD. Methods: A cross-sectional sample of children with ADHD (N=13; F=7; M Age = 9.88 ± 2.69) and NT controls (N=13; F=3; M Age = 10.9 ± 3.39) completed the Woodcock-Johnson IV Test of Achievement (WJ IV) and an ERP task. Groups were age-matched and classified based on clinical diagnosis. The ERP task utilized a classic auditory oddball paradigm presenting semi-synthesized English phoneme contrasts (/pa/ standard, 255 trials; /ba/ deviant, 45 trials). Children responded via button press to standard and deviant stimuli. The P300 component was identified across a cluster of 10 central-parietal electrodes, with mean amplitude and peak latency extracted between 300–700 ms. Independent samples t-tests examined group differences, paired t-tests compared standard and deviant trials within groups, and Spearman's rho correlations explored associations between ERP and reading measures. Results: No significant group differences were found for deviant mean amplitude (ADHD: $0.76 \mu V \pm 5.18$; NT: $2.18 \mu V \pm 1.75$; $t(24) = 0.94$, $p = .36$) or deviant latency (ADHD: $487 \text{ ms} \pm 130.9$; NT: $526 \text{ ms} \pm 75.6$; $t(23) = 0.91$, $p = .37$). Paired t-tests revealed no significant amplitude or latency differences between standard and deviant trials for the ADHD group. In contrast, NT children showed a significantly greater amplitude for deviant ($2.18 \mu V \pm 1.75$) versus standard trials ($.41 \mu V \pm 1.93$; $t(12) = -3.81$, $p = .002$), suggesting a robust P300 response. No significant latency difference emerged for NT children. Correlational analyses indicated that greater P300 deviant amplitude was associated with higher Sentence Reading Fluency scores on the WJ IV for NT children ($R_s(11) = .92$, $p < .001$), but not for children with ADHD ($R_s(9) = -.51$, $p = .11$). Conclusions: Preliminary findings suggest that NT children exhibit stronger neural responses to phonological deviant stimuli during PWM tasks, as indexed by the P300 component, compared to children with ADHD. Moreover, the association between P300 amplitude and reading fluency in NT children—but not in those with ADHD—points to potential differences in how PWM processes contribute to literacy development across groups.

A76 Sandbox Series - Cortical temporal dynamics of tracking linguistic and paralinguistic elements

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Emerging evidence suggests temporal neurodynamics track a broad spectrum of linguistic features, including acoustic-phonetic, syntactic, lexico-semantic, and prosodic elements (Gnanateja et al., 2025; Mai et al., 2024; Gwilliams et al., 2024, 2022; Bhaya-Grossman and Chang, 2021; Law and Pytkänen, 2021) across multiple, hierarchically organized timescales (Gwilliams et al. 2022, 2024). While the neurodynamics of linguistic processing are becoming increasingly well characterized, it remains unclear how the brain encodes and tracks paralinguistic elements such as speaker emotion. Paralinguistic information varies temporally with speech, relies on the same overlapping acoustic elements such as pitch and voice quality (Ní Chasaide and Gobl, 2004), and provides social and affective context that contributes to a speaker's intended meaning (Guyer et al., 2021). We hypothesize that paralinguistic and linguistic information are jointly encoded within a unified hierarchical structure, with paralinguistic processing unfolding at similar timescales and in parallel with linguistic processing. We

investigate this hypothesis with a natural listening task using magnetoencephalography (MEG). Stimuli consist of 90 speech excerpts (30-90 seconds each) from the Buckeye corpus (Pitt et al. 2007), first selected based on computational estimates of emotional valence diversity (Kounadis-Bastian et al. 2024), and subsequently evaluated by naïve human raters (N = 156), who rated speaker valence continuously over time from most positive to most negative. Raters also rated speech excerpts in which semantic content was degraded by low-pass filtering and in which prosodic information was abolished (reading time-locked transcripts). Excerpt conditions were presented between-subjects. Preliminary results indicate strong inter-rater reliability of valence ratings (mean standardized Cronbach's $\alpha = \sim 0.86$). As expected, perception of speaker emotion was modulated by the availability of acoustic and lexical content, where all excerpts show significant condition differences in average time-resolved valence ratings above condition-shuffled controls. If speaker emotion exhibits similar cortical tracking to linguistic elements, we predict that the continuous valence rating for each speech excerpt can be uniquely decoded from whole-head MEG sensor data independent of linguistic elements (King et al., 2020). We also expect that the temporal generalization (King and Dehaene, 2014) of valence rating decoding shows larger significant temporal windows than linguistic elements. Full-speech valence ratings should be significantly decoded when either semantic- or prosodic-degraded excerpts are presented, and decoding performance should depend on the strength of the valence ratings, their divergence across conditions, and specific linguistic features present in the signal. We will also examine the time-varying cortical structures underlying both linguistic and paralinguistic processing by projecting relevant feature vectors to constrain MEG source imaging onto signal covariates (Huang et al., 2024) to understand how linguistic and paralinguistic processing interact across spatio-temporal loci.

A77 - Stereoelectroencephalography reveals neural signatures of multisensory integration in the human superior temporal sulcus during audiovisual speech perception

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Human speech perception is multisensory, integrating auditory information from the talker's voice with visual information from the talker's face. Studies using BOLD fMRI have implicated the superior temporal gyrus (STG) in processing auditory speech and the superior temporal sulcus (STS) in integrating auditory and visual speech, but as an indirect hemodynamic measure, fMRI is limited in its ability to track the rapid neural computations underlying speech perception. We directly recorded neural activity in the STG and STS across 42 epilepsy patients implanted with stereoelectroencephalography (sEEG) electrodes. Patients identified single words presented in auditory, visual and audiovisual formats with and without added auditory noise. Seeing the talker's face provided a robust perceptual benefit, improving perception of noisy speech in every participant. Neurally, a subpopulation of bimodal electrodes concentrated in mid-posterior STG and STS showed short latency responses to auditory speech (71 ms) and visual speech (109 ms). Significant multisensory enhancement was

observed in STS bimodal electrodes: compared with auditory-only speech, the response latency for audiovisual speech was 40% faster and the response amplitude was 18% larger. In contrast, STG bimodal electrodes showed neither faster multisensory latencies nor response enhancement. Overall, auditory-only speech responses were fastest in the STG while audiovisual speech responses were fastest in the STS. Significantly faster responses for audiovisual speech suggest the possibility that seeing the face of the talker may increase the speed, as well as the accuracy, of speech perception.

A78 - Behavioral identification and neural representations of talkers' voices vary with lifelong language experience

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Listeners identify talkers by the sound of their voice less accurately in a foreign language than in their native language, a phenomenon known as the language familiarity effect. Previous studies on language familiarity effect have shown that listeners' prior knowledge of phonology and lexicon facilitates talker identification in their native language, and that greater lifelong immersion in a second language can improve the listeners' ability to identify voices speaking that language. While some studies have shown that international adoptees with early exposure to a specific language retain trace memory of their birth language without conscious awareness, it is unclear whether the brief exposure to their birth language very early in their development can give them some advantage to their birth-language talker identification. Building upon previous neuroimaging studies showing functional integration of processing linguistic and talker information, we aimed to identify how the neural representation of talkers varies between people with different language backgrounds. We recruited three groups of adult participants in Montreal -- native French speakers (French), native Mandarin speakers who also spoke French (Mandarin), and French speakers who were adopted from China early in their lives (Adoptee; mean age of adoption = 10.29 months). Participants listened to ten Mandarin sentences spoken by four male native Mandarin speakers and learned to identify talkers over three blocks. While they were performing the task, their brain scans were acquired using structural and functional magnetic resonance imaging (fMRI). All participant groups learned to identify talkers more accurately by the last block of the study compared to the first block, and the results showed a clear language familiarity effect such that the Mandarin group identified Mandarin-speaking voices significantly more accurately than the French group. Interestingly, the Adoptee group was significantly less accurate than the Mandarin group in the second block, and was significantly more accurate than the French group in the third block, suggesting a slower trajectory of voice learning relative to the Mandarin group and a subtle advantage relative to the French group. Univariate analysis of the fMRI data showed a general increase in the activity of auditory, speech related brain regions including bilateral superior temporal regions when listeners are identifying voices, without significant group differences. To further investigate how the voices are represented in the brain, we ran a representational similarity

analysis (RSA) by computing the representational dissimilarity matrices (RDMs) of the brain activity patterns and comparing them to talker model RDMs. Results from RSA showed that talker identity was most robustly represented in the Mandarin group among the three groups across the auditory speech associated brain regions bilaterally, and talker representation in the Adoptee group fell between the Mandarin and French groups. Multivariate analysis of our fMRI data revealed that listeners' language experience defined by their native language fundamentally shapes how talkers' voices are represented in the brain depending on the language of the talker. Moreover, this study provides us with a unique insight into how trace memory of birth language may impact international adoptees' ability to identify talkers in that language.

A79 - Acoustic degradation of speech through time compression and background noise independently affects content memory and neural tracking of speech

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The growing use of online education platforms offers students greater convenience and flexibility to access knowledge and content remotely. However, this also means students often attempt to learn in environments that are less acoustically controlled compared to live lectures. For example, students often prefer to watch recorded lectures using accelerated playback speeds and often in places where other irrelevant noise is present. While listeners can rapidly adapt to acoustically distorted speech signals like time-compressed speech or speech in noise, memory retention of the speech content declines with higher time-compression rate, especially in adverse listening conditions. However, the neural bases of the content memory detriment from acoustic degradation through accelerated speech and/or background noise remains unclear—that is, whether the memory detriment is due to the brain's inability to track speech signals during encoding. Here, we examined how speech distortions from time-compression influence neural tracking of speech, and whether the presence of background noise exacerbates this effect. We recorded and modeled the electroencephalogram (EEG) of 28 participants who listened to six recorded audio lectures at varying time-compression rates (1.0x, 1.5x, 2.0x) and background noise levels (quiet vs. babble noise at +10 dB SNR). We assessed participants' ability to learn and retain the spoken content based on lecture-specific content-knowledge quizzes administered immediately following each lecture. To determine neural tracking of speech, we used a backward modeling approach with the speech acoustic feature (i.e., speech envelope onsets). Behaviorally, listeners' memory of the lecture content was significantly worse with higher time-compression and in the presence of background noise. The fidelity of the neural representation of the speech signal, indexed by speech envelope reconstruction accuracy, was relatively unaffected by the time-compression rate, but was significantly lower when background noise was present. In addition, the strength of neural tracking, assessed through the amplitudes of temporal response function (TRF) peaks, was significantly reduced with background noise, as reflected in attenuation of early TRF

peaks (P1 and N1). In contrast, speech neural tracking was enhanced with higher time-compression rates, particularly reflected in the later (N1 and P2) TRF peaks. These findings suggest that while background noise can disrupt early stages of speech encoding, potentially due to masking acoustic features of speech, the brain can robustly track faster rates of speech, possibly by engaging top-down processes related to attention. Overall, these findings indicate that although both time-compression and background noise degrade the speech signal, they can independently create the bottleneck at different stages of speech processing, which can ultimately impair content memory.

A80 - Low-frequency Cortical Activity Reflects Context-dependent Parsing of Word Sequences

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During speech listening, it has been hypothesized that the brain builds representations of large linguistic structures such as sentences, which are tracked by neural activity entrained to the rhythm of these structures. Alternatively, it has been proposed that the brain may only encode words, and neural activity supposedly tracking structures may be confounded by the predictability or syntactic properties of individual words. Here, to disentangle the neural responses to sentences and words, we design word sequences that are parsed into different sentences in different contexts. By analyzing neural activity recorded by magnetoencephalography, we find that low-frequency neural activity strongly depends on context – the difference between MEG responses to the same word sequence in two contexts yields a low-frequency signal, most strongly generated in the superior temporal gyrus, which precisely tracks sentences. The predictability and syntactic properties of words can partly explain the neural response in each context but cannot explain the difference between contexts. In summary, low-frequency neural activity encodes sentences and can reliably reflect how same-word sequences are parsed in different contexts.

A81 Sandbox Series - Structural priming in comprehension with RPVP

Julia Cataldo¹, Amilleah Rodriguez¹, Liina Pykkänen¹; ¹New York University

The neural representation of syntax remains debated (Friederici, 2011; Matchin and Hickok, 2020; Fedorenko et al., 2020; Matar et al., 2021). This study uses MEG and a structural priming paradigm to test whether syntactic structure persists as a mental representation after exposure to a grammatical expression. Structural priming effects are well-documented in language production (Mahowald et al., 2016) but are less consistently observed in comprehension (Toohey & Traxler, 2010), possibly due to the more passive nature of comprehension (van Lieburg et al., 2023). Here we explore another potential explanation for the asymmetry: the serial nature of sentence processing may lessen the synchronicity of the activation of a syntactic tree representation, and consequently its availability as a primed

representation in a priming paradigm. This would happen because in serial presentation, more trees are likely to be considered by the parser, lessening the strength of the “right” tree as the prime representation. We hypothesize that removing serial presentation via the rapid parallel visual presentation (RPVP) method might lessen syntactic ambiguity, allowing a more robust syntactic representation to persist. Thus, under the priming paradigm, we predict that residual activation from a previously processed structure should help the recognition of the same syntactic structure in a subsequent sentence. However, if parallel presentation does not alter the fundamental nature of syntactic processing, it may not yield reliable syntactic priming in comprehension—only lexical priming, which we also manipulated. To test this, we eliminate the serial unfolding of language by employing RPVP (Wen et al., 2021; Snell & Grainger, 2017) in combination with structural priming. The two syntactic structures used were Det-Adj-Noun sequences such as ‘the green color’ and Det-Noun-Noun sequences such as ‘the color green.’ They were entered into a 2×2 factorial design manipulating Syntactic Structure (Same/Different), Lexical Overlap (Same/Different words between prime and target) and Compositionality (Phrase/List). Color lists such as ‘tan green black’ were used as noncombinatory controls. Participants are presented with two strings of words, a prime and a target, flashed onscreen for 300ms each, with an SOA of 800ms. Their task is to decide whether the strings are the same. Pure structural priming in the absence of lexical overlap should manifest as reduced activation for a target with a shared syntactic structure to the prime, when compared to a target that differs from the prime in both syntactic structure and lexical material. Alternatively, in the matching task, shared syntactic structure in the absence of lexical overlap could also manifest as an inhibitory effect, delaying no-responses and increasing neural signals. The list condition is used to assess whether effects of different syntactic structures simply reflect swapped orders of words. MEG data collection for this study is ongoing and will be completed by the time of the annual meeting.

A82 Sandbox Series - An MEG Investigation of Adjective Order Preferences as a Syntactic Constraint in English

Boxuan Li¹, Amilleah Rodriguez¹, Liina Pykkänen¹; ¹New York University

When multiple adjectives are used in a noun phrase, as in beautiful blue dress or large brown bag, their relative order tends to follow a consistent pattern across speakers. This pattern, known as adjective ordering preferences, reflects a shared sense of which adjectives should come first. Linguists have argued that these preferences arise not from surface-level habits but from an underlying syntactic structure. According to this view, different adjective types, such as size, color, and material, occupy distinct syntactic positions within the noun phrase, forming a fixed hierarchical order (Cinque, 1994; Scott, 2002). For example, we prefer big red ball over red big ball because “big,” as a size adjective, appears earlier in the syntactic structure than “red,” a color adjective. This syntactic account contrasts with alternative explanations based on semantics (Scontras et al., 2017). If adjective order preferences are syntactic in nature, then violating them should produce behavioral and neural effects like those elicited by

uncontroversial syntactic violations, such as violations of phrase structure. In this study, we tested this prediction using behavioral and MEG measures, asking whether the brain treats adjective order violations as genuine syntactic violations. Our data collection is ongoing and will be completed before the annual meeting. We designed three combinatory test conditions and two non-combinatory control conditions. Each test condition consists of a noun phrase composed of two adjectives and a noun, while in the control conditions, a list of three plural nouns is presented. The test conditions were: (1) Right order: adjective phrases that followed canonical English ordering preferences; (2) Wrong order: adjective phrases that violated the preferences by reversing the two adjectives (e.g., red big ball) and (3) Phrase structure violation: phrases where the noun appeared ungrammatically between the adjectives (e.g., big ball red). The control conditions were: (1) Related list: three semantically related plural nouns in a list (e.g., cats dogs rabbits); (2) Unrelated list: three unrelated plural nouns in a list (e.g., desks clouds apples). In a Rapid Parallel Visual Presentation (RPVP) paradigm, noun phrases and word lists are presented for 300 ms and followed by a 500 ms blank screen, creating a total of 800 ms of processing time. This was then followed by a task stimulus, which either matched or mismatched the first stimulus, with the participant's task being to indicate whether the two stimuli were identical. We length matched the test stimuli and the following task stimuli. In mismatch trials, one word was replaced in the task stimuli with a same-length distractor. We measured reaction time and accuracy as behavioral indices and track neural responses with MEG, with the first test stimulus being the target of MEG analysis. If adjective order violations are processed similarly to phrase structure violations, we expect similar behavioral and neural responses for the wrong-order and phrase-structure violation conditions. However, if adjective order violations are perceived as grammatically correct, their responses should resemble those of the right-order condition in the earliest stages of structure perception (Fallon & Pykkänen, 2024; Flower & Pykkänen, 2024).

A83 - Intracranial signatures of syntax in the absence of conceptual semantics are isolated from non-linguistic recursive representations in frontotemporal language sites

Elliot Murphy¹, Oscar Woolnough², Nitin Tandon³; ¹University of Texas Health Science Center

How the human brain constructs syntactic structures remains perhaps the most challenging topic in the neuroscience of language. We present an intracranial investigation of the spatiotemporal dynamics of basic syntactic structure processing in a cohort of 23 epilepsy patients. Data were acquired from subdural grid electrodes or stereotactically placed depth electrodes (sEEG). We had generous electrode coverage over frontotemporal language sites, in addition to parietal and ventrotemporal sites. Three patients had sEEG probes in thalamus (pulvinar, anterior nucleus, centromedian nucleus). Four patients were subject to an awake intraoperative surgery and conducted the task in the OR. We utilized a novel phrase reading paradigm involving Function/Content word pairs to manipulate conceptual content. We mixed combinations of these words, followed by a third phrase-completing word to remove wrap-up effects, analyzing effects at the onset of the structure-marking second word. Patients were instructed to engage metalinguistic judgements concerning whether the

phrase was acceptable (2AFC). Stimuli were presented in RSVP (500ms per word). 50% of trials included a grammatical or semantic violation, either at the second or third word. Behavioral performance was high (>95%) and only correct trials were analyzed. We contrasted grammatical Function-Function trials ('to the car') with ungrammatical ('they the car') and asemantic ('ti the car') trials to focus on logico-semantic and syntactic information. We also contrasted phrases with and without conceptual content. After isolating structure-sensitive electrodes in high gamma power (70-150Hz) (>10% amplitude increase from baseline, then a two-sided paired t-test: alpha-level 0.01), we applied a more stringent test by isolating electrodes that were also sensitive to the contrast between Content-Function ('swim the ocean') versus unacceptable Function-Function trials. We isolated sites in left posterior temporal cortex and inferior frontal cortex that exhibited increased high gamma activity initiating between the 200-400ms window after the onset of the second word for grammatical structures, with effects lasting around 200ms. Greater activity for unacceptable trials was found in parietal cortex. A number of ventrotemporal sites were sensitive to semantic but not syntactic composition. We also discovered thalamocortical low-frequency phase-locking during the composition of phrase structure. Next, in three of these patients we used a separate paradigm to isolate visual recursive processing using a series of increasingly complex geometric shapes via RSVP that either violated or adhered to a recursive rule at the final shape. We used this to determine if the syntax-sensitive electrodes were also recruited for non-linguistic hierarchical structure. We discovered that most of the cortical sites sensitive to visual recursion were immediately neighboring but still distinct from the linguistic sites in the temporal lobe, but in frontal cortex there was a greater degree of overlap. These results indicate the rapid sensitivity of frontotemporal cortex to minimal syntactic structure building in the absence of conceptual semantics, with a potential role for thalamocortical control. This research thus provides neurobiologically plausible signatures of natural language syntax recoverable from isolated fragments of grammatical structure, helping to mitigate for common confounds (such as working memory, world knowledge and situation model construction) found in sentence-level and naturalistic paradigms.

A84 Sandbox Series - Untangling musical and linguistic cognition using machine learning on low-resolution EEG data

Samantha Wray¹, Lily Arrom¹; ¹Dartmouth College

Music and language are universal, with no known human communities lacking either. Cognition of both stems from a shared foundation of pattern recognition processes and utilizes processing of many of the same acoustic features, such as pitch, prosody, timing, but research also shows resources for processing them are ultimately separable, with distinct neural responses for unexpected or syntactically invalid items in both music and language (Patel 2003, Koelsch et al. 2005). However, like so much of psycholinguistic research, existing research can be limited in its scope to WEIRD societies (Bylund 2022), missing structurally more complex musical systems or rare practices such musical speech surrogacy. The current project aims to validate usage of a high-portability, low-resolution, commercial-grade EEG system – a 14 sensor EEG system (Emotiv Epoc X) – well-suited to field sites that allow the study

of both language and music outside of lab settings to expand the scope of current research. While previous work has established feasibility of high-portability EEG systems for coarse-grained sensory processing (Williams et al 2020), the current work expands this into finer-grain domains. Crucially, EEG recordings – especially from high-portability low-resolution 14 sensor systems – are plagued by a poor signal-to-noise ratio, even more so than those present in higher resolution systems. Computational approaches may address this weakness. N=25 (at time of submission, half of projected N) right-handed participants (age M=20.5 SD=2) read sentences presented in rapid serial visual presentation while a tonal sequence played simultaneously. The sentences varied across three conditions: grammatical, semantically implausible, and syntactically ungrammatical. Tonal sequences varied across four: regular tonic sequences and music-syntactically irregular final notes (Neapolitan), with both having the possibility of an instrument change partway through (stimuli structure largely following Koelsch et al. 2005). Two tasks ensured participant attention: an occasional grammaticality judgement, and monitoring for the instrument change. A simple ERP analysis with data epoched from -100 ms prior to the onset of the last tone/word and to 700 ms post onset and bandpass filtered from 0.1 to 30 Hz (processing implemented in EEGLab (Delorme & Makeig 2004)) showed separable components for semantic and syntactic incongruencies as well as irregular tone sequences, with no visible effect of instrument change, but with appreciable cross-subject variation in component time course and polarity. Work in progress focuses on comparing multiple machine learning approaches with the traditional ERP analysis to boost the signal and reduce noise. This includes comparing decoding algorithms that have seen success with EEG data before, including convolutional neural networks (Schirmer et al. 2017, Song et al. 2022) and support vector machines (Saeidi et al. 2021), which are investigated alongside cebra.ai (Schneider & Mathis 2023) which uses self-supervised learning to create embeddings and map neural space to decode neural activity. From the current work we aim to learn how to best analyze data from low-signal high-noise equipment that may be well-suited to field sites that allow us to study and document linguistic and musical practices outside of lab settings and address data sparsity in commercial systems.

Poster Session B

Friday, September 12, 4:30 - 6:00 pm, Field House

B1 - A language network in the individualized functional connectomes of over 1,000 human brains doing arbitrary tasks

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A century and a half of neuroscience has yielded many divergent theories of the neurobiology of language [1–10]. Two factors that likely contribute to this situation include (a) conceptual disagreement about language and its component processes, and (b) intrinsic inter-individual variability in the topography of language areas. Recent functional magnetic resonance imaging (fMRI) studies of small numbers of intensively scanned individuals have argued that a language-selective brain network emerges from individualized functional connectomics (iFC) in

task-free or task-regressed activation timecourses [11–13]. We tested this hypothesis at scale and evaluated its practical utility for task-agnostic language localization: we applied iFC to the entire history of scanning in the Fedorenko lab: 1,957 (fMRI) scanning sessions (1,199 unique brains), each consisting of diverse tasks. We developed a data-driven network parcellation procedure for arbitrary fMRI data. In brief, within each scanning session, irrespective of task, we used activity correlations between brain regions to compute probabilistic assignments of voxels to putative networks. We then assigned interpretable labels to the networks based on topographic similarity to reference network atlases defined by prior work, including a language network [12,14]. Finally, we studied the functional properties of these networks by comparing their topography to diverse task contrasts within the same individuals across domains, including language, theory of mind, executive functions, and high-level visual processing. To ensure data independence, a critical language localizer task contrasting sentences with nonword lists (S-N) [15] was held out from parcellation. We found that our iFC-derived language network (LangFC) replicated prior task-based claims about the existence and functional properties of an integrated language network [9]. LangFC was similar in topography to the reference atlas for the language network (spatial Fisher correlation or $z(r)=0.55\pm0.002\text{SEM}$) and highly selective for language, with strong responses to linguistic tasks (S-N: $t=2.42\pm0.03\text{SEM}$) and weak/negative responses to nonlinguistic tasks (e.g., hard vs. easy spatial working memory: $t=-0.51\pm0.02\text{SEM}$). LangFC dissociated spatially and functionally from nearby networks (e.g., frontoparietal network A, default network B, and the auditory network) and was more stable within participants across sessions ($z(r)=0.80\pm0.01\text{SEM}$), than between participants ($z(r)=0.41\pm0.0001\text{SEM}$), indicating reliable inter-individual variability in structure-function tethering for language. Further analyses showed that LangFC was robust to task state, identifiable from only a few minutes of fMRI data, and successful as a drop-in replacement for task-based localization in reanalyses of a prior experiment [16]. We conclude that iFC reveals a left-lateralized frontotemporal network that is more stable within individuals than between them, robust to task state, and selective for language. These results support the hypothesis that this network is a key structure in the functional organization of the adult brain and show that it can be recovered retrospectively from arbitrary imaging data even without localizer tasks, with implications for neuroscience, neurosurgery, and neural engineering. 1. Geschwind (1970) 2. Hickok... (2007) 3. Hagoort (2005) 4. Friederici (2017) 5. Bornkessel-Schlesewsky... (2013) 6. Matchin... (2020) 7. Pallier... (2011) 8. Brennan (2012) 9. Fedorenko... (2024) 10. Aliko... (2023) 11. Braga... (2020) 12. Du... (2024) 13. Salvo... (2024) 14. Lipkin... (2022) 15. Fedorenko... (2010) 16. Shain... (2024)

B2 - How well do language models describe the brain?: A robust reanalysis of six fMRI datasets

James Fodor¹; ¹University of Melbourne

The rise of large language models (LLMs) has led to extensive interest in their potential value as cognitive models of how the brain represents language. In the past decade, dozens of studies have investigated this question using fMRI of participants reading or listening to linguistic stimuli. The resulting

patterns of brain activity are typically compared to embeddings derived from LLMs and other vector-based semantics models. Most studies use an encoding paradigm, in which a regression model is trained for each voxel to predict brain activity using model embeddings. Many such studies have found robust correlations between brain activations and representations derived from LLMs (Arana et al., 2023; Hale et al., 2021; Karamolegkou, et al., 2023; Oota, Gupta, et al., 2023). However, several limitations hinder the interpretation of these results. The first is the substantial methodological variability across studies makes it difficult to compare findings and assess whether certain LLMs consistently match brain activity better than others. The second is the reliance on voxelwise encoding models, which involve fitting many regression parameters for each voxel, and have recently been shown to be susceptible to overfitting due partly to insufficiently controlling for autocorrelation of the BOLD signal (Hadidi et al. 2025). To overcome these limitations, we use a consistent framework to reanalyse six fMRI datasets with a total of 74 participants, covering a range of stimuli including written sentences (Pereira, et al., 2018, Anderson et al., 2017), audio narratives (Y. Zhang et al., 2020, Bhattasali et al. 2020), and written stories (Wehbe, et al., 2014). To reduce the risk of overfitting due to autocorrelation, we segment narrative stimuli into individual sentences and fit a general linear regression model in the same way as studies using discrete sentences. We then train a separate voxelwise regression model using cross-validation over stimuli for each participant. To further assess the robustness of these results to the chosen technique, we also performed representational similarity analysis (RSA), in which we compare the similarity structure of brain representations to the similarity structure of the model embeddings. Overall, we find significant positive correlations between every computational model and each fMRI dataset using both voxelwise encoding and RSA methods. We also find that while LLMs typically outperform older models based on static word embeddings, the magnitude of this effect is modest and somewhat inconsistent across datasets. Our results constitute the first systematic comparison between voxelwise encoding and RSA, and show that these techniques generally yield similar results in terms of the relative fit of different models. Our findings also highlight the importance of controlling for confounds like autocorrelation when evaluating semantic models against BOLD data, and cast doubt on previous claims that LLMs match brain representations substantially better than older static embedding models.

B3 - Investigating the neural correlates of nonlinguistic cognitive control in left hemisphere stroke survivors

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While studies of left hemisphere stroke survivors tend to focus on deficits in linguistic abilities and their underlying processes following impairment, some studies have also suggested deficits in domain-general executive functions (e.g. Dekhtyar et al., 2020, Farooqi-Shah et al., 2018). In the current study we

examined the relationship between cognitive control abilities and integrity of white matter tracts of interest in left hemisphere stroke survivors. We assessed nonlinguistic cognitive control abilities in 98 left hemisphere stroke survivors through their performance in a Simon task. In this task participants were presented with either a red or blue flash in one of two side-by-side squares at the top of a touchscreen laptop. Below the squares was a response button with a red square on one side and a blue square on the other. In a given trial, participants were asked to indicate the color of the flash by selecting the appropriate colored square as quickly as possible while ignoring the location of the stimulus. Diffusion weighted images were collected in 67 of these participants. We used DSI Studio to generate tractograms and apply the DTI matrix. Auto-segmentation was used to obtain the tracts of interest (arcuate fasciculus, frontal aslant tract, superior longitudinal fasciculus, uncinate fasciculus, and corticostriatal connections) and their corresponding measures of white matter integrity (FA and MD). Data preprocessing is ongoing and has been completed for 41 of the 67 participants with available diffusion weighted images. When considering our whole sample ($n = 98$), we observe significant effects of Condition on both Accuracy (Wald $\chi^2(1) = 26.92$, $p < .001$) and Reaction Times (Wald $\chi^2(1) = 102.36$, $p < .001$). Participants were less accurate ($\beta_{\text{raw}} = -.394$, $SE = .076$, $z = -5.19$, $p < .001$) and slower ($\beta_{\text{raw}} = .015$, $SE = .002$, $t = 10.12$, $p < .001$) in their responses to Incongruent relative to Congruent trials. However, when restricting our analyses ($n = 41$), preliminary findings show that only the significant effect of Condition on Reaction Times remains (Wald $\chi^2(1) = 28.42$, $p < .001$). Participants were slower in their responses to Incongruent relative to Congruent trials ($\beta_{\text{raw}} = .013$, $SE = .002$, $t = 5.33$, $p < .001$). A partial correlation analysis, controlling for effects of lesion volume and aphasia severity, revealed a significant positive association between structural integrity of the left uncinate fasciculus (UF) and the effect of condition on reaction times ($r(38) = .505$, $p = .015$). Structural integrity of the UF has previously been implicated in the mediation of semantic control during word comprehension (Harvey et al., 2013). Greater structural integrity of the right UF has also been associated with better performance in executive functions (Sasson et al., 2013). The preliminary evidence presented here suggests that the left UF is not only engaged in semantic control but also in domain-general cognitive control, as is involved in Simon task performance.

B4 Sandbox Series - When Meaning Shifts and Language Switches: Investigating the Role of Domain-General Inhibitory Control in Bilingual Prediction Errors

Yifei Gong¹, Zachary Maher¹, Janet van Hell¹; ¹The Pennsylvania State University

During language processing, the human brain continuously generates predictions to facilitate efficient comprehension. When incoming input violates these predictions, the brain must rapidly adapt. For bilingual individuals, this process is further complicated by the co-activation of multiple language systems, making prediction errors—such as those triggered by an unexpected twist in meaning or a sudden switch in language—particularly challenging to resolve. While domain-general inhibitory (motor) control has been implicated in resolving semantic violations in monolinguals, its role in reconciling prediction errors during bilingual comprehension remains poorly

understood. Here, we propose a study that integrates a stop-signal task with either a semantic violation or a language-switching paradigm to investigate the neurocognitive mechanisms underlying prediction error resolution during the processing of semantic violations and language switches. This novel dual-task design allows us to test whether domain-general inhibitory processes—typically associated with motoric response inhibition—are engaged in the resolution of prediction errors during bilingual comprehension, and whether semantic violation and language switching recruit overlapping cognitive resources. We combine behavioral measures, electroencephalography (EEG), and multivariate EEG decoding analysis to characterize potentially shared cognitive and neural dynamics across domains. Ultimately, the proposed study aims to advance our understanding of the neural and cognitive mechanisms that support flexible bilingual language processing under conditions of unpredictability.

B5 - Neural correlates of conflict adaptation in word production

Nazbanou Nozari¹, Nikhil Lakhan², Michael Freund³; ¹Indiana University, ²University of Pennsylvania, ³Brown University

Introduction. Overriding a prepotent but incorrect response requires cognitive control. One way to identify the neural correlates of such control is by comparing high-conflict and low-conflict conditions. However, a more precise method is to study dynamic changes in control as a function of exposure to prior conflict. This can be captured by studying the congruency sequence effect (CSE) or conflict adaptation. CSE refers to the easier resolution of conflict in high-conflict trials if preceded by another high-conflict vs. a low-conflict trial. New theories of cognitive control attribute CSE to learning. This implies that CSE is long-lasting and survives interference from unrelated tasks. To test this prediction, we interleaved the picture-word interference (PWI) paradigm with another task that involved different representations and examined the neural correlates of CSE in language production. **Methods.** Twenty-five native speakers of English completed a picture-word interference (PWI) paradigm, interleaved with trials from a non-linguistic visuospatial task, in a 3T Siemens MRI scanner. PWI trials were either C (congruent; low-conflict) or I (incongruent; high-conflict). Congruent trials paired the picture with its correct name (e.g., apple/apple). Incongruent trials paired the picture with a semantically related word (e.g., apple/pear). The preceding PWI trial was also either congruent or incongruent, denoted by small letters c or I, creating four conditions: cC, iC, cI, and iI. Behavioral and neuroimaging data were analyzed from the PWI task. **Results.** Behaviorally, the typical CSE pattern was obtained, with an interaction between current and preceding congruency, despite the intervening task, pointing to a long-lasting effect. Neurally, the comparison of current incongruent and congruent trials revealed increased activation in frontal and temporal regions, as expected. The CSE analysis revealed greater activity in cI vs. iI trials in left dorsal anterior cingulate cortex (dACC), bilateral inferior frontal gyri (pars opercularis) and insula, bilateral dorsal prefrontal cortices, and left middle and inferior temporal gyri. **Conclusions.** The neural correlates of conflict adaptation in word production are compatible with conflict models that propose domain-specific conflict among lexical items (in the left posterior middle and inferior temporal gyri) is monitored by central medial frontal regions (e.g., dACC),

which recruit and implement control in conjunction with the lateral (inferior and dorsal) prefrontal regions. The two new contributions of this study are that (a) these regions dynamically modulate control over word production, and (b) in line with the prediction of the learning account of control, CSE is long-lasting and resilient against the insertion of irrelevant tasks and representations.

B6 Sandbox Series - Characterizing Semantic Verbal Fluency Tasks using Behavior, Computational Models and fMRI

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In a semantic verbal fluency task individuals are asked to name as many exemplars of a given category (e.g. "animals") as possible. Beyond the number of produced words, the task can be analyzed regarding the quality or creativity of responses - for example if a speaker produces more original words or is able to switch between distant words. Semantic distance can be quantified using computational models based on word embeddings. Furthermore, behavioral and computational data can be related to brain activity, with the goal of inferring which cognitive processes are engaged during the task. Combining these different data types can allow a deeper understanding of how verbal fluency performance depends on the semantic category used and what role creative thinking plays. One hundred participants performed a behavioral version of the verbal fluency task with twenty-four semantic categories, along with the Alternate Uses Task (AUT) as a measure of creativity. We analyzed the number of words produced for each category and examined their correlation with the AUT. Word embeddings (fasttext) were used to represent the semantic categories and their distance to each other. A sample of ten participants performed the verbal fluency tasks while undergoing functional MRI. Voxel-wise analyses were used to relate activity strength to the number of words produced. In addition, Representational Similarity Analysis (RSA) was used to compare the similarity of brain activity patterns to the word embeddings. The behavioral data allowed to order the twenty-four categories regarding the average number of words produced. Speakers produced the highest number of words for the categories "first names" and "animals" and the lowest numbers for "amphibians" and "mountains". Correlations with the AUT revealed highest correlations for the categories "fabrics" and "vessels", while correlations with "precious stones" and "amphibians" were the lowest. Word embeddings allowed to group the categories into intuitive patterns, e.g. the category "body parts" being close to "clothes" which in turn is close to the category "fabrics". The fMRI data showed that the fluency tasks consistently activate a left-lateralized perisylvian language network, including Broca's area. Correlations with the behavioral data showed that the activity of the fronto-parietal multiple demand network increased with the number of words produced. The similarity of whole-brain activity patterns revealed similar groupings to the ones found in the word embeddings, with the RSA showing a correlation of $r=0.28$ between model and neural data. The results highlight how behavioral and neural performance in verbal fluency tasks

varies depending on the semantic category used. The fMRI data showed that activity in the multiple demand network is closely linked to the number of words produced. A next step will be to analyze how brain activity differs for categories depending on their relation to creativity measures, such as the AUT. Regarding the RSA, we plan a searchlight analysis to identify the brain regions where word embeddings and brain activity are most closely related. This will provide a more precise characterization of how verbal fluency tasks differ in their cognitive and neural underpinnings depending on the semantic category used.

B7 - Neural Interaction of Reading Words and Spatial Attention

Lauren E. Magliocco¹, Sage G. Placer¹, Sofia E. Ortega¹, Katherine J. Midgley¹, George R. Mangun², Tamara Y. Swaab², Karen Emmorey¹, Phillip J. Holcomb¹; ¹San Diego State University, ²University of California Davis

Previous research has found that visual-spatial selective attention is modulated by a host of neural mechanisms that unfold over the course of stimulus processing. The P1 event-related potential (ERP) is characterized by a positive deflection occurring around 100-130 ms and is the earliest brainwave that has been consistently shown to be sensitive to spatial attention (the ability to focus on a particular region in space while ignoring others). More specifically, the amplitude of the P1 is larger to stimuli when they occur at an attended as opposed to an unattended location. However, there is limited research on how the P1 to visually presented words is modulated by selective spatial attention. Another ERP component, the N400, has also been shown to be sensitive to attention - e.g. it is usually larger when words are attended – although only a few studies have examined the N400 when spatial attention was manipulated. The current ERP study used a blocked cueing paradigm with four-letter English words and symbol strings, to explore how the P1 and N400 differ as a function of visual spatial attention. Data were collected from a sample of right-handed, native English speakers. The experiment contained 900 trials consisting of 240 words (e.g., desk – referred to as standards) and 60 four-character symbol strings (e.g., &*!#, referred to as targets) each presented three times. The location of stimuli was rapidly alternated (150 ms duration, average ISI = 275 ms, range 75-475 ms) across three left-to-right screen locations (5.15° left, 0° center and 5.15° right) each 4.58° above a central fixation cross which remained on screen throughout the experiment. Prior to each of the 12 blocks of trials, participants were randomly cued to direct attention to one of the three locations (i.e., left, center, right) while maintaining fixation on the central cross. The cued location was changed prior to each block. The task was to press a button whenever a symbol string target occurred at the cued location but to ignore all stimuli at the other locations. This design allowed us to compare ERPs to the so-called “standard” (word) stimuli, presented in the same location when attended vs. unattended. Overall, we found larger P1 and N400 amplitudes to attended words compared to unattended words, reinforcing the notion that spatial selective attention modulates both the earliest perceptual as well as later cognitive processing of language stimuli. Furthermore, we found that for the P1 this effect of attention was greater over left occipital sites for words presented in the right visual field which is consistent with a very early sensitivity to either the superior language processing abilities of the left hemisphere or the right visual field advantage

observed in readers of left to right languages. The latter possibility was bolstered by the finding of a larger N400 attention effect for RVF words but no difference in its lateral distribution.

B8 Sandbox Series - Speech and language markers of cognitive decline and neurodegeneration: Generalizability across languages

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Introduction: Recent work has demonstrated the potential of automatically extracted speech and language features for the early detection and monitoring of neurodegenerative conditions such as Alzheimer's disease. But within this rapidly growing field, the predominance of English has sparked calls for global equity in the development of clinical language technology tools and “timely actions to counter a looming source of inequity in behavioral neurology” (García et al., 2023). To address this lack of linguistic diversity in research on speech and language biomarkers of neurodegeneration, we bring together data from multiple studies where language samples were collected from participants with Mild Cognitive Impairment (MCI) and Alzheimer's disease (amyloid-positivity confirmed) across three languages: Icelandic, Korean and English. The main goal is to investigate language-specific and potentially language-universal manifestations of neurodegeneration and assess the generalizability of clinical speech and language features already identified for English to less-studied languages, both related (Icelandic) and unrelated (Korean) to English. Methods: We automatically extract acoustic and text-based features from language samples (oral picture descriptions of line drawings) obtained from speakers of Icelandic (n = 77), Korean (n = 106) and English (n = 174). Participants had a diagnosis of MCI (n = 88) or mild dementia (n = 69) due to Alzheimer's disease (amyloid-positivity confirmed) and healthy controls (n = 210) were also tested. Features were selected based on previous work (Petti et al. 2020, Cho et al. 2021), the availability/accuracy of relevant NLP tools and comparability across the three languages (using the Universal Dependencies framework for POS-tags). The acoustic pipeline consists of speech activity detection and pitch-tracking with in-house tools, the pya Python package and Praat and we use language-specific POS-taggers and UPOS conversion for the text-based features. For each feature, we model the difference between cohorts (MCI, AD and controls) within and across languages in R. Results: Feature extraction and data analysis are currently in progress. We expect more generalizability across languages for features that can be argued to be in part independent of varying typological characteristics of linguistic structure, e.g. average length of speech segments and pause rate/length. This is hypothesized to contrast with variables such as POS-category metrics where e.g. pronoun rate has been shown to be increased in English speakers with Alzheimer's disease but the opposite might be true for a language that allows for more extensive argument-

drop (Korean) as Bose et al. 2021 show for Bengali. We also explore the potential of more language-specific manifestations of neurodegeneration, with preliminary results in our data pointing to an increased rate of nominative in Icelandic-speaking participants with Alzheimer's disease for example. Conclusion: The project highlights the importance of increasing linguistic diversity and linguistically informed research in the context of speech and language markers of neurodegeneration. Additionally, we argue for the value of such work to advance our understanding of the neurobiological basis for language: The language-specific and potentially language-universal manifestations of neurodegeneration and Alzheimer's pathology provide insights into the neural underpinnings of the memory-language interface and the interplay of language and cognition more broadly.

B9 - Language improvement following a Transcranial Magnetic Stimulation protocol in chronic post-stroke aphasia: evidence from two case studies

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Transcranial magnetic stimulation (TMS) has been increasingly explored as a non-invasive approach for neurorehabilitation in different neurological and psychiatric conditions. Protocols specific for post-stroke aphasia have been published, but its effectiveness remains under investigation. In this work, we report two case studies of chronic stroke patients with severe aphasia (CR, a 69-year-old female and GC, a 49-year-old male) who underwent a TMS protocol adapted from the Northstar-CA model (Zumbansen et al., 2022). The intervention consisted of daily sessions of 1 Hz stimulation of the contralesional pars triangularis (inferior frontal gyrus), delivering 900 pulses over 15 minutes for 15 consecutive days, immediately followed by 45-minute speech-language therapy sessions. A comprehensive language assessment was conducted before (day 1) and after (day 15) the protocol, including 11 tasks covering semantic, phonological, and syntactic processing in both oral and written modalities. After the intervention, both patients showed improvements in several tasks, measured as the difference in weighted scores at post-TMS compared to pre-TMS testing, particularly in writing (GC Δ post-pre = 1.0; CR Δ post-pre = 1.0), reading of words (GC Δ post-pre = 0.16; CR Δ post-pre = 0.5) and pseudowords (CR Δ post-pre = 0.125), repetition of words (GC Δ post-pre = 0.21; CR Δ post-pre = 0.42) and pseudowords (GC Δ post-pre = 0.07; CR Δ post-pre = 0.5), and image (visual) comprehension (GC Δ post-pre = 0.17; CR Δ post-pre = 0.67). Additional individual gains were observed, such as improved diadochokinesis and semantic verbal fluency in patient GC (diadochokinesis Δ post-pre = 0.38; semantic verbal fluency Δ post-pre = 0.5). Interviews with family members and reports from the clinical staff also indicated marked language improvements, specifically during day-to-day tasks and in perceived contrast to baseline performance. In patient CR, improvement was markedly greater during the post-TMS period than before treatment (even though these time frames were

similar and no new TMS protocols were applied), suggesting TMS protocols may confer relatively long-lasting effects whose underlying mechanisms we have yet to elucidate. These preliminary findings suggest that the combination of TMS and behavioral therapy support language recovery in chronic aphasia, although further studies are needed to evaluate the long-term maintenance of these benefits and the role of emotional and motivational factors in the rehabilitation process.

B10 - Identification of the neural network involved in naming famous people from voices: a multimodal mapping study in patients with low-grade glioma

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Proper names (PNs), particularly person names, refer to unique entities and allow humans to structure their social environment. From a psycholinguistic standpoint, common names are related to categories and are meaningful while PNs are related to individualities and lack of meaning. This unique cognitive status makes the PN retrieval especially demanding. Accordingly, brain-damaged patients often have impaired lexical retrieval of PNs. As such, many neuropsychological and neuroimaging studies have examined the brain regions implicated in accessing the lexical output of PNs. They showed the involvement of a predominantly fronto-temporal network, centered on the left anterior temporal lobe (ATL)/the temporal pole. However, only a small body of neuropsychological studies have sought to identify the underlying anatomical tracts. The most recent works have shown the central role of the left inferior longitudinal fasciculus (ILF) in naming famous people from faces, consistent with ILF's connections between the ATL and the visual associative cortex. In contrast, the left middle longitudinal fasciculus (MdLF), which also projects its fibers into the ATL and is topographically close to the auditory associative cortex, may be preferentially involved in naming people from voices. To investigate this hypothesis, sixty patients who underwent awake neurosurgery for a left low-grade glioma, were behaviorally assessed, at least six months postoperatively. The evaluation consisted in the administration of tasks requiring the naming of famous people based either on spoken or sung voices. Importantly, patients' performance was compared to that of eighty matched healthy subjects and controlled for the influence of various sociodemographic (age and education) and cognitive factors (mainly within-task control factors and common entity naming, depending on the auditory/visual modality), through several statistical models. Then, lesion-symptom mapping methods were applied, using both lesion topography and structural disconnections. At the cortical level, our results revealed that PN retrieval deficits were associated with lesions of the middle/posterior part of the ventro-temporal structures (rather than the ATL), likely due to their implication in visual-auditory integration processes. In terms of white matter connectivity, the MdLF did not appear to play an essential role. Nevertheless, the low lesion distribution in the mid-to-posterior superior temporal structures, consistent with the spatial stereotypy of low-grade gliomas, does not allow

definitive conclusions to be drawn on its involvement. Furthermore, the neuroplasticity usually induced by these tumors may have resulted in its functional compensation. Instead, the posterior part of the corpus callosum and the superficial fibers of the occipito-temporal structures were involved in lexical access to voice names in spoken condition while the ventromedial fibers of the ILF, but also the arcuate fasciculus to a lesser extent, were involved in sung condition. Interestingly, the ILF's implication in voice-based famous people naming seemed also to reflect a role in visual-auditory integration. In sum, our work advances the understanding of the cognitive and neural mechanisms underlying PN anomia, particularly within the framework of the dual pathway model of language. Although these primary results require replication, they open promising avenues for future research. Clinically, they contribute to the refinement of intraoperative mapping strategies in awake neurosurgery.

B11 - Mapping and decoding semantic representations in aphasia after stroke

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People with aphasia often report knowing what they want to say but not being able to say it. This suggests that semantic representations are relatively preserved but the mapping to lexical-phonological output is disrupted. One potential way to help people with aphasia is to predict what they want to say by decoding their semantic representations. Semantic decoding has been demonstrated in neurologically healthy participants by using naturalistic stimuli to map the concepts that are encoded in each cortical region. Given new brain responses, these semantic maps can be used to predict the concepts that the participants are thinking about. However, most neuroimaging studies in participants with aphasia have relied on controlled stimuli that lack the conceptual coverage required to map the semantic system. As a result, it is unclear how the organization of the semantic system is affected in aphasia, and whether semantic representations are sufficiently preserved to be accurately decoded. In this study, we used functional magnetic resonance imaging (fMRI) to record brain responses from two participants with stroke-induced aphasia and three neurologically healthy controls. One participant had mild-moderate aphasia predominantly affecting language production, while the other had severe expressive-receptive aphasia and motor speech impairment. All participants watched one hour of silent movies and listened to three hours of narrative stories. We separately recorded brain responses from the neurologically healthy controls while they listened to a larger set of narrative stories. We used the larger set of narrative stories to train encoding models for mapping linguistic representations and semantic decoding models for reconstructing continuous language from new brain responses. We finally transferred these models from the neurologically healthy controls to the participants with aphasia by functionally aligning their brain responses to the shared movies and stories. To assess how the functional neuroanatomy of speech-language processing is affected in aphasia, we compared prediction performance across encoding models that capture information from different linguistic levels. We found that semantically selective regions

are consistent between participants with aphasia and the neurologically healthy controls in spared cortical regions. To assess how the organization of the semantic system is affected in aphasia, we visualized the weights of a lexical semantic encoding model, which predict the concepts that are encoded in each cortical region. We found that the organization of semantic concepts is also consistent between participants with aphasia and the neurologically healthy controls in spared cortical regions. To test whether semantic representations can be decoded in people with aphasia, we applied the semantic decoders to brain responses while the participants watched new movies and listened to new stories. We found that the decoders could successfully recover the gist of the movies and stories. Together our results indicate that people with stroke-induced aphasia can have preserved semantic representations, and that the organization of these representations is consistent with that of neurologically healthy controls. These results demonstrate the potential for semantic brain-computer interfaces to improve communication in people with aphasia.

B12 - Verbal fluency and brain integrity in behavioral variant FTD

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Introduction: The behavioral-variant FTD (bvFTD) is a neurodegenerative disorder primarily characterized by progressive deterioration in personality and social behavior (Rankin et al., 2005). While language and other cognitive abilities are also affected in this population, the relevant research is scarce. A recent study on verbal fluency reported differences in performance between bvFTD individuals, healthy controls, and individuals with Primary Progressive Aphasia (PPA) (a left-hemisphere language-based neurodegenerative disorder) (Van Den Berg et al., 2024). Atrophy in bvFTD is primarily found in the frontal and temporal lobes, with greater right, compared to left, hemisphere atrophy (Krill et al., 2005). Prior research in PPA has shown associations of phonemic fluency with the volume of the left superior temporal regions (STG) and the right middle frontal gyrus (MFG), and of semantic fluency with the left inferior temporal gyrus (ITG) (Riello et al., 2022). This study aimed to investigate the contribution of these bilateral regions, as indexed with cortical thickness, in verbal fluency in bvFTD. **Methods:** Participants were 46 bvFTD Greek-speaking individuals (age=65.6). Verbal fluency was assessed using (1) Phonemic Fluency and (2) Semantic Fluency (i.e., name as many words as possible from a given category/starting from a given letter in 1-minute). Brain integrity was indexed with average cortical thickness for the bilateral STG, MFG and ITG (i.e., regions previously implicated in verbal fluency). The statistical analysis included simple linear models assessing whether (i) each region, separately for each hemisphere, is associated with verbal fluency and (ii) whether, for a given region, each hemisphere explains unique variance in verbal fluency (i.e., variance explained by one hemisphere, beyond what is accounted for by the contralateral hemisphere). **Results:** Phonemic Fluency: (i) Statistically significant effects were found for the left MFG ($p=0.042$) and the left STG ($p=0.019$). (ii) Statistically/marginally significant unique variance was also explained by these regions: left MFG ($p=0.069$), left STG

($p=0.008$). Semantic Fluency: (i) Statistically/marginally significant effects were found for the left MFG ($p=0.088$), the left STG ($p=0.044$), and the left ITG ($p=0.099$). (ii) Statistically/marginally significant unique variance was explained by all three regions (left MFG ($p=0.024$), left STG ($p=0.011$), and left ITG ($p=0.095$)) as well as the right STG ($p=0.086$). Conclusion: We showed, for the first time, a relationship between verbal fluency and brain integrity (cortical thickness), in bvFTD. Except for one region, all associations were found in the left hemisphere. Importantly, the variance explained by the left-hemisphere regions was unique (i.e., beyond what the respective right-hemisphere regions explained). Compared to previous findings in PPA, the results showed some differences in the extent and laterality of the effects. For Phonological Fluency we found an effect in the left, instead of right MFG. For Semantic Fluency, we showed more widespread left-hemisphere effects and unique variance explained by the right STG. Future analyses will investigate the effect of the laterality of atrophy on these associations. Finally, both fluency scores were associated with the MFG and STG - endpoints of the extreme capsule fasciculus, a white matter tract linked to selective lexical retrieval (Petrides et al., 2002).

B13 Sandbox Series - Effect of musical training on neural processing of pitch and rhythm in young adults with dyslexia

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The ability to create and evaluate expectations of upcoming events is a critical brain function that serves a variety of skills, including music, language, and reading. In language and reading, such predictions support rapid processing of input that must be integrated and understood quickly. In music, predictions support perception of rhythms in the context of a known time signature as well as perception of minor keys. Adolescents who self-report increased skill in sight reading music score significantly higher on passage comprehension, suggesting a possible link between prediction of upcoming notes and prediction of upcoming text. Research suggests that people with dyslexia exhibit a significant relationship between the degree of reading deficit and level of musical skill. For example, children with dyslexia exhibit deficits in both rhythm perception, beat synchronization, and in perceiving rise times (the rapid acoustic changes at the beginning of speech sounds). Given the growing body of work reporting significant relationships between music skills and reading ability, there are likely shared neural mechanisms subserving both music and reading, specifically those related to expectation. Given some recent discussion about a cerebellar deficit in dyslexia, and the cerebellum's role in expectation, the poor rhythm abilities observed in dyslexia could be due to a deficit in prediction. The present study was designed to evaluate whether musical training is associated with improved expectation for pitch and/or rhythm in those with dyslexia. Young adults with and without dyslexia completed two tasks while wearing a 256-channel high density EEG net (MagStim/EGI). The first task is a published mode perception task in which participants listen to a single line melody and will indicate whether the melody was in a major or minor key. The second is a validated rhythm perception task in which

participants listen to a rhythm and indicate whether a target beat was regular or irregular in the context of that rhythm. Following pre-processing, ERP data were analyzed for the P3a and P3b components during unexpected events compared to the expected events. While data collection and analysis are ongoing at the time of abstract submission, our current data suggest that musical training is associated with the expected P3 to the minor critical note in both groups but was surprisingly also present in nonmusicians with dyslexia. In the context of rhythm, musical training seems to have a similar influence on neural responses to unexpected beats in typical readers and those with dyslexia. Those with dyslexia did, however, exhibit increased P3 in the frontal lobe during unexpected beats while their typically reading peers did not, perhaps in support of prior evidence of frontal lobe compensation in dyslexia. Data collection is expected to conclude in early summer 2025. In addition to ANOVAs and post hoc t-tests our planned future analysis will include correlational analyses to evaluate the link between amount of musical training and the amplitude of these P3 responses. We will also evaluate functional connectivity during these tasks to evaluate potential compensatory networks in dyslexia.

B14 - Neural dynamics during morphological processing in Hebrew reading: a comparative study of dyslexic and typical readers

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Developmental dyslexia is commonly associated with deficits in phonological awareness, however, studies showing impairments also in non-linguistic tasks in these individuals suggest that the underlying deficit may be more domain general (Ullman et al., Annual Review of Psychology, 2020). Morphological processing is crucial for reading development in both dyslexic and typical readers across orthographies. Morphological processing also plays a central role in reading Hebrew, a morphologically rich language, where most words are formed by combining roots and patterns. While imaging studies show that dyslexic Hebrew readers exhibit enhanced morphological effects in the Fusiform gyrus (Bitan et al., Cortex, 2020), behavioral studies of dyslexic readers also show deficits in learning and benefiting from morphological regularities (Ben-Zion et al., Neuropsychologia, 2023; Kimel et al., Neuropsychologia, 2020). One possible explanation for these morphological deficits in readers with dyslexia, is their decreased ability to benefit from regularities in previously encountered stimuli (Ahissar, TICS, 2007; Jaffe-Dax et al., eLife, 2018). Indeed, neuroimaging studies show attenuated neural adaptation for repeating stimuli in Dyslexic readers across multiple stimulus types, including written word stimuli in the Fusiform gyrus (Perrachione et al., Neuron, 2016). The current study examined whether impaired morphological sensitivity in dyslexic readers can be explained by attenuated neural adaptation to morphologically related words. Thirty-nine Hebrew speakers (20 dyslexic, 19 typical) were scanned using fMRI in five conditions, each comprised of blocks of 6-word lists: Identical (6 repetition of the same word), Root (6 words that share a 3-consonant root), Letters (6 words sharing 3 letters which are not part of the root), Unrelated (6 unrelated words), and Symbols. While reading these lists of words, participants were asked to count words with larger fonts. The region of

interest (ROI) for our analysis was defined based on voxels showing decreased activation between the first and second halves of the blocks across all conditions. It was located in the left Fusiform gyrus and contained the Visual Word Form Area (Dehaene & Cohen, TICS, 2011). Our analysis showed a three-way interaction between condition, block-half and phonological ability. Follow-up analysis showed a positive correlation between phonological awareness and the extent of the neural adaptation in the fusiform gyrus during the morphological (root) condition. This correlation was not evident for any of the other lexical conditions. These findings suggest that readers with poor phonological abilities exhibit attenuated neural adaptation during morphological processing which implies that they may struggle to efficiently recognize and process morphemic units (like roots) that are critical for fluent reading. Moreover, this weaker attenuation to morphologically-related stimuli was independent of a formal dyslexia diagnosis. Furthermore, the presence of this correlation in the Fusiform gyrus suggests that this deficit is already in effect during early stages of orthographic processing.

B15 - Compensatory Connectome Reorganization in Children with Cochlear Implants: Insights from Naturalistic fNIRS Imaging

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Congenital hearing loss and deafness constitute a connectomic disorder characterized by disrupted cortical-cortical connections, fundamentally altering brain organization (Kral et al., 2016). Such disruptions significantly influence the development of cortical networks and can have long-term implications for language and cognitive development. Hearing intervention such as cochlear implantation initiates the reorganization of the connectome, particularly in auditory and language-related networks. However, the extent and nature of this neuroplastic reorganization and its impact on higher level cognitive domains such as multisensory integration, attention, and memory remains poorly understood. A key limitation is the lack of dynamic, network-level measurements under ecologically valid conditions that engage multiple higher-order cognitive processes simultaneously. In this study, we measured whole brain activity using functional near-infrared spectroscopy (fNIRS) in children with CIs, to investigate neural response during movie viewing. The participants included 75 children (Ages 7 – 17), of whom 50 were children with CIs (CI, mean age = 11.5 ± 2.7 years) with severe to profound congenital bilateral hearing loss, and 25 were children with typical hearing (TH, mean age = 12.1 ± 3.1 years). fNIRS data were collected using the NIRSout system (760 nm and 850 nm) with a whole-head montage consisting of 39 sources and 31 detectors, resulting in a total of 122 channels. All participants viewed the same 10-minute clip from the animated children's movie *Despicable Me*. Pairwise correlation analyses of the time series were performed between regions of interest in frontal, temporal, parietal, and occipital areas of both hemispheres. In addition, we examined connectivity for different parts of the movie clip – chosen to contain contrasting language and non-language (music, minion vocalizations) audio-visual stimulation to assess the effects of acoustic, linguistic and cognitive contrasts. Distinct intra- and

inter-hemispheric connectivity patterns differentiated the groups during language segment. TH showed strong bilateral parietal connectivity, which was weaker in CI. CI exhibited moderate bilateral frontal correlations absent in TH. Left occipital-parietal connectivity was strong in TH but absent in CI, which instead showed negative correlations between left parietal and frontal regions. Inter-hemispherically, TH displayed strong occipital-parietal and temporal-parietal connections, and negative temporal-occipital correlations, all diminished or absent in CI. CI showed unique negative parietal-frontal inter-hemispheric connectivity. During the non-speech movie segment, TH maintained strong bilateral parietal connectivity, while CI relied more on left occipital and right occipital-temporal connections, with further reduced parietal involvement. TH also showed a strong parietal-frontal negative correlation. In summary, children with typical hearing show efficient, specialized inter- and intra-hemispheric connectivity supporting multimodal speech integration. In contrast, children with CIs exhibit compensatory reorganization, characterized by reduced parietal integration, increased reliance on frontal and occipital regions, and atypical inter-hemispheric dynamics. These patterns suggest altered cortical resource allocation and increased cognitive load in children with cochlear implants. Our findings demonstrate that naturalistic movie viewing with fNIRS is a viable and informative paradigm for assessing functional brain organization in CI users. This approach holds promise for guiding evidence-based interventions aimed at optimizing speech and language outcomes.

B16 Sandbox Series - Neural dynamics of stuttered versus fluent speech

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Stuttering is a neurodevelopmental communication disorder affecting approximately 80 million individuals worldwide, characterized by involuntary disruptions in speech fluency, including sound and syllable repetitions, prolongations, and articulatory blocks [1,2]. Converging evidence links stuttering to dysfunctions in the basal ganglia-thalamocortical (BGTC) loop, a cortico-subcortical network implicated in the initiation and temporal sequencing of speech motor programs [2,3]. However, the precise neurophysiological mechanisms by which BGTC dysfunction leads to speech disfluencies remain poorly understood. Here we investigate the neural dynamics within the BGTC network during stuttered vs. fluent speech via a functional connectivity analysis of magnetoencephalography (MEG) data. While the assessment of neural dynamics using MEG is relatively straightforward, its application to stuttered speech suffers from two main issues. First, it is notoriously difficult to elicit a balanced number of stuttered and fluent trials inside the scanner to allow for meaningful comparisons between these conditions. Second, overt speech production introduces significant muscle and movement-related artifacts, which can be exacerbated during stuttered speech due to common accessory behaviors such as rapid eye blinking and lip tremors. To elicit a balanced number of stuttered and fluent speech, we will use a paradigm previously validated on both adults and children who stutter [4,5,6]. In a nutshell, PWS can predict stuttering on certain words with high accuracy (> 85%); the approach consists of interviewing PWS for words on which they anticipate stuttering and using those words to generate prompts that will

be presented during the MEG session, each prompt requiring a response containing one of the anticipated words. To mitigate the effect of speaking-related artifacts, we will use concurrent electromyography and speech audio recordings. Artifact reduction will be achieved using a combination of regression-based techniques and signal space projection methods, enabling the removal of artifacts from the MEG data arising from non-neural sources [7]. MEG data during the speech production task will be acquired from a matched sample of adults who stutter (N=30) and typically fluent controls (N=30). Diagnoses and stuttering severity will be confirmed by a speech-language pathologist using standardized clinical protocols (SSI-4). To assess the temporal dynamics within the BGTC loop during stuttered and fluent speech, we will perform source localization via beamforming to reconstruct neural activity and use phase-based measures in these key speech-related regions to characterize connectivity profiles for stuttered speech and for fluent speech in both controls and PWS. We hypothesize significantly different profiles for stuttered and fluent speech and no differences between the fluent speech of PWS and controls. The direction of putative information flow for each condition will be confirmed using Granger causality. References: 1. Stuttering . <https://www.nidcd.nih.gov/health/stuttering> ; 2. Alm, P. A. (2004), *J Commun Disord* ; 3. Chang et al., (2019), *Neuroscientist* ; 4. Jackson et al., (2019), *J Fluency Disord* ; 5. Orpella et al., (2024), *Neurobiol Lang (Camb)* ; 6. Goldfarb et al., (2023), *J Speech Lang Hear Res* ; 7. Abbasi et al., (2021), *Front Neurosci*

B17 - Complementary hemispheric lateralization of language and social processing in left-handers

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One of the oldest findings in human neuroscience is that some cognitive functions are lateralized, predominantly processed in one cerebral hemisphere or in both (Ocklenburg & Güntürkün, 2024). Recent research (Rajimehr et al., 2022) suggest a complementary hemispheric lateralization for language (typically left-lateralized) and social processing (typically right-lateralized). Here, we extend this line of research by examining these cognitive processes in a sample of left-handed individuals with typical and atypical language lateralization. Using Glasser multimodal cortical parcellation, we assess functional asymmetry in language and social networks. Following the framework proposed by Rajimehr et al. (2022) and the causal hypothesis (Kosslyn, 1987; Hellige, 1990), we hypothesize that individuals with atypical language lateralization will exhibit reversed lateralization patterns. A total of 97 left-handed individuals participated (62 with typical and 35 with atypical language lateralization). Language lateralization was calculated using the LI toolbox from an fMRI verb-generation task. Additionally, participants performed two fMRI tasks adapted from Human Connectome Project task: a) Auditory language task, in which participants listened to adapted fables; b) Social task, in which they watched short videos and indicated whether the scenes depicted social interactions or not. Activations were segmented using Glasser's multimodal cortical parcellation atlas, focusing on language-related regions and their contralateral homologues. Lateralization patterns were statistically assessed through repeated-measures analyses,

comparing the LI values across tasks (language vs. social) and between groups (typical vs. atypical lateralization of language), applying multiple-comparison corrections. Analyses were conducted using SPM12 and SPSS software. Significant hemispheric asymmetries were observed in regions such as STSa ($F(1,91)=6.71$; $P=0.011$), PGI ($F(1,91)=24.46$; $P<0.001$), PSL ($F(1,91)=14.98$; $P<0.001$), Broca ($F(1,91)=12.55$; $P<0.001$) and SFL ($F(1,91)=3.41$; $P=0.068$). For language task, the atypical group showed a right lateralization and the typical group a left lateralization in STSa ($P<0.001$), PGI ($P<0.001$), PSL ($P<0.001$), Broca ($P<0.001$) and SFL ($P<0.001$). In the social task, marginal differences were observed only in PGI ($p=0.026$) and a trend in SFL ($p=0.075$), where the typical group showed right hemisphere lateralization, while the atypical group exhibited reduced lateralization compared to the language task. Our results largely support the regions proposed by Rajimehr et al. (2022) as key language-related areas, as most showed functional lateralization consistent with typical or atypical profiles, defined through a verb-generation task. However, only one region the inferior parietal gyrus exhibited a possible pattern of complementary lateralization across language and social tasks depending on the type of lateralization. This suggests that, although language regions are also engaged during social processing, not all of them clearly reflect the dual hemispheric organization proposed in the previous study.

B18 - From parent to child: Intergenerational transmission of neural networks during language comprehension and calculation

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Competencies in language comprehension and calculation are essential for academic achievement. Previous work has demonstrated associations between children's and parents' abilities in these domains, reflecting intergenerational transmission (IGT) from parents to children. Despite behavioural evidence, the neural mechanism of IGT remains largely unknown. The hypothesis of functional specificity posits that the engagement of brain networks varies with cognitive functions. Building on this hypothesis, we aimed to test whether IGT displays network-specific patterns aligning with the demands of each domain. Furthermore, given emerging evidence of greater maternal than paternal IGT, we also investigated whether the parent's gender influences IGT. The present study included 54 children aged 8–12 and 90 adults, comprising 54 mother-child and 54 father-child dyads, who listened to spoken stories and performed aurally presented calculation tasks in the MRI. Our data analytics hinge on the premise that linguistic and mathematical information is similarly represented in the brain across parents and children, allowing us to quantify fine-scale IGT. To this aim, we investigated spatial similarity within left and right-hemispheric functional networks of interest. Given the involvement of the language network (LN) in language comprehension and of the control network (CN) in mathematical processing respectively, we anticipated greater IGT in LN during language comprehension and in CN during calculation. We first

established significant behavioral IGT across neuropsychological assessments of language and mathematics. Second, we observed significant IGT across both tasks, evidenced by significantly greater spatial similarity in parent-child dyads than unrelated adult-child pairs. Specifically, significant IGT was observed during language comprehension in the right LN ($r = .14$, $p = .012$) and CN ($r = .06$, $p = .026$). Additionally, IGT was found across both tasks in the left auditory (story: $r = .10$, $p = .012$; math: $r = .12$, $p = .048$), left visual (story: $r = .03$, $p = .012$; math: $r = .04$, $p = .048$), and right visual networks (story: $r = .03$, $p = .048$; math: $r = .04$, $p = .009$). We further trained a classifier to distinguish multivariate activations of stories and calculations across parents and children. The classifier revealed that this task distinction was similarly represented between parents and children in the right LN and CN. Third, we identified mother-child and father-child IGT in aforementioned brain networks across both tasks. We further quantified maternal-specific and paternal-specific IGT by controlling for the effect of the other parent. Results revealed (marginally) significant maternal-specific IGT in the right LN and CN during language comprehension, as well as in the right visual network and left auditory network across both tasks. In contrast, paternal-specific IGT did not reach significance. Collectively, this study reinforces evidence of parent-offspring IGT by uncovering its neurobiological basis across multiple brain networks, cognitive tasks, and both maternal and paternal contributions. To further disentangle the genetic and environmental influences, an ongoing analysis using a twin dataset will be used to substantiate these findings. Together, this work enriches our understanding of the familial role in shaping the neural underpinnings of child development across cognitive domains.

B19 - Grounded experiences and linguistic regularities jointly contribute to the development of categorical knowledge in preschoolers

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Introduction: Human semantic knowledge is organized into conceptual categories (e.g., animals, tools), facilitating efficient processing of complex information. Behavioral studies suggest that children develop categorical concepts during the preschool years, potentially through exposure to shared co-occurrence patterns of words (e.g., dogs and cats often occur with pet). Meanwhile, eye-tracking and imaging studies reveal, as early as in infancy, humans are sensitive to object features, such as shape, that are available through grounded experiences and help distinguish between categories. However, it remains unknown whether and how grounded experiences and/or linguistic statistical information contribute to the development of the categorical concepts that underlie children's semantic behavior. **Methods & Results:** To address this question, we tested 42 preschool children (56.3 ± 12.6 months, 36–83 months, 26 female) and 36 adults (21.9 ± 2.7 years, 18–30 years, 22 female) using a spatial arrangement task. Participants arranged 16 objects familiar to children under 3 (four per category: animals, humans, tools, scenes) on a gridded board such that semantically related objects were placed closer together. To quantify categorical organization, we computed a semantic dissimilarity matrix for each participant based on Euclidean distances between object placements. A "categoricalness"

score was obtained by correlating each matrix with a binary theoretical category matrix (0 = same category, 1 = different categories), followed by Fisher Z-transformation. We first characterized developmental changes in categorical knowledge. Categoricalness scores showed a significant positive correlation with age ($r = 0.58$, $p < 0.001$). When children were analyzed by age group, categoricalness scores were not significantly different from zero in 3–4-year-olds ($t_{13} = 1.93$, $p = 0.08$) or 5-year-olds ($t_{10} = 1.78$, $p = 0.11$), but were significantly positive in 6-year-olds ($t_{16} = 5.60$, $p < 0.001$) and adults ($t_{35} = 13.94$, $p < 0.001$). Next, we examined the contributions of object features and linguistic statistical information to children's categorical knowledge. The 16 objects were rated on 65 brain-derived semantic dimensions (Binder et al., 2016) using GPT-4o, which were reduced via principal component analysis into 10 components (explaining 79% of variance). Ten feature-based dissimilarity matrices were created from the absolute pairwise differences between objects on each component. Linguistic co-occurrence dissimilarities were derived from the Mandarin CHILDES corpora using 3-, 7-, and 11-token windows. For each participant, linear regression models were used to predict semantic dissimilarity from each of the featural and linguistic matrices. The resulting coefficients of all predictors were then entered into a second-level regression with categoricalness as the outcome. Results showed that coefficients for the 11-token co-occurrence pattern and five featural components—related to positive and negative visual experiences, auditory-tactile, temporal, and numerical features, significantly predicted categoricalness (all $p < 0.05$). **Conclusion:** These findings indicate that categorical knowledge emerges gradually during the preschool years. Crucially, both linguistic co-occurrence patterns and object features enriched through grounded experience contribute to the development of children's categorical knowledge. These results suggest that early semantic development and organization reflects an integration of language-based regularities and experiential knowledge acquired through interaction with the world.

B20 - Neural Signatures of Filler-Gap Dependency Processing in L1 and L2 English Speakers

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Language processing is a complex task requiring our brain to rapidly integrate various linguistic information from unfolding words and quickly build comprehension. While native speakers (L1) are widely assumed to engage in both incremental and predictive processing in real time, debates persist regarding how second language speakers (L2) process sentences in real time and whether their processing mechanisms align with or differ from those of native speakers. The present event-related potential (ERP) study thus aimed to examine whether late L2 speakers recruit the same neural mechanisms as L1 speakers when resolving the English filler-gap dependency – a long-distance relationship between a fronted wh-word (filler) and its canonical syntactic position (gap). We compared online wh-dependency resolution in English between 11 native English speakers and 20 late Mandarin-English learners, divided by a cloze test median into High versus Low proficiency groups. Participants read 24 globally grammatical sentences with manipulations of filler plausibility (plausible vs. implausible) and gap licenser types (transitive verb vs. preposition). For example, the filler could be either a plausible or implausible match for the

first verb “wrote,” as in “Lucy identifies which article/woman the author wrote a column to describe _ in the newspaper.” The gap licenser could be either a transitive verb or a preposition, as in “Lucy identifies which article the author wrote a column to describe/about _ in the newspaper.” Sentences were presented word by word for 500 ms with a 400 ms interval using the Rapid Serial Visual Presentation (RSVP) paradigm, while participants’ EEG was recorded. Mean amplitudes were analyzed at three regions of interest: the first verb (wrote), the filled-gap noun phrase (column), and the gap licenser (describe vs. about). At the first verb, the L1 group showed a robust N400 effect for the implausible fillers compared to plausible fillers in the 300–500 ms time window. L2 speakers with high proficiency showed a delayed N400 in the 500–600 ms time window. At the filled-gap noun phrase, high proficiency learners displayed an N400 when an expected gap appeared to be filled, indicating an expectation violation, whereas low proficiency learners showed a frontal P600-like positivity consistent with syntactic reanalysis. Native speakers showed no significant effect, likely because reanalysis had already been completed at the determiner. At the gap licenser, all three groups – L1, L2-High, and L2-Low – showed more negative-going waveforms for prepositions than transitive verbs. This pattern was consistent across time windows: an N280 (250–320 ms) typically associated with function words like prepositions, an anterior negativity (300–500 ms) reflecting increased working memory demands, and a late negativity (500–900 ms) indicating continued working memory processing. Crucially, the absence of Group $\times$ Condition interactions across all critical regions challenged theories suggesting fundamental differences between L1 and L2 processing. Overall, the findings of the current ERP study provide evidence for qualitatively similar L1 and L2 neural mechanisms during the real-time processing of wh-dependencies in English. Moreover, high-proficiency L2 speakers showed delayed sensitivity to filler-verb plausibility compared to native speakers but more advanced predictive processing than low-proficiency speakers.

B21 Sandbox Series - Bridging models of linguistic planning and speech production: The case of lexical stress in English

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Speaking involves both the linguistic planning of an utterance and its motor execution. While some aspects of speech emerge dynamically at the sensorimotor level, others—such as prosody—are shaped by high-level planning. Lexical stress, in particular, influences speech duration, intensity, and pitch. Theories of word production have addressed the planning of lexical stress within psycholinguistic frameworks (Levett, Roelofs, & Meyer, 1999) or, independently, its execution in speech production (Guenther, 1995, 2015). Yet, no proposal formally captures the trajectory from an abstract prosodic specification to a motor command. To formalize this trajectory, we align the representational assumptions and neural mappings of the WEAVER++/ARC model of lexical access (Roelofs, 2014) and the GODIVA model of speech sound sequencing (Bohland & Guenther, 2010). We focus specifically on the aspects of these models that address phonological planning, which we propose

involves two key functional demands: (i) managing serial order, movement initiation and timing, and (ii) generating prosody and realizing syllable stress in the speech signal. First, managing serial order involves coordinating segmental and metrical information. The Lexical Output Form in left pSTG activates the phonemic segments of a word, its metrical pattern, and their relative order. These are buffered in working memory: phonemic segments in the Segmental Content Buffer (left pIFS, IPS), and the weak-strong metrical frame in the Sequential Structure Buffer (preSMA). We propose that phonemic content in left pIFS is assigned to syllable positions in the metrical frame through rule-based interactions with preSMA, mediated by subcortical structures. Movement initiation and timing, in turn, depend on interactions between the sequencing buffer and motor planning regions. Contents of the Segmental Content Buffer are read out to left vPMC, where the most appropriate motor program(s) for the sequence is selected. Their initiation and intensity is gated by the Sequential Structure Buffer via the Initiation Map in SMA. Second, generating prosody involves coordination between the buffers and the frontal operculum region. These regions may jointly shape utterance prosodic contour, with the SMA modulating intensity, duration, and pitch to realize syllable stress in the speech signal. We plan to evaluate the framework through computer simulations of multisyllabic word production, comparing simulated speech acoustics with recordings of human speakers producing the same utterances under controlled conditions. By interfacing the models, we aim to provide a neurobiologically grounded account of how prosodic specification such as lexical stress can shape motor output. This approach extends our understanding of how high-level linguistic planning is translated into continuous motor behavior, and bridges a key gap between psycholinguistics theory and speech motor control.

B22 Sandbox Series - ERPs during compound picture-naming to dissociate morphosyntax and phonology

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Novel compound formation as in ‘lemon basket’ or ‘cat seat’ necessarily involves the combination of existing phonological (/kaet/, /sit/), syntactic (Noun1, Noun2), and meaning ({cat}, {seat}) units. But what happens in the case of known compound nouns with fixed meanings, like ‘airbag’ and ‘strawberry’, is a more interesting question with broader implications: do mental representations and computations continue to make reference to smaller units, even when it seems not to be strictly necessary for successful production and comprehension? Previous research on the production of known compound nouns in error patterns of patients with aphasia (e.g. Blanken, 2000; Badecker, 2001; Chiarelli et al. 2007) and using behavioral and ERP measures (e.g. Koester & Schiller 2008; Lorenz et al. 2021) has provided considerable evidence that production of known compounds continues to make reference to smaller linguistic units. However, whether those smaller units are morphosyntactic, phonological, or both, is still a matter of some debate. Here we use an auditory priming manipulation during a compound picture naming ERP study to provide further evidence. A recent ERP study by Cuonzo et al. (2024) found that compound constituent priming of naming (‘bag’ -> ‘airbag’) resulted in an ERP effect with a qualitatively different polarity

and distribution from phonological priming ('bat' --> 'airbag'). However, in their materials, the amount of phonological overlap was smaller in the phonological prime condition (onset and nucleus) than in the compound constituent prime condition (full syllable). In the current ERP study, we use phonological wordforms containing embedded wordforms ('acorn') to create a non-compound phonological priming condition ('corn' --> 'acorn') that contains full syllable overlap. Participants hear the spoken prime word (e.g. 'corn'), followed by a target picture (an acorn) which they must name. Phonological priming effects are assessed by comparing the response to picture naming when preceded by a phonological prime vs. an unrelated control (e.g. 'truck' --> 'acorn'). Compound constituent priming effects are assessed by comparing the response to compound picture naming when preceded by the compound head ('bag' --> 'airbag') vs. an unrelated control (e.g. 'tree' --> 'airbag'). Each participant sees 30 items from each of the 4 conditions, with condition-item pairings counterbalanced across two lists, intermixed with 134 monomorphemic picture naming fillers. Participants are familiarized with the list of picture names prior to the experiment but not with the pictures themselves, to minimize the contribution of episodic memory to the task. We will measure production accuracy, reaction time, and ERPs from the onset of the picture, during the production planning period from 0-700ms (any trials with faster naming RTs will be excluded to prevent motor contamination of ERPs). If compound constituent priming in picture naming is due to shared morphosyntactic units, we predict qualitatively different ERP effects from phonological priming. On the other hand, observing qualitatively similar priming effects across conditions will suggest that these effects largely reflect facilitation due to shared phonological form. Data collection is currently underway.

B23 Sandbox Series - A novel treatment approach for word retrieval deficits in connected speech in aphasia: Integrating working memory and retrieval practice

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Word retrieval deficit – difficulty retrieving words from meaning – is a common and persistent deficit in chronic aphasia that often hinders effective communication in daily life. It can manifest as producing an incorrect word (e.g., saying “orange” for “apple”) or failing to produce any word at all. These difficulties extend beyond single-word tasks and are often more pronounced in connected speech, such as sentences and discourse, likely due to increased task demands and the working memory (WM) required to retrieve and maintain multiple words for production (Schwartz & Hodgson, 2002; Slevc, 2011). Word retrieval deficits in connected speech are likely multi-determined, arising from impairments in single-word retrieval and/or WM. Treatment for word retrieval deficit in confrontation naming tasks is a well-studied topic. Retrieval practice (RP) is a robust learning principle that involves actively retrieving information from long-term memory to strengthen future recall of that information. When applied to naming treatment, retrieval practice (RP) involves naming attempts and has been shown to significantly enhance word retrieval in confrontation naming tasks (Middleton et al., 2019; Middleton et al., 2015; Middleton et al., 2016; Schuchard & Middleton, 2018a, 2018b). However, naming treatment’s generalization to connected speech has been

inconsistent and remains understudied (Boyle & Coelho, 1995; Coelho et al., 2000; Conroy et al., 2009). One possible reason for the limited transfer is that most naming treatments do not target the additional WM demands required for connected speech. Some prior studies using cross-domain treatment series that include both WM and anomia treatments have shown promise in improving word retrieval (Hashimoto, 2023; Martin et al., 2006; Simic et al., 2022). However, these studies often do not isolate the specific mechanisms driving improvement and primarily assess outcomes at the single-word level, with limited focus on connected speech. Rather than treating each component separately, the present study uses a multiple-case, within-subject design to investigate whether a novel training approach – integrating WM into the well-established RP-based naming treatment – can improve word retrieval in connected speech in aphasia. This combined training approach is designed to (1) increase cognitive demands during RP training to enhance its effectiveness and promote generalization to connected speech, and (2) improve the ability to retrieve and maintain multiple words for production. Treatment effects will be evaluated across linguistic levels, including content word retrieval in sentence production, single-word naming, and discourse informativeness and efficiency.

B24 - Causal parametric language mapping using electrical stimulation

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Introduction: Direct Electrical Stimulation (DES) is the standard for functional language mapping during awake brain surgery. Mapping is based on a binary measure of performance: regions are ‘eloquent’ if DES elicits errors in naming, or ‘safe to remove’ if it does not. This approach assumes DES has no impact on language processing on correct (negative mapping) trials. Methods: We analyzed 2,498 picture-naming trials from awake surgeries in 19 patients, targeting left perisylvian areas. Response times were measured from picture onset to spoken response on correct trials. Variance in DES intensity, location, duration, and timing (relative to picture onset) was assessed. Parallel analyses spatially mapped the relation of DES parameters to performance at the group level using ‘searchlight’ analyses. Results: Higher stimulation intensity was associated with increased error rate ($p < 0.0004$) and slower response times ($p < 0.0002$). Closer proximity to errors (within or across patients) predicted slower response times on correct trials ($p < 0.0001$, $p < 0.005$). DES duration was positively related to error rate ($p < 0.0001$) and response times ($p < 0.0001$); this relation is location-dependent, with the strongest effect in speech motor cortex and anterior supramarginal gyrus. When DES (relative to picture onset) caused the greatest delay varied by region, and the neurophysiological time course of activity (measured in 14 SEEG patients) accounted for 28% of the variance in when DES

had its strongest effect in each region. A cross-validated predictive model found that DES intensity, location, duration, and timing collectively predicted 54% of response time variance on negative mapping trials. Discussion: Causal Parametric Mapping provides a novel approach to integrate positive and negative mapping trials into a graded measure reflecting each region's role in language. These findings suggest that binary mapping methods may underestimate the extent of 'eloquent' cortex. An ongoing multisite trial will assess whether indices from negative mapping trials explain unique variance in language outcomes 3months post-surgery.

B25 - "Mmm... They look so good": TDCS influences sarcasm evaluation and gaze patterns in the right TPJ

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Background: Neural processing of Theory of Mind (ToM) and cognitive empathy has been consistently linked to activity in the right temporoparietal junction (rTPJ). These social-cognitive abilities also support pragmatic language comprehension. In the current study, we test the hypothesis that the rTPJ plays a critical role in understanding pragmatic language, including sarcasm and teasing. Methods: This study examines how rTPJ inhibition via transcranial Direct Current Stimulation (tDCS) influences pragmatic processing while accounting for individual differences. First, participants receive 20 minutes of cathodal tDCS (1.5 mA or sham) to transiently reduce cortical excitability in the rTPJ. Participants then evaluated sarcastic, teasing, and sincere interactions while seated at an eye tracker. The stimuli consisted of 96 dynamic video interactions drawn from the Relational Inference in Social Communication (RISC) database. Primary measures include fixation count and duration towards target speakers' faces, accuracy a sincerity question, friendliness of the interaction, and reaction time. Participant also filled out surveys about their personality, anxiety, empathy, psychopathy, and sarcasm use to model individual differences in eye tracking patterns and behavioral response. Results: Preliminary analyses indicate that the effect of rTPJ inhibition on pragmatic language processing is moderated by individual differences in empathic concern. Participants with high empathic concern exhibited slower reaction times under tDCS compared to sham stimulation, suggesting that reduced rTPJ excitability disrupted efficient integration of speaker intent. In contrast, those with low empathic concern responded more quickly following tDCS, potentially reflecting shifts in processing strategy. Reaction time change scores followed three broad patterns: positive changes (slower responses under tDCS), negative changes (faster responses), and near-zero changes (minimal or variable effects). Notably, slower responses under tDCS were accompanied by increased visual scanning of speaker faces, suggesting greater cognitive effort during social interpretation when rTPJ function was inhibited. Conclusion: These findings support a role for the rTPJ in pragmatic language comprehension, particularly in interpreting socially complex, nonliteral speech. The results also suggest that empathy modulates how individuals adapt to neural disruption, probably through distinct compensatory strategies across participants. Increased visual attention to social cues during tDCS suggests that when typical inferential processes are disrupted, individuals may rely more heavily on visual information to interpret speaker

intent. This study advances understanding of the neural basis of pragmatic reasoning and sets the stage for future investigations in clinical populations with social-cognitive impairments.

B26 Sandbox Series - Do pragmatic abilities modulate language processing? Exploring the effect of pragmatic abilities on NPI licensing in English.

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Among neurotypical and neurodivergent populations alike, individuals may possess traits associated with autism spectrum disorder (ASD), which may be modulatory of language processing (e.g., Nieuwland et al., 2010; Xiang et al. (2013)). Xiang et al. (2013) observed that participants' scores on the communication subscale of the Autism Spectrum Quotient (ASQ; Baron-Cohen et al., 2001) modulated processing of complex constructions containing negative polarity items (NPIs) in an acceptability judgement task. NPIs are items that must appear only in negative or "non-positive" contexts (e.g., Giannakidou, 2006). NPIs are exemplified by the word "ever" in sentences (1) and (2) below: (1) No young athletes have everNPI won the regional marathon (2) Only young athletes have everNPI won the regional marathon (3) *Most young athletes have everNPI won the regional marathon. Sentences (1) and (2) are grammatical given the presence of negation. In (1), negation is overt, given the negative operator "no". In (2), negation is introduced via negative implicature, "young athletes and no others have ever..." which implicates an additional pragmatic computation, given implicature is pragmatic in nature. These sentences can be contrasted with (3) which is ungrammatical, because the quantifier "most" is positive. To current knowledge, no study has investigated the effect of "pragmatic competency" – as indexed by the communication subscale of the ASQ – using simple sentences containing NPIs, or using ERP methodology. We conducted three studies which investigated the effect of pragmatic competency and individual licensing environment (e.g., negative environment, "no vs. only") on NPI processing in English. We utilized a grammaticality judgment task (GJT) (n=168), a self-paced reading task (SPR; n=180), and an ERP experiment (n=21; data collection ongoing). We investigated the effect of pragmatic abilities on individuals' processing of NPIs under two different negative contexts (overt negation as in (1) vs. negative implicature as in (2)). No effects of pragmatic abilities were observed in our offline experiment. In our SPR task, collapsed over language groups, we observed overall faster reading times (RT) on the critical word (CW) "ever" as pragmatic abilities decrease (ASQ score becomes higher; $b=-0.02$, $SE=0.01$, $t=-2.3$, $p<0.05$). This was also the case for the word following "ever" ($b=-0.02$, $SE=0.01$, $t=-2.57$, $p<0.05$). Preliminary analyses of the ERP data suggest that the overall P600 amplitude (600-800ms time-window) at the word "ever" decreased with decreasing pragmatic abilities (increasing ASQ Score) ($b=-0.24$, $SE=0.10$, $t=-2.3$, $p<0.05$). A Grammaticality by ASQ score interaction approached significance on the second word following the CW "ever" ($b=0.39$, $SE=0.21$, $t=1.80$, $p=0.07$): as pragmatic abilities decrease (ASQ score increases), the amplitude difference between grammatical and ungrammatical conditions increases. Our SPR results suggest that pragmatic abilities may modulate language processing in general, given the main effect of ASQ score on RT. However, no interaction effects were observed in

our SPR task. Our preliminary ERP results suggest that pragmatic abilities may be modulatory of semantic-pragmatic processing more specifically, given the nearly-significant interaction between ASQ score and grammaticality; data collection is ongoing.

B27 - Linguistic features affect the formation of our semantic networks

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As we read, text we have already read primes semantic networks, resulting in predictions of upcoming words making reading more efficient. Cognitive accounts propose that this priming is primarily defined by semantic similarity, whereas linguistic accounts emphasize the roles of other features, such as hierarchy (super- vs. sub-ordinate categorical relationships). In the current study we sought to explore the impact of semantic similarity and hierarchical relationships simultaneously. 576 participants completed a lexical decision task (real vs. pseudoword) across 144 independent and trial-unique stimuli (500ms). Pseudowords were constructed to precisely match the real words in letters but remain phonologically plausible. Trials were arranged in counterbalanced pairs, such that real and pseudowords followed each other equally often. Unbeknownst to participants, prime and target pairs were embedded in the trial structure and could appear either in the order of superordinate (category head) followed by the subordinate (category member), or the subordinate followed by the superordinate. Stimuli were tightly controlled for frequency, string length, and semantic similarity. If the cognitive account of spreading activation predicted by semantic similarity is accurate, the Superordinate-Subordinate and Subordinate-Superordinate conditions should be equal in response time as similarity is the driving factor and identical across the conditions. However, linguistic accounts would predict that the Subordinate-Superordinate condition should be faster as subordinate terms contain specific features, with more information, leading to a larger priming effect. Contrary to both theories, the strongest priming effect was observed in the Superordinate-Subordinate condition. Thus, neither theory accurately predicted the outcome, as hierarchy directly affected priming but in the opposite direction from the linguistic prediction. However, we were able to explain this apparently hierarchical effect through a more thorough modeling of the semantic neighborhood of, and the presumptive spreading activation caused by, the prime words. We utilized GPT-4 responses for the 50 closest neighbors of the prime, and SpaCy to determine the similarity of those neighbors to the target. Superordinate primes (e.g., color) tended to yield neighbors that more broadly overlapped with the subordinate targets (e.g., blue), but not vice versa. Subordinate terms are anchored in specific context and thus co-occur with a wider range of domain-relevant superordinates, whereas superordinates appear in diffuse contexts and rarely co-occur with any single subordinate. This asymmetry, recoverable purely from co-occurrence patterns, shows that hierarchical structure can emerge naturally from a mechanism that simply captures co-occurrence patterns. The natural statistics of language create hierarchical priming with no need for a specific mechanism to capture it. Our findings suggest that both cognitive and linguistic theories are right, but describe the language mechanism at two different levels. Even simple

statistical models, when trained on rich input, can recover complex effects like hierarchical priming due to the nature of language. This result has significant implications for computational modeling, language learning, and our understanding of related disorders. These results provide a conceptual framework for unifying experience-based learning with structured semantic knowledge.

B28 - fNIRS-Guided TMS Distinguishes the Function of the Left ATL and AG in the Semantic Integration of Chinese Compound Words

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Abstract: Lexical semantic integration involves the activation of two crucial regions on the left hemisphere: the left anterior temporal lobe (ATL) and the angular gyrus (AG). The current study investigated their precise function in morpheme-meaning integration by combining the neural correlation (functional near-infrared spectroscopy, fNIRS) and neural causality (transcranial magnetic stimulation, TMS) techniques. The participants performed a lexical decision task after viewing two consecutively presented Chinese characters while their brain activation was recorded using the fNIRS technique. Three types of two-character words were used for two experiments: transparent compounds (e.g., 炽热, hot) with the word meaning that is same to their two characters (both 炽 and 热 mean hot), opaque compounds (e.g., 风流, dissolute) with the word meaning that is different from either the first (风, wind) or the second character (流, flow), and monomorphemic words (e.g., 伶俐, clever) with two characters that are not two independent morphemes. Experiment 1 found a different pattern of results at the left ATL and AG channels. The left ATL showed a morpheme complexity effect that its activation was stronger for two types of compound words than monomorphemic ones, with no difference between transparent and opaque compounds. In contrast, the left AG showed a semantic transparency effect that its activation was stronger for transparent than opaque compounds, with no difference between opaque compounds and monomorphemic words. Experiment 2 further investigated the causal relationship between the activities of the left ATL and AG and their function in the semantic integration of Chinese compound words. Two group participants performed the same task as Experiment 1 after they received a 40-second virtual lesion at the left ATL or the left AG. The results found that the ATL-impaired group showed no activation differences among the three types of words either at the ATL or the AG channels. In contrast, the AG-impaired group showed no difference among three types of words at the ATL channels. As for the AG channels, the activation for two types of compound words was inhibited thus the semantic transparency effect disappeared, and a reversed morpheme complexity effect was observed that the activation for monomorphemic words was stronger than for two types of compound words. These findings suggested a different function of the left ATL and AG for the semantic integration of Chinese compound words. The left ATL likely undertakes domain-general integration processing, while the left AG is specifically involved in domain-specific semantic feature integration. This study finely distinguishes the roles of ATL and AG in the semantic integration of Chinese compound words. **Keywords:**

semantic integration, compound words, semantic transparency, fNIRS, TMS

B29 - Automatic processing of relational structure in language: A frequency-tagging EEG study of Chinese compounds

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Language is a primary means of exchanging information about the world, and much of the exchange concerns relations between entities in the world. On a par with lexical means for expressing relations, such as prepositions (e.g., lamp ON the bench, lesson AFTER the break), relations can also be expressed morphologically either using overt affixation (possession: Ivy's cat) or null morphemes (raincoat 'a coat FOR rain', snowball 'ball MADE-OF snow'). Previous studies argued that relational structure is accessed routinely, as shown by facilitatory priming effects between compounds sharing the same semantic relation, e.g. raincoat [coat FOR rain] facilitates rainboots [boots for rain] relative to rainwater [water ORIGINATING FROM rain] (Gagné & Spalding, 2009; Raffray et al, 2007). However, this finding was confounded by the fact that compounds sharing semantic relation frequently also contained semantically related second constituents (e.g., coat & boots are semantically closer than coats & rain), hence the facilitation couldn't be definitively attributed to the shared semantic relation. More definitive demonstration of automatic extraction of relational structure is needed; we address this question via a frequency-tagging EEG study of Chinese compounds. Twenty native Chinese speakers viewed 60-second-long sequences of Chinese compounds presented at a regular rate of 166.7ms/compound (i.e. frequency-tagged @6Hz). Each sequence consisted of four base stimuli alternating with a fifth oddball (@1.2 Hz). Base compounds all featured the FUNCTION relation between constituents within each XY compound interpretable as 'Y for X'; e.g. 酒瓶 (/jiǔpíng/, wine bottle – 'bottle FOR wine'), the second constituent 瓶 (/píng/, bottle) specified the function of the first constituent 酒 (/jiǔ/, wine). Oddball stimuli varied across five conditions: a) POSSESSION ('Y of X'): 蛋 (/dàn/, egg) + 壳 (/ké/, shell) → 蛋壳 (/dànké/, eggshell, 'shell of egg'); b) COORDINATION ('X and Y'): 花 (/huā/, flower) + 草 (/cǎo/, grass) → 花草 (/huācǎo/, 'flowers and grass'); c) ACTION ('X act on Y'): 弹 (/tán/, play) + 琴 (/qín/, instrument) → 弹琴 (/tánqín/, 'play[action] instrument [object]'); d) PSEUDO-COMPOUND ('PC'): 头 (/tóu/, "head") + 柴 (/chái/, "firewood") → 头柴 (/tóuchái/, illicit compound); e) FUNCTION ('Y for X'): 药 (/yào/, medicine) + 箱 (/xiāng/, box) → 药箱 (/yàoxiāng/, medicine box, 'box for medicine'). If semantic relations are extracted automatically, we expected that a spectral peak would appear at the rate of oddballs (i.e. 1.2 Hz and its harmonics) in conditions (a-d) in which the semantic relation within the oddball stimuli was different from that in the base stimuli. This prediction was confirmed by the results of non-parametric cluster-based permutation tests: the power at the oddball rate 1.2 Hz and its harmonics was significantly higher than in the neighboring bins in conditions (a-d), but not in condition (e) in which base and oddball stimuli shared the same relation. These results demonstrate that participants

automatically extracted the detailed semantic relations between constituent morphemes in compounds, providing the first neural demonstration of extraction of latent relational structures in language. We place these results into a larger theoretical framework that considers the role of relations across cognitive domains, including vision and memory (Hafri & Firestone, 2021).

B30 - Task-Invariant Decoding of Semantic Representations with Intracranial Human Neurophysiology

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INTRODUCTION: The human brain's ability to store and retrieve semantic knowledge is a fundamental aspect of cognition, and in particular language. A key characteristic of semantic representations is that they must achieve invariance over inputs, ensuring that, for instance, the concept of a "knife" retains stable meaning across contexts, tasks (e.g., naming, reading), and input modalities (e.g., picture, word, sound). But what is the spatio-temporal neural signature of task-invariant in semantic representations? While prior work has significantly advanced our understanding of this question, it has typically relied on methods that emphasize either spatial or temporal resolution. Here, we build on prior work by using stereoelectroencephalography (SEEG), which offers direct neural recordings with both high spatial and temporal precision. **METHODS:** Fourteen pre-surgical epilepsy patients participated in a task involving picture naming and word reading with intracranial recording. Importantly, the task did not require explicit semantic judgments, allowing us to capture spontaneous semantic activation. Using SEEG data (local field potential) from all electrodes within each participant, we trained linear classifiers to distinguish among seven semantic categories—animals, body parts, clothes, fruits and vegetables, furniture, tools, and vehicles—at each time point (100 Hz) from stimulus onset (0 ms) to 800 ms. We then tested the models' ability to generalize across the picture naming and word reading tasks at all pairs of timepoints (t_{picture} , t_{word}). This approach allows to identify representation of semantic categories that are de-confounded from task- and stimulus-specific representations. Timepoints where models successfully generalized across tasks indicated when such representations were activated, while the spatial patterns of the models revealed where in the brain these representations were localized. **RESULTS:** Our results show that semantic representations that were activated during picture naming at ~175–400ms after stimulus onset generalized to the word reading task at ~200–600ms. This cross-task generalization reveals the temporal dynamics of spontaneously activated, task-invariant semantic representations, in the absence of an explicit categorization task. Invariant semantic representations were distributed across the cortex but showed strongest localization in the left anterior temporal lobe (ATL), a region previously associated with modality-independent semantic processing. We also observed strong activation patterns in the posterior lateral temporal lobe, suggesting a

broader network supporting task-invariant semantic knowledge. Finally, we also present preliminary results of connectivity analyses describing the functional networks supporting semantic invariance. **CONCLUSION:** Our findings provide electrophysiological evidence for the spatio-temporal dynamics of spontaneous, task-invariant semantic representations in the human brain. These results contribute to a growing body of evidence that semantic knowledge is supported by distributed, yet convergent networks.

B31 - Backward surprisal in serial and parallel reading

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Predictive processing is central to our neurobiological models of language, but recent work across domains has questioned the traditional focus on forward prediction—the likelihood of the present given the past—by emphasizing backward prediction, or the likelihood of the past given the present. Backward prediction has been shown to influence linguistic processing (Onnis et al., 2022), statistical learning and perception (de Lange & Press, 2025), and decision making (Sharp & Eldar, 2024). Yet its role in language neuroscience remains largely unexamined. For example, the extent to which the N400 reflects backward rather than forward prediction is unclear, as the two are naturally correlated. We used MEG to disentangle forward and backward prediction, quantified using surprisal, during the reading of adjective-noun phrases. To test whether any observed effects are dependent on the adjective temporally preceding the noun, we presented stimuli both serially using RSVP and in parallel using RPVP. Prior MEG work identifies the left anterior temporal lobe (LATL) as a key site for combinatory processing (Pykkänen, 2019), making it a plausible locus for backward surprisal effects. In contrast, classic N400 signals localize to the left posterior temporal lobe and the LIFG (Lau et al., 2013; Halgren et al., 2002). While high forward surprisal is typically associated with increased neural responses, backward surprisal may have the opposite effect. Prior studies have found that strongly associated bigrams evoke larger LATL responses (Li et al., 2021), and it has been hypothesized that high backward probabilities may lead to stronger bidirectional feedback between the current item and its context, enhancing activation for sequences with stronger backward associations (Onnis & Huettig, 2021). Participants read adjective-noun phrases that varied in forward and backward surprisal—such as ‘romantic comedy’ (LowForw-LowBack), ‘lunar calendar’ (LowForw-HighBack), ‘live coverage’ (HighForw-LowBack), or ‘untitled piece’ (HighForw-HighBack)—and were then presented with a semantic task probe. Analyses were time-locked to the noun’s onset in RSVP and to the whole phrase onset in RPVP, enabling us to directly compare the neural signals elicited by the noun in its temporally preceding context and that same noun when its context could be read in parallel with the noun. Cluster-based permutation tests revealed a robust main effect of backward surprisal in the LATL at 207–300ms, with higher amplitudes for less surprising contexts—an anti-surprisal effect. This effect was consistent across presentation modes. Forward surprisal also showed main effects, though only marginally after correction, emerging in the LIFG (203–306ms), LATL (474–580ms), and left posterior temporal lobe (522–584 ms), without interactions with presentation mode. Overall, backward surprisal was a more reliable and earlier modulator of neural responses than forward

surprisal, with effects beginning before the typical N400 window. The anti-surprisal direction of the backward effect also differentiates it from the typical forward surprisal response. Notably, presenting the two words in parallel did not eliminate the distinction between forward and backward surprisal. This suggests that both predictive (forward) and retrodictive (backward) processes are active during phrase comprehension, even when the stimulus does not unfold over time.

B32 - Processing Definiteness Ambiguity: Sustained ERP Response May Reflect Computations Specific to Semantic Definiteness

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Previous ERP research on the processing of noun phrases with a definite marker reveals that they pose a givenness and uniqueness demand on their referents within a discourse (Anderson & Holcomb 2005; Schumacher, 2009; Kirsten et al., 2014). However, semantic definiteness is not necessarily tied to the presence of definite markers. For example, the subject of ‘The dinosaurs are extinct’ does not refer to a group of specific dinosaurs even though it has the definite marker, whereas the subject of ‘Handouts are on the table’ does even though it is a bare noun phrase. It thus becomes an interesting question whether phrases with and without a definite marker still show any neural correlates of semantic definiteness/indefiniteness when presented without a disambiguating context. Here we report a study aimed at taking a preliminary step towards addressing this question by comparing ERP responses to coordinated vs. uncoordinated definite and bare plural noun phrases. Our results are consistent with the view that a sustained ERP response reflects computations specific to semantic definiteness. In a prior ERP study (Lau & Liao, 2018), a sustained anterior negativity (SAN) response was observed in coordinated bare plural noun phrases compared to their uncoordinated counterparts (e.g. sunlit ponds and green umbrellas vs. sunlit ponds ### green umbrellas) for natural language but not jabberwocky materials, providing potential evidence that the sustained response reflects the semantic consequences of bare plural coordination. However, their exact nature is indeterminate in this study, as bare plurals are ambiguous between a definite (an existing group of entities) and an indefinite (a conceptual kind) reading. One possibility is that coordination biases the bare plurals towards a definite reading. Here we compared coordinated and uncoordinated bare plurals with definite plural noun phrases (e.g. the scented gardens and the ardent dancers vs. the scented gardens ### the ardent dancers). If the previous SAN effects reflect differential computations specific to the definite vs. indefinite bare plural reading, we expect to see a different ERP response to the unambiguous definite plurals. We conducted one experiment presenting participants with only the definite sequences, and a subsequent within-subject experiment presenting both definite and bare plural sequences. In both experiments (n=18, 22 respectively), text materials were presented using RSVP, 600/ms per word. Participants’ task was to respond to an occasional recognition memory probe following some of the trials. We examined epochs of -200:2000ms time-locked to the

coordinator/placeholder. In both experiments, we found no evidence of the SAN for definite plural coordination. However, at the second NP we observed a numerical posterior positivity for coordinated vs. uncoordinated definite plurals. Unexpectedly, when bare plurals were intermixed with definite plurals in the second experiment, they no longer demonstrated a SAN for coordination. We hypothesize that intermixing definite plurals and bare plurals might make their semantic contrast more salient, biasing the bare plural coordination towards the indefinite reading.

B33 - A functional connectivity study between the cerebellum and frontotemporal language areas

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Introduction: In a previous, preregistered fMRI study (accepted, preprint available: https://osf.io/preprints/osf/rvgs9_v1), we showed that phonological mechanisms are especially involved in morphological processing of sentences. Specifically, the posterior Superior Temporal Gyrus (pSTG) and Inferior Frontal Gyrus Opercularis (IFGop), two brain areas well recognized for their role in phonological processing, were activated during a grammaticality judgement task of sentences with a morphological error (i.e., every day she walk* the dog). Semantic areas were activated to a lesser extent: we observed a small but significant cluster in the IFG triangularis (IFGtri). Most surprisingly, exploratory whole brain correlations with language skill revealed a brain-behavior correlation in the cerebellum showing that greater activation was related to lower language abilities. While implicated in motor processing, the “linguistic cerebellum” has received increased interest in recent years (e.g., Casto et al., 2025; LeBel & D’Mello, 2023; Vias & Dick, 2017). The location of the correlation we identified was in the anterior lobe of the cerebellum, in lobules I-IV. This area has consistently been implicated in articulatory processes including somatosensory movement of the tongue (Prati et al., 2024) and phonemic and phonological processing (see for a literature overview LeBel & D’Mello, 2023). Moreover, this region has been relatively consistently implicated in developmental language disorder (Ullman et al., 2024). We hypothesized that the cerebellum may be used to amplify and refine cortical phonological representations in children with lower language skills, allowing them to use a phonological mechanism to process morphemes (Booth et al., 2007). The current study: In this study, we will examine if the anterior lobe cerebellum is connected to known language areas in the fronto-temporal cortex during morphological processing by performing a task-based functional connectivity design. We will examine the pSTG and IFGop implicated in phonological processing and the posterior middle temporal gyrus (pMTG) and IFGtri implicated in semantic processing. Our hypothesis is that the anterior lobe of the cerebellum is functionally connected to language areas related to phonological processing. We hypothesize that those with lower language skill will show higher functional connectivity between the anterior lobe and the cerebellum and pSTG/IFGop. To examine our hypotheses, functional connectivity between the seed region in the cerebellum to anatomical/functional masks of the dorsal versus ventral language areas will be extracted using gPPI in SPM. The seed region will be placed in the significant cluster in the anterior lobe of the cerebellum as identified in our previous analysis. We will use activation during the

grammaticality task (sentences with a morphological violation > grammatical sentences) and run a general linear model (GLM). The following regressors will be entered into the GLM at the individual level analysis: the timeseries from the seed region in the cerebellum, the experimental parameter regressors for the grammaticality task, and six motion regressors for head movement. The task modulated connectivity within dorsal and ventral masks will be calculated for morphological processing. Lastly, we will examine a correlation between the task modulated connectivity in dorsal and ventral masks and language as measured by sentence repetition. Preliminary results will be discussed.

B34 Sandbox Series - The neural basis of derivational morpheme acquisition under semantic uncertainty

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Our knowledge of derivational affixes ([*-er*], [*-ify*]) helps us understand new words based on their familiar parts, whose meaning we generalized across words that contain them. This generalization is essential in first and second language acquisition, during which new derived words are frequently encountered. It also occurs in code-switching when affixes are borrowed across languages. However prevalent, the brain basis of meaning generalization is largely unknown. Further complicating matters, affixes often mean disparate things, like *-ery* in *brewery* and *savagery*. How do we generalize the meaning of a morpheme with disparate meanings, and how is the ambiguity represented? Building on our previous experiments in Arabic that have found a neural substrate for the meaning typicality of affixes, with methods refined by studies on artificial morphological acquisition, we attempt to elucidate this question by teaching English speakers new derivational suffixes. Within an English-base artificial grammar paradigm, we introduce two novel but plausible nominalizing suffixes (e.g., [*paint*][*le*], [*run*][*ock*]) with contrasting typical meanings: places and objects. Following rule generalization findings^{1, 2, 3}, we employ a skewed frequency distribution (many low-frequency types per class) and a skewed distribution of typical/atypical meanings (40 typical, 10 atypical words per suffix) with one suffix typically creating place names and the other object names. Suffix meanings are counterbalanced across participants, and all stimuli are normed for well-formedness prior to the study. Using magnetoencephalography, participants are first presented with the target stimuli (*‘paintle’*) in isolation, matched with existing complex words (*‘violinist’*) and new-suffixed words that will stay untrained (*‘lighteen’*). Next, they are trained on all target stimuli in sentences that disambiguate the suffix’s general meaning for the stimulus stem (*‘The drinkle is closed on Mondays’*). The subsequent test phase includes trained and novel words with the target suffixes to test for meaning generalization. Training sets continue for each participant until they reach a satisfactory learning cutoff, with a minimum/maximum amount of training blocks. Finally, after participants learned the suffix meanings, they are presented with the stimuli in isolation again, mixed with novel words with the learned suffixes, to allow us to measure the effect of training on the processing of our novel suffixes. We predict participants

to generalize suffix meaning onto untrained words. We expect learning to be influenced by suffix-meaning type frequency and by the meaning disjunction, with a skew in interpreting novel words towards the typical meaning of their suffix. After training, we predict brain activity for trained suffix words to indicate multimorphemic processing unlike untrained new suffix words, as evidenced by stem-to-suffix surprisal effects on the M170 response from the Visual Word Form Area4, and a difference in processing meaning-typical vs. -atypical words like in our Arabic study. This ongoing study importantly connects across neuroscience, rule generalization studies, artificial grammar learning paradigms, and linguistic theory. It addresses an important cross-linguistic phenomenon – affix ambiguity -- which is currently overlooked. We are currently finalizing our study design and expect to have analyzed data collected from a substantial set of our participants by the time of the conference.

B35 Sandbox Series - Incremental versus global visual word recognition in the M170

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This study compares the neural correlates of two models of word recognition to assess whether the initial stages of visual lexical processing incrementally or globally compute the morphological relationships within complex words. Previous neurolinguistic work (e.g. Wray et al. 2022) has shown that morpheme surprisal is correlated with decreased M170 amplitude, a Magnetoencephalographic (MEG) response component associated with the earliest stages of visual word processing. This surprisal measure has been taken as an index of obligatory morphological decomposition and tracking of incremental expectations of linearly adjacent morphemes during early stages of lexical processing in the Visual Word Form Area (VWFA) (e.g. tracking the relationship of “work” and “-ed” in the word “worked”). A set of psycholinguistic work (e.g. Milin et al. 2009) has explicitly disputed the relevance of this incremental surprisal measure, suggesting that a global relative entropy (RE) between the probability distribution of a word’s inflected forms (e.g. “work”: “works”, “worked,” etc.) and the class level distribution of identically inflected words (e.g. “stem”: “-s”, “-ed”, etc.) can better account for the data. This model predicts that for a word like “worked”, rather than computing the local relationship between “work” and “-ed”, lexical processing tracks information associated with the stem “work” regardless of whether the word appears with the ending “-ed” or “-s”. While proponents of both models have argued against the other model, this is the first study to directly test both. Participants completed a visual lexical decision task online (n=54) or in-person with simultaneous MEG recording (n=25) in Spanish. Data collection for both experiments is complete. The stimuli consisted of 84 verbal and pseudo-stems (distributed across 3 inflection classes), conjugated with 13 different inflectional endings. We created statistical models with either global RE or incremental surprisal values. For the behavioral response times, AIC model comparison was computed on lmer models fit with surprisal and RE values. For the MEG data, we will conduct the following analyses: 1) we will average activity over the space defined by an fROI (see Gwilliams et al. 2016) and the time-frame around the M170 and fit RE and surprisal GLM models to the averaged activity; 2) fit RE and surprisal GLMs to each spatial vertex and run a spatio-temporal permutation test over the GLM beta values. Comparing the models fit to behavioral

response times, we find substantial improvement for surprisal compared RE models (AIC-Difference: 34.7). Our MEG data is still being analyzed. As an initial analysis to show the study is sufficiently powered, we averaged brain activity per participant over the entire BA37 and found significant effects of surprisal from 223-243ms and RE from 207-209ms. Our behavioral model comparison strongly suggests that lexical processing tracks incremental morpheme-by-morpheme rather than global stem information. However, from behavioral results alone, it is unclear whether our models are indexing early stages of lexical processing, or down-stream bottlenecks of syntactic and semantic processing. The analyses of the M170 response should reveal whether the outperformance of the surprisal models compared to RE models truly reflects these early processing stages.

B36 - Complex word processing in single trial EEG shows evidence for partial decomposition

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The processing of complex words has been a long-standing area of interest in psycholinguistics. While recent evidence from MEG studies (e.g., Stockall et al. (2019)) supports the separate processing of prefixes in visually presented words, little work has addressed whether this is also the case in speech perception. The present study uses single-trial EEG data to investigate auditory processing of complex spoken words, providing evidence for partial decomposition. In an ERP experiment, participants (N=28) were presented 40 real and 80 altered complex words and asked to indicate whether each was a well-pronounced word of English. Words were coded for frequency of the full word (e.g., 'unlikely'), the root (e.g., 'like'), and the prefix (e.g., 'un-'). Altered words were derived by substituting a single segment in the prefix of an existing complex word (e.g., 'tisprove' from 'disprove'), and were coded for root frequency ('prove'), as well as whole-word and prefix frequency of the original words ('disprove' and 'dis-'). Data from midline sites (Fz, Cz, Pz) was separately modeled for words and altered words using a generalized additive mixed model (GAMM). Root and prefix frequencies were each residualized against whole-word frequency to reduce collinearity, and all three frequency measures were log normalized. Tensor product smooths were used to estimate the non-linear interaction between time and each frequency measure. Subject, item, and channel within subject were included as random effects in the models. In word responses, we found significant interactions between time and both prefix and whole-word frequency ($p_s < 0.005$), with no significant interaction between time and root frequency ($p > 0.1$). Visual inspection of the tensor product smooths illustrates that in real words, a greater negativity is observed for low-frequency prefixes onsetting around 450msec, and for whole-word frequency onsetting around 600msec. For altered words, all three measures of frequency were significant (prefix, word, and non-word; all $p_s > 0.001$). Visual inspection of these smooths shows greater negativity for low-frequency roots onsetting around 500msec, and for whole words and prefixes both around 600msec. This data suggests that complex words are subject to partial decomposition, but not full decomposition. In real words,

prefix and whole word frequencies predict EEG signal amplitude sequentially in separable effects. However, this decomposition is not total, as participants do not appear to separately access the root. In altered words, where prefixes do not provide a reliable cue to the current complex word, we observe a response that indexes access to the root first, followed by the prefix and whole-word frequency effects thereafter. Taken together, this data provides evidence for partial decompositional parsing of morphologically complex words, with sub-elements of complex words, such as prefixes, accessed individually, prior to the fully composed word. Only in cases where the identity of the prefix is unreliable do we find evidence of separate access to the root.

B37 - Individual Differences Shape ERP Responses to Bilingual Code-Switched Sentences

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Bilinguals often switch between languages within a single utterance—a phenomenon known as code switching, which offers a powerful lens for examining cross language interaction and the cognitive control mechanisms engaged during comprehension. Prior auditory ERP research (Fernandez, Litcofsky, & Van Hell, 2019) revealed that bilinguals' listening to sentences that switched from their dominant to their weaker language elicited an N400 effect (semantic access) followed by an LPC effect (sentence level reanalysis), whereas switches from the weaker to the dominant language elicited only an N400 effect. While these and related findings highlight different neural responses for the two code-switching directions at the group level (for review, see Van Hell, 2022), the extent to which individual cognitive and linguistic profiles shape these neural responses remains underexplored. This study examined how individual differences in language proficiency, cognitive control, and familial sinistrality shape ERP responses to code switched sentence comprehension. Forty-four native Spanish speakers highly proficient in English listened to 160 sentences across four conditions: English only, English to Spanish switches, Spanish only, and Spanish to English switches. EEG was recorded while participants completed the task. We assessed Spanish and English proficiency with the MINT, cognitive control via the AX CPT task, and familial sinistrality through a handedness inventory. ERP responses were analyzed in the N400 (300–500 ms) and LPC (500–900 ms) windows using linear mixed-effects models. At the group level, results replicated prior findings (Fernandez et al., 2019): dominant-to-weaker switches elicited both N400 and LPC effects, while weaker-to-dominant switches showed only N400 responses. This indicates that both switch directions involve lexical access challenges, but only dominant-to-weaker switches require additional sentence-level integration. Crucially, individual differences modulated these effects. Higher dominant-language proficiency was linked to smaller N400 amplitudes and larger LPC effects during dominant-to-weaker switches, as well as reduced N400 amplitudes for weaker-to-dominant switches. These results suggest that stronger dominant-language skills help facilitate meaning access, but requires continued integration in dominant-to-weaker switches. It also enhances efficient lexical access in weaker-to-dominant switches. In contrast, higher weaker-language proficiency was associated with larger N400 amplitudes during dominant-to-weaker switches but did not affect responses in the other direction. This pattern indicates

that individuals with stronger weaker-language skills engage in deeper semantic processing when switching from their dominant to weaker language. Participants with stronger cognitive control showed reduced N400 amplitudes in both switching directions, suggesting that better regulation supports more efficient processing across language boundaries. In addition, participants with a familial sinistrality background exhibited smaller LPC effects and larger N400 amplitudes during dominant-to-weaker switches, and larger N400s during weaker-to-dominant switches. This pattern is consistent with prior research showing that individuals with familial sinistrality tend to focus more on lexical-level meaning than sentence-level integration (Lee, 2018). Together, these findings reveal that individual differences in linguistics skills, cognitive control and familial sinistrality shape the neural mechanisms underlying code-switched sentence comprehension. They highlight the importance of moving beyond group-level analyses to understand how bilingual listeners manage code-switches in real time.

B38 - Language experience shapes predictive processing: Anticipatory brain states and prediction-related facilitation in bilinguals and monolinguals

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Previous research examining prediction during language processing in bilinguals has shown mixed results in the second language (L2), finding robust effects, reduced effects, or no prediction effects at all. One explanation for altered prediction in bilinguals' L2 is that they may have limited or qualitatively different experience with the target language, leading to weaker prediction effects compared to monolinguals (Kaan, 2014; Schlenter, 2023). However, most of these studies have only compared bilinguals using their L2 to monolinguals, making it difficult to determine whether the differences are due to L2 proficiency or bilingualism more generally. Notably, studies that have examined bilinguals in their L1 have also found differences in predictive processing compared to monolinguals (Dijkgraaf et al., 2016; Foucart et al., 2014), suggesting that broader aspects of bilingual language experience may influence prediction. It remains unclear whether effects observed in L2 prediction—such as reduced or altered neural markers of anticipation—are driven by experience with the target language, or by broader cognitive and neural differences associated with bilingualism, such as managing two languages, increased demands on language control, or greater linguistic uncertainty. We hypothesized that sufficient target-language experience is required to generate robust prediction effects. In addition, we explored whether bilinguals with high proficiency might still show differences in the nature or distribution of prediction-related neural responses compared to monolinguals, reflecting the influence of dual-language experience. To index predictive engagement, prior studies have examined the relationship between aperiodic slope—a measure of broadband, non-oscillatory EEG activity linked to global brain state—and the N400 effect of prediction facilitation, finding that steeper slopes are linked to larger N400 effects (Dave et al., 2018). We explored the effects of target- and dual-language experience on

prediction in EEG during reading of English high- or low-constraint sentences. Mandarin-English bilinguals of varied English proficiency and English monolinguals participated. Bilinguals were median split into high and low English proficiency groups, with the high-proficiency group matched to monolinguals. Aperiodic slope was measured before target word onset, and N400 amplitude was measured at the target. High proficiency bilinguals showed larger N400 effects than low proficiency bilinguals, and more posterior and enhanced N400 effects compared to monolinguals—suggesting that, when target-language experience is sufficient, dual-language experience may enhance prediction in supportive contexts. To assess whether language knowledge contributes to predictive facilitation, we conducted a continuous analysis using LexTALE—a standardized vocabulary test estimating English proficiency. LexTALE predicted N400 amplitude across all groups, indicating that greater vocabulary knowledge enhances prediction, regardless of bilingual status. Finally, we replicated Dave et al. (2018), showing that steeper aperiodic slope predicted larger N400 effects at the target. This suggests that individuals in an enhanced preparatory brain state—indexed by steeper slope—are more likely to engage in predictive processing. Within bilinguals, this relationship was modulated by language dominance, indicating that dual-language experience influences reliance on prediction. Together, these findings suggest that target-language experience supports predictive processing, while dual-language experience may shape how prediction is engaged.

B39 - Cross-linguistic and bilingual effects on morphological awareness in young bilingual Chinese-English readers

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Reading a word involves the integration of sound, meaning, and print supported by a distributed neural network. The superior temporal gyrus and supramarginal gyrus are involved in phonological processing, the middle and inferior temporal gyri support semantic processing, and the inferior frontal gyrus contributes to cognitive control. However, due to the linguistic differences between languages such as Chinese and English, children place different weights on sound-based and meaning-based processing during literacy development. To uncover the universal, language-specific, and bilingual effects in neural architecture for learning to read, we investigated the neural organization for word recognition in monolinguals and bilinguals in the US and Taiwan. We predicted that bilinguals would show the increased superior temporal gyrus and/or supramarginal gyrus activation in English (sound-based) processing, the greater middle temporal gyrus activation in Chinese (meaning-based) processing, and the elevated inferior frontal gyrus engagement in Chinese due to higher cognitive demands associated with their limited proficiency. The target sample size is 60 children per group, and the current findings were based on approximately 40 children per group. Forty-six English

monolingual (mean age: 11.12 ± 1.68 years, range: 8.65 – 14.54) and 43 bilingual children (mean age: 10.85 ± 1.90 years, range: 7.23 – 14.54) from the United States completed a lexical morphology task during functional near-infrared spectroscopy (fNIRS) neuroimaging. Future analysis will include 40 Chinese monolinguals to explore the nature of cross-linguistic transfer effects in Chinese processing in bilinguals. The current two groups were matched on age and several language abilities, including morphology, phonology, and word reading, although monolinguals exhibited greater vocabulary knowledge than bilinguals. During the imaging task, participants heard three spoken words sequentially (classroom-bedroom-mushroom) and indicated whether the 2nd or 3rd word was a better match on meaning to the 1st word (classroom). Behaviorally, cross-linguistic comparisons revealed faster reaction time in Chinese relative to English. Between-group comparisons revealed similar performance across bilinguals and monolinguals in English. fNIRS results revealed effects of bilingualism. In Chinese, bilingual children showed stronger activation in the left inferior frontal gyrus, whereas in English, they showed stronger activation in the bilateral supramarginal gyri. Notably, bilinguals' Chinese vocabulary knowledge was negatively associated with the activation levels in inferior frontal gyrus in Chinese, suggesting that greater proficiency may reduce the cognitive control of morphological processing. This pattern indicates that for young bilingual children, English morphology engages more phonological pathways, while Chinese morphology demands greater cognitive control for language processing. Additionally, cross-linguistic transfer effects were observed. In English, the bilinguals exhibited greater activation in the left middle/inferior temporal gyrus and the right inferior frontal gyrus, whereas monolinguals showed enhanced engagement of the bilateral superior temporal gyri. These findings suggest that monolingual children rely more on sound-based processing in English, while bilingual children's exposure to Chinese enhances meaning-based processing and requires additional cognitive control for semantic retrieval. Overall, this study demonstrates how early bilingual experience and linguistic characteristics interact to shape the developing neural architecture for reading. Young bilingual children appear to flexibly recruit language-specific networks, reflecting adaptations to both linguistic systems.

B40 Sandbox Series - Cross-linguistic interactions in phonological and orthographic processing in Spanish-English bilingual children: an fNIRS study

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Learning to read in English requires the development of several important skills including orthographic, phonological, and semantic representation of words, and the connections between these skills. In bilingual children, reading relies on the distributed knowledge of these components across their two languages. While prior research has established neurobiological models of reading based on monolingual evidence, it is unclear how dual-language experiences influence the neurocognitive mechanisms and networks underlying reading. Cross-linguistic transfer, where skills in one language influence performance in another, is mediated by language similarities and differences. For example, consistent sound-to-print mappings in Spanish support reading in more opaque languages like English. In the

current study, we investigate Spanish–English simultaneous bilingual children's neural activation during an English word reading task, with a focus on resolving conflicts between orthography and phonology. We test two research questions: (1) What neural mechanisms do bilingual children rely on when resolving phonological and orthographic conflicts? (2) How does bilingual language proficiency influence neural recruitment; do balanced bilinguals use similar mechanisms as English-dominant bilinguals? Using functional near-infrared spectroscopy (fNIRS), we recorded hemodynamic responses from 46 bilateral channels spanning fronto-temporo-parietal regions while participants completed a word reading task in English (48 trials). Children were presented with two written words and were asked to make a phonological judgement on whether the words start with the same sound. There were four trial types: O+P+, orthography and phonology match (e.g., look–lake); O-P+, phonology match but orthography differs (e.g., flower–photo); O-P-, neither orthography nor phonology match (e.g., dog–mom); and O+P-, orthography match but phonology differs (e.g., cent–cold). Language proficiency was assessed using the Bilingual English-Spanish Assessment – Middle Extension (BESA-ME) semantic and morphosyntax subtests and the Woodcock-Johnson/Muñoz phonological awareness and word reading subtests in both languages. The research questions and hypotheses of this study are being pre-registered. The final sample will be selected from an existing dataset of 157 Spanish-English bilingual children after pre-registration. We estimate the final sample to be between 50-70 participants. We will use a mixed-effects general linear model to analyze brain activation within the inferior frontal gyrus (IFG), inferior parietal lobe (IPL), and the superior temporal gyrus (STG). We hypothesize that bilingual children will engage all three regions IFG, STG, and IPL when processing conflicts between phonology and orthography. Based on prior literature, we expect that balanced bilinguals will show greater activation in STG and IPL as they might rely more on phonological representations and sound-to-print mappings. In contrast, we expect English-dominant bilinguals may rely more on IFG activation due to greater demands on phonological access and control processes when resolving conflicts. The outcomes of this study will enhance our understanding of how bilingual proficiency shapes neural mechanisms of reading. These insights can inform instructional strategies in educational settings by identifying which children may benefit from targeted phonological or orthographic training. Additionally, findings of this study may support the development of more linguistically responsive assessment tools for clinicians that consider the influence of both languages in bilingual children's reading development.

B41 - Facilitated Orthographic and Semantic Cognate Processing in Bilinguals

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How words and concepts are stored in the brain and accessed during language use is a central question in cognitive science (Poeppel & Idsardi, 2022). This becomes more complex in bilinguals, who manage and switch between two languages effortlessly. One way to explore this phenomenon is through the study of cognate words, which provide a unique crosslinguistic overlap for understanding how bilinguals represent and process

coactivated languages (Dijkstra et al., 2010; Roembke et al., 2024; Von Holzen et al., 2019). The Bilingual Interactive Activation Plus (BIA+) model suggests that bilinguals recognize cognates faster than non-cognate words due to their shared orthographic and semantic properties (Dijkstra et al., 2019). However, this facilitation effect is not always consistent and may depend on the degree of orthographic overlap and individual factors like language proficiency and age of acquisition (Hsieh et al., 2021; Schwartz & Tarin, 2021). Building on these findings, the present study investigated how sensitivity to orthographic overlap modulates semantic and orthographic (spelling) processing across bilinguals compared to monolinguals. Thirty-five volunteers participated in the study, including 14 Spanish–English bilinguals (mean age = 23.6, SD = 5.1) and 21 English monolinguals (mean age = 21.9, SD = 4.6). Participants completed two tasks in English. In Experiment 1, the Spelling Task, participants listened to audio recordings and provided written responses by spelling the words they heard. In Experiment 2, the LOWKAT (Level of Word Knowledge Assessment Task), they were asked to demonstrate their knowledge of a list of cognates and noncognates by providing a definition or synonym or using the word in a sentence. In Experiment 1, we found a significant interaction between group and spelling time ($F(1, 33) = 6.02, p = .02$). Post hoc comparisons showed that bilinguals were significantly faster at spelling cognates with high compared to low orthographic similarity, defined here as the similarity between the English word and its Spanish translation (mean difference = 0.56, SE = 0.14, $t = 3.996, p = .002$). No significant differences were found among monolinguals across similarity levels. In Experiment 2, we found significant group and cognate status effects on word knowledge responses. Monolinguals were more likely than bilinguals to provide a definition (Estimate = 0.87, 95% CrI [0.15, 1.61]) and a synonym (Estimate = 1.16, 95% CrI [0.54, 1.77]). Additionally, Bilinguals were more likely to use definitions and synonyms for cognates compared to noncognates (Definition: Estimate = 0.47, 95% CrI [0.11, 0.85]; Synonym: Estimate = 0.76, 95% CrI [0.36, 1.15]). These results together suggest that orthographic overlap in cognates facilitates access to both form and meaning in bilingual lexical processing. Moreover, the cognate facilitation effect appears to extend beyond early lexical access, persisting in offline tasks. This may reflect stronger or more readily accessible conceptual representations for cognates in bilinguals.

B42 Sandbox Series - Bilingual vs. diglossic code-switching in multilingual listeners: MEG evidence from English and Arabic

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Recent work in bilingualism and executive control (Blanco-Elorrieta and Caramazza, 2020) suggests that a single language system is in use for bilinguals, governed by mechanisms such as word frequency and communicative context between languages. Within these mechanisms is an assumption of a shared language space between each of a speaker's languages, in which all words compete with each other depending on linguistic context and communicative need. In order to evaluate the interaction between languages in a shared space, previous studies have focused on code-switching

between languages such as Emirati Arabic and English (Blanco-Elorrieta and Pykkänen, 2017) or Korean and English (Phillips and Pykkänen, 2021). However, Arabic exists on a continuum between standard and dialectal varieties leading to the phenomenon known as diglossia (Ferguson, 1951), in which two registers of the same language exist side by side, each associated with specific functions, and exhibiting substantial structural and lexical differences. Arabic maintains a highly codified formal register Modern Standard Arabic (MSA) and a more familiar spoken register Colloquial Arabic (CA). Speakers of Arabic are exposed to both varieties daily in different contexts and to achieve different functions. This provides an opportunity to further characterize the mechanism of bilingual language control as bilingual speakers of Arabic and English not only need to manage switching between languages (bilingual code-switching), but also between varieties of one language (diglossic code-switching) which share significant representational space. Using magnetoencephalography (MEG), we examine the neural time-course of diglossic switching by comparing sentence-internal switches between MSA, Egyptian Arabic—a variety of CA, and American English. This pilot study describes work in progress (n=4 at time of submission). Participants listened to 164 pairs of sentences which contained a single-word code-switch and 164 sentences with no code-switch. Switch materials included utterances in which the matrix language was either MSA or Egyptian Arabic, while frequency-matched code switched words were either MSA, Egyptian Arabic, or English. Data were analyzed using a temporal response function (TRF) approach (Brodbeck et al., 2023) that set as impulse predictors (a) the presence of a switch of any kind (diglossic or bilingual) and (b) that distinguished between a diglossic and a bilingual switch. A time window of up to one second after the switch was analyzed for its relationship to the impulse predictors, and predictive power of each model was assessed. Preliminary results show that model (b), which modeled diglossic code-switching, did not outperform model (a), which modeled all types of code-switching, bilingual and diglossic. This is consistent with contemporary models of bilingualism that posit a shared language space with activity at the switch modulated by mechanisms such as frequency and communicative context. Further analyses will explicitly examine the contribution of these mechanisms at the moment of switching. Our results have important implications for second language pedagogy, suggesting the current practice of integrating MSA and CA in the same classroom is comparable cognitively to integrating two distinct languages (Arabic and English, for example).

B43 - The neural bases of morphological inflection in bilinguals

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Morphological inflection is central to successful language use. However, languages differ widely in their inflection systems and in the phonological forms those inflection processes take. Theories of bilingual language organization are yet to adjudicate whether bilingual individuals rely on the same neural substrates to compute inflection across languages. One possibility is that once the mind/brain develops a mechanism for morphological inflection in one language, it will always be recruited for the same computation regardless of the language that computation is performed in (The Unified Competition Model, MacWhinney,

2022). Alternatively, bilinguals may necessitate distinct mechanisms for morphological inflection in each of their languages (Shallow Structure Hypothesis, Clahsen & Felser, 2018). The first hypothesis is particularly intuitive when languages share the same distinctions and forms for a particular morphological process (e.g., plural +s), since it would seem redundant to develop distinct processing mechanisms for the same purpose. In contrast, the latter hypothesis could be intuitively appealing in cases where each language has distinct morphological instantiations (e.g., gender marking vs not). To address this question, we collected magnetoencephalography (MEG) data from 23 Spanish-English bilingual participants during a phrase-completion task designed to elicit morphological inflection. Participants viewed a visually presented noun (e.g., "boat") followed by an auditory cue initiating a phrase (e.g., hearing "two" after reading "boat"). They were then required to complete the phrase aloud (e.g., responding "boats"). This paradigm required participants to either inflect the noun or simply repeat it, depending on the auditory prompt. Critically, Spanish and English share similar number inflection systems, marking singular and plural using three phonologically identical forms (+s, +es, and +∅). This allowed us to orthogonalize phonological realization from morphological processing within and across languages to characterize i) when and where morphological inflection is computed in the bilingual brain, ii) whether the same neural bases compute this process across languages, and iii) whether the same neural processes are recruited for the overt (-s and -es) and the covert (+∅) morphological markers. We performed permutation-based spatiotemporal ANOVAs to understand the neural computation of morphological inflection i) across different languages, and ii) in overt vs. covert realizations. We identified an effect of inflection in the inferior frontal and anterior temporal lobes between 300-400ms after the offset of the auditory cue, with higher activation for inflection trials compared to repeat trials. This effect was shared across languages, and was independent of the phonological form the inflection took. We also found a main effect of inflection type across languages in the inferior frontal lobe (100ms), where overt inflection (+s and +es) elicited increased activity over the covert inflection (+∅). This result provides evidence to support theories of bilingual language organization that posit shared neural substrates across languages and finds evidence for abstract morphological inflection, even in the absence of a phonological realization.

B44 Sandbox Series - Bilingualism, Cognition, and Brain Health in Aging: Population-Scale Investigations in the NIH All of Us Research Program Cohort

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INTRODUCTION. There has been a high level of popular and scientific interest in the idea of bilingual "benefits" or "advantages" in cognition. Current theories posit that bilinguals' day-to-day language control, shifting, planning, perception, and production experiences rely heavily on domain-general executive function networks in the brain, providing a kind of regular cognitive exercise. Cumulative bilingual life experiences are thought to result in a "cognitive reserve" that delays onsets and improves outcomes for aging-related neurodegeneration and cognitive decline. In parallel, extensive research on dementia has identified a host of modifiable risk factors for

cognitive decline and dementia across early, midlife, and later life (e.g. social isolation, hearing impairment). Given the evidence from behavioral, clinical, and neuroscience studies (albeit in modest samples), could monolingualism be a potentially modifiable risk factor for neurodegeneration in aging? In behavioral studies, healthy bilinguals often show greater EF test performance in older adulthood; and bilingual adults show differential brain structure, function, brain chemistry, and resting state activity (compared to monolinguals). While it is commonly acknowledged that low English proficiency is a social determinant of health, bilingual experiences in high English proficiency contexts are underexplored in the context of large-scale population health approaches. With over 15.5% of individuals in the US above 65 years old now identifying as bilinguals who are highly proficient in English (2022 American Community Survey), we need a clearer understanding of the biologically-driven effects language background can have on health in the population. This effort will require large-scale and well-powered data that can account for individual differences in multiple ways. **APPROACH.** This project tests the central idea that bilingualism is a biologically-relevant life experience that could positively impact brain health in aging. We will conduct a well-powered study of associations (logistic regressions) between being bilingual – with low or high English proficiency – and clinical markers of brain health in aging (e.g. Alzheimer's disease and related dementias, mild cognitive impairment). Further, we will examine associations (logistic regressions) between being bilingual, and measures of cognition (e.g., attention and executive function) available in All of Us including a version of the Flanker Task; gradual onset continuous performance task (GradCPT); and delay discounting task. Due to very large sample sizes afforded by the All of Us study ($N > 100,000$ with language background and EHR data; $N > 30,000$ have cognitive measures available), we will be able to rigorously control for multiple known modifiable risk factors of interest for neurodegeneration and dementias (e.g. smoking, physical activity levels, BMI, hearing impairment, and more: Livingston et al., 2024), with sufficient statistical power. Preliminary analyses show that $N \sim 15,000$ of those asked about their language background are bilingual. **SIGNIFICANCE.** The majority of scientific and clinical research on cognition, brain health, and aging, currently does not account for bilingual life experiences as clinically or biologically relevant. All of Us data presents a massive opportunity to investigate the impact of bilingualism on brain health outcomes at population scales, integrating methods from the cognitive neuroscience of language, epidemiology, and biomedical informatics methods.

B45 - Neural modulation of pitch and formants during altered feedback

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Precise and intelligible speech output depends on intact cortical-subcortical circuits controlling the ability to incorporate auditory feedback into ongoing motor commands. When auditory feedback is perturbed, a typical behavioral reaction is to compensate for the spectral perturbations (pitch/formants) by shifting frequencies in the opposite direction to the perturbation.

There is substantial evidence from functional magnetic resonance imaging (fMRI) for early error detection in superior temporal gyrus (STG) and subsequent motor correction in sensorimotor regions in response to both pitch and formant perturbations (e.g., Niziolek & Guenther, 2013). However, fMRI lacks the temporal resolution to precisely characterize the dynamics of this circuit. One study employing electrocorticography has shown that pitch perturbations elicit feedback-related responses in posterior STG and near supramarginal gyrus (SMG) (Chang et al., 2013). However, precise neural mechanisms and dynamics of responses to pitch versus formant perturbations have not been investigated within the same individuals. In the present study, we used stereotactic electroencephalography (sEEG) to map within-subject neural responses to pitch (± 200 cents) and first formant frequency (± 250 mels) perturbations in patients with Epilepsy undergoing clinical monitoring. At bedside, patients sustained /ε/ in words while perturbations were applied in real time. We analyzed high gamma broadband neural signal (70–150 Hz), a robust marker correlated with BOLD and single unit responses, to characterize response to pitch and formant perturbations. From 875 electrodes spanning cortex across nine patients, unsupervised clustering revealed three distinct general patterns of spatiotemporal neural activity. A cluster localized to bilateral STG and left SMG showed early auditory error detection for both pitch and formant perturbation conditions, characterized by a brief increase in high gamma activity between 0–400 ms after perturbation onset. A second cluster centered in bilateral Heschl's gyrus showed sustained neural activity (0–1500 ms) in both perturbation conditions, consistent with prolonged auditory feedback monitoring and suggesting involvement in transmitting error signals to motor-related regions. Interestingly, a third cluster in temporal pole and inferior frontal cortex showed sustained suppression across the trial, consistent with default mode network deactivation. To quantify perturbation-based effects, a one-way ANOVA for each time point grouped by condition (Bonferroni corrected for multiple comparisons, with ≥ 100 ms of continuous significance) revealed a group of 28 electrodes in Heschl's, superior temporal, and insular gyri significantly encoding differences between perturbation conditions (pitch/formant/none). Among significant electrodes, post-hoc analysis identified 24 of these electrodes with significantly higher magnitude response to pitch than formant perturbations ($p < 0.002$), with peak difference at 156 ± 64 ms after perturbation onset. This is the first study employing the high spatiotemporal resolution of sEEG to investigate neural mechanisms of both laryngeal phonatory (pitch) and oral articulatory (formant) control in the same individuals. We provide evidence for the roles of STG and surrounding areas in detecting error signals and ongoing feedback monitoring in response to pitch and formant perturbations. Further, we identify neural regions showing magnitude-based differences distinguishing sensorimotor control of phonatory versus articulatory subsystems, a finding with implications toward development of neuromodulation therapies for targeted sensorimotor learning in these domains in patients with motor speech disorders.

B46 - Visual Speech Differently Restores Temporal and Spectral Speech Information in the Auditory Cortex

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Seeing a speaker's face facilitates accurate speech perception. Previously, research has shown that listeners make use of lipreading to restore degraded auditory speech information, but these influences fail to account for the full benefits imparted by visual speech. Prior work has hypothesized that visual speech can restore information from two additional features of speech: spectral (relative pitch) and temporal information (sound changes over time). For example, listeners can recover spectral information using speakers' mouth width and the speaker's lip closure helps listeners parse the temporal boundary between words. However, it remains poorly understood whether, and how, spectral and temporal information is restored in the auditory cortex. In the current study, we asked two questions: first, is visual speech integration regionally specific, where auditory temporal and spectral information is restored in separate areas, or regionally nonspecific, where the same region restores both kinds of information? Second, how does visual speech alter the spatial pattern of auditory system activity to improve audibility of speech? We hypothesized that visual speech restores the spatial pattern of auditory activity evoked by degraded auditory speech, making it more similar to the pattern of activity evoked by clear speech. We collected functional magnetic resonance imaging (fMRI) data from 64 subjects who listened to 200 sentences presented across five conditions--auditory-alone original, auditory-alone temporally smeared, auditory-alone spectrally smeared, audio-visual temporally degraded, and audio-visual spectrally degraded. Univariate contrasts reveal that the same visual signal has different effects on auditory processing depending on the degraded auditory feature. Visual speech increased BOLD in the STG for both types of degraded speech, but differed across conditions in other regions: AV spectral recovery increased BOLD in Heschl's gyrus whereas AV temporal recovery increased BOLD in anterior STG. Second, we used Representational Similarity Analysis to compare fMRI data of audiovisual conditions to the auditory unfiltered condition. Our preliminary results from RSA analysis suggest that visual restoration of speech uses distinctly different mechanisms from auditory speech perception. To verify this finding, we plan to build a single-trial-based GLM regressor to examine if representational distance is closer between audiovisual filtered speech and original auditory speech than that of audio-alone filtered speech. Together, we show that auditory cortex uses visual speech signals to selectively recover features of the auditory signal that have been degraded.

B47 - Separating Acoustics from Phonology with Rotated Speech

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Underspecification theory claims that specific contrasting phonological features are absent from the lexical representation of phonemes (Lahiri & Reetz, 2002; 2010), predicting an interaction between Mismatch Negativity (MMN) amplitude and phoneme when minimally contrasting pairs are presented to listeners in a varying standards paradigm (Eulitz and Lahiri, 2004). Previous research (Hestvik & Durvasula, 2016; Schluter et al., 2017) observed larger MMN to deviant [d] compared to

standard /t/ than deviant [t] compared to standard /d/, which follows if /d/ is underspecified for [-spread (glottis)], because the phonetic deviant [t] with [+spread] is not contradicting the underspecified memory trace for /d/. Alternatively, the asymmetry could be due to the acoustic VOT differences between [d] and [t], not phonemic interpretation. We tested this by measuring MMN to "rotated speech". Rotation perturbs the formant structure of the vowel, rendering the signal unintelligible as speech while preserving VOT (Blessner, 1972). If the MMN asymmetry is simply driven by short vs long VOT, the same asymmetry should then be observed with rotated speech. Methods: 46 native English speakers aged 18-35 participated. The rotated stimuli were generated from the original speech syllables of [ta] and [da] by multiplying the speech waveform by a sine wave with a carrier frequency of 7 kHz. Participants heard the stimuli in a varying standards paradigm, with one group hearing [d] as deviant and [t] as standard, and the other group hearing [t] as deviant and [d] as standard. Rotated speech was presented in the first block, and normal speech in the second, resulting in deviant type (deviant [d] vs. deviant [t]) as between-subject, and stimulus type (standard vs deviant) x speech type (rotated vs normal speech) as within-subject. Results: Two difference waves for speech and rotated speech were decomposed into 14 temporo-spatial PCA components (Dien, 2010). One component (TF5SF2) was identified as the MMN, peaking at 204ms at FCz. Its factor scores were analyzed as dependent measures in a 2 x 2 repeated measures ANOVA, with group as between-subjects factor and speech type as within-subject factor. No main effect of speech vs rotated speech or group was observed in the difference wave, but the interaction between speech type and deviant group was significant ($F(1,44)=33.46$, $p < 0.00001$), stemming from a crossing interaction: for normal speech, the difference score for deviant [d] was significantly below zero, deviant [t] was not. For rotated speech, the opposite pattern was observed, with significantly larger MMN for the rotation of deviant [t] than deviant [d]. Discussion: The speech stimuli replicated previous findings with larger MMN for deviant [d] than deviant [t], while the rotated speech did not exhibit this pattern, leading to the inference that the speech MMN asymmetry reflects phonemic underspecification rather than differences in acoustics. Furthermore, rotated speech resulted in the opposite pattern. We speculate this could be acoustically driven, stemming from the "double-on" vs "single on" neuronal response to short vs. long VOT observed in monkey brains (Steinschneider, 2013), which is presumably also true for humans when purely acoustic VOT differences are processed.

B48 - Phonological Processing: A Critical Review and Meta-Analysis of 150 Functional Imaging Studies

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Phonological brain processes include mechanisms for perceiving speech sounds, activating long-term representations of speech sounds for tasks like naming and silent reading, and maintaining and manipulating such representations in working memory as needed. The neural correlates of these distinct facets of phonological processing are not yet clear, and prior functional imaging meta-analyses of phonological processing

have not attempted to distinguish them. We performed a search of PubMed, Medline, PsychInfo, NeuroQuery, and Neurosynth databases for the years 1980-2023 using inclusive search terms for phonological processes and combined this list with corpora from previous phonology-related meta-analyses. Studies were reviewed if the published abstract indicated use of fMRI or PET in healthy adult individuals. We performed a full review of 1496 papers, 150 of which passed all inclusion/exclusion criteria and reported activation foci for at least one phonological contrast of interest. Contrasts were grouped in 4 categories: Phoneme Perception contrasts comparing semantically meaningless speech sounds to a low-level auditory control with comparable task requirements (41 studies); Phonological Retrieval contrasts comparing tasks or stimuli emphasizing retrieval of phonological codes from visual input (letter strings or pictures) with controls for low-level sensory, motor, semantic, and executive processes (44 studies); Phonological Short-Term Memory contrasts emphasizing maintenance of semantically meaningless phonological information in short-term memory (23 studies); and Executive Load contrasts using letter or number n-back task comparisons (42 studies). Coordinates were coded in MNI space and analyzed with GingerALE 3.0. The resulting maps were thresholded using a cluster-forming threshold of $p < 0.001$ and cluster-level family-wise error correction at $p < 0.05$. Phoneme Perception contrasts activated bilateral but left-lateralized areas of the superior temporal gyrus (STG), extending from the lateral aspect of Heschl's gyrus to the superior temporal sulcus (STS). Phonological Retrieval contrasts activated an exclusively left hemisphere network including posterior STG and STS, posterior planum temporale, supramarginal gyrus, precentral sulcus, and posterior inferior frontal gyrus. STG involvement in the Retrieval studies was mostly posterior to the areas involved in Perception, with a small region of overlap in the posterior left STS. Phonological Short-Term Memory contrasts activated a primarily motor network including left precentral gyrus, left putamen, left supplementary motor area, and bilateral anterior insula. Executive Load contrasts activated a bilateral and more dorsal network including anterior intraparietal sulcus, inferior frontal junction and middle frontal gyrus, anterior insula, and supplementary motor area. Retrieval, Short-Term Memory, and Executive Load activations overlapped near the inferior frontal junction. The results highlight distinct networks supporting qualitatively different aspects of phonological processing corresponding to speech sound perception, mental code retrieval, code maintenance, and manipulation of phonological codes in working memory. The limited overlap between Perception and Retrieval networks suggests largely distinct input (mid-STG) and output (posterior STG) phonological streams in the superior temporal cortex.

B49 - The Parallel Function of Common and Prosodic Boundary : Evidence from Chinese

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The study investigated the brain mechanisms underlying sentence segmentation in both visual and speech modalities, examining whether the two modalities serve parallel functions.

Previous studies have shown that the Closure Positive Shift (CPS), an event-related potential (ERP) component, occurs during prosodic boundary perception in speech and during sentence segmentation in reading. Although this component has been explored in German and Dutch, no direct evidence has been found in studies using natural sentences. Steinhauer and Friederici (2001) used sentences with comma errors, and Kerkhofs et al. (2008) observed CPS effects only in the auditory modality. Previous studies showed that the results were also heavily influenced by participants' awareness of commas. This study focused on Chinese, a language that may provide novel insights due to its unique syntactic structures and higher awareness of comma usage because of the absence of word spacing in written Chinese. Twenty-four native Mandarin speakers participated in the experiment, aged between 18 and 30. The material included 120 unambiguous sentences, disambiguated either by a prosodic boundary in the auditory modality or by a comma in the reading modality (e.g., 小明找不到爸爸, 妈妈很着急 [Xiaoming couldn't find his dad, and his mom was very anxious] and 小明找不到爸爸妈妈, 很着急 [Xiaoming couldn't find his dad and mom, and he was very anxious]), along with 120 filler sentences. In the reading task, sentences were presented using the Rapid Serial Visual Presentation (RSVP) paradigm, with the comma shown together with the critical word (e.g., [爸爸, father]). Each word was displayed for 500 ms, followed by a 400 ms blank interval before the next word appeared. In the listening task, participants listened to each full sentence. After each sentence in both tasks, participants answered comprehension questions to assess their understanding of sentence structure and meaning. Each task lasted approximately 40 minutes, and the order of tasks was counterbalanced across participants. Epochs were extracted from 200 ms before to 1000 ms after the onset of the critical stimuli, which included the comma-carrying words in the reading task (e.g., [爸爸, father]) and the prosodic boundary (e.g., pauses) in the listening task. The time window for the visual task was set from 300 ms to 400 ms, and for the auditory task, it was from 350 ms to 600 ms, based on previous studies. Preliminary analyses revealed that both visual and auditory conditions elicited the CPS component, though its amplitude was significantly larger in the auditory modality than in the visual modality. These results supported the implicit prosody hypothesis showing that implicit prosody triggered during reading served a similar function to explicit prosodic boundaries in auditory processing. The smaller CPS amplitude in the visual modality suggested that implicit prosody may be less pronounced or salient than explicit prosodic boundaries in the auditory condition. References: Steinhauer, K., & Friederici, A. D. (2001). Prosodic boundaries, comma rules, and brain responses. *Journal of Psycholinguistic Research*, 30, 267–295. Kerkhofs, R., Vonk, W., Schriefers, H., & Chwilla, J. (2008). Sentence processing in the visual and auditory modality: Do comma and prosodic break have parallel functions? *Brain Research*, 1224.

B50 - Always Adding Alliteration: An investigation of word form in sentence processing using alliteration

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Despite suggestions of wordform pre-activation during silent reading, there is little consensus on which factors determine the

impact (nature & timing) of orthographic and phonological feature activation in sentence comprehension. Specifically, there is continued debate over the interaction of wordform and semantic preactivation with prediction by production accounts suggesting semantic prediction is required prior to wordform preactivation. In two experiments, we used sentences comprising alliterative words that set up moderate expectancies for a critical word that either continued the alliterative sequence or did not. Critically, these sentences are low-constraint, thereby unlikely to generate a strong semantic prediction. Event-related brain potentials (ERPs), especially the N400 and post N400 positivity triggered by the critical word, served as an indices of feature preactivation and integration, respectively. In Experiment 1, 26 participants read 80 low-constraint sentences one word at a time. The first five alliterative words were followed by one of two equally low cloze critical sixth words: alliterative (AL) or non-alliterative (NA); e.g., Becky's bewildered beagle barked before beggars/workers entered the tunnel. There was a small but significant reduction in N400 amplitude (300 - 500 ms) for alliterative vs non-alliterative critical continuations suggesting preactivation based on orthographic and/or phonological wordform and not semantic features. In Experiment 2 this alliterative sentence context paradigm was used to address whether orthographic features, phonological features, or both were pre-activated during silent sentence reading. Forty participants read 120 low-constraint sentences whose first four alliterative words were followed by one of three possible critical continuations. The Orthographically Related sentence set (60 sentences) included critical words that were alliterative in sight and sound (AL), non-alliterative (NA), and orthographically- but not phonologically-alliterative (OR); e.g., Carly's curious cat carried cardboard (AL)/toothpicks (NA)/chewtoys (OR) around the house. The Phonologically Related sentence set (60 sentences) likewise included AL and NA critical words as well as phonologically- but not orthographically-alliterative critical words (PR); e.g., Sam sipped some sour sangria (AL)/beer (NA)/cider (PR) at the new bar. Replicating Experiment 1 findings, there was a significant reduction in N400 amplitudes to fully alliterative (AL) compared to NA critical words. In addition, there was a significant reduction in N400 amplitudes for the OR vs NA critical words ($p=0.0006$) but only a marginally significant reduction for the PR vs NA critical words ($p=0.056$). These results suggest that both phonological and orthographic information can be pre-activated, to a degree influenced by individual differences (still under investigation). Together these experiments suggest that wordform processing and preactivation may be more readily utilized than production accounts (which rely on strong semantic feature preactivation) have proposed.

B51 - Rethinking reading without sound: gaze patterns reveal phonological and orthographic processing in deaf skilled readers

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Reading is a complex process that involves the activation of both orthographic and phonological representations to achieve lexical access and comprehension. Limited access to auditory

phonology is considered one of the main causes of the challenges that prelingually deaf readers face when acquiring reading proficiency. In this study, we focus on a group of highly skilled deaf readers to investigate which factors contribute to their achievement. We examine whether, despite the absence of auditory input, these readers still engage in phonological processing; alternatively they might develop a heightened sensitivity to orthographic codes compared to hearing readers. We collected eye-tracking data from 44 prelingually deaf skilled readers of Spanish who have low or no access to auditory phonology. Participants read sentences manipulated with the invisible boundary paradigm: target words were primed in the parafovea (prior to fixation) with either pseudohomophones (e.g., kasa for casa), transposed-letter pseudowords (e.g., mecidina for medicina), their corresponding unrelated replaced-letter pseudowords (e.g., dasa or mevihina), or the same word (e.g., casa or medicina) as a baseline. Participants also performed a separate behavioural task to measure reading comprehension where they read narrative and expository texts and responded to multiple-choice comprehension questions testing both explicit and implicit information. We used linear mixed-effect models to examine the effects of word manipulation in the parafovea and reading comprehension on early measures of reading processing, such as first fixation and gaze duration, separately for the phonological (pseudohomophone) and orthographic (transposed-letter) manipulations. Deaf participants did not exhibit any pseudohomophone effect for either eye-tracking measure, indexed by a lack of significant difference in parafoveal priming between the pseudohomophone and pseudoword conditions. This result is consistent with previous findings showing that deaf readers do not necessarily access phonological codes during single word reading (Costello et al., 2021; Fariña et al., 2017). In contrast, in the orthographic manipulation, we found that transposed-letter words provided parafoveal priming benefits relative to pseudowords, resulting in shorter gaze durations on the target word. This result suggests that deaf skilled readers activate orthographic coding — and specifically, letter position — in a similar way to hearing readers (Belanger et al., 2013). Finally, we found a significant reading comprehension effect in all models, showing that higher comprehension scores were linked with faster reading times independently of the parafoveal manipulation. Results from this study expand the current literature on reading processes in the deaf population, providing evidence for skilled sentence reading in a transparent language like Spanish despite the apparent absence of phonological processing. On the other hand, preserved orthographic processing may be key to understanding alternative strategies that contribute to high reading achievement among prelingually deaf readers.

B52 - Lesion-based evidence that top-down connections from the language network support posterior visual word form area function

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Reading relies on a region of the brain's object recognition system in the ventral occipito-temporal cortex (vOTC) that becomes specialized for word recognition with literacy: the visual word form area (VWFA). Prior fMRI studies in neurotypical adults have proposed a posterior-to-anterior gradient in the VWFA, reflecting increasing sensitivity to larger orthographic units, and suggest that the VWFA is shaped by top-down input from the language network. Lesions to left perisylvian language regions frequently result in alexia, possibly due in part to network-level disruptions of top-down support to the intact VWFA. However, this has not been directly tested. While right hemisphere (RH) homologues of language regions can be recruited after left hemisphere (LH) stroke, it remains unknown whether the RH homotope of the VWFA (rVWFA) contributes to reading post-stroke. This study examined how LH language network lesions affect the localization and magnitude of VWFA activity in left and right vOTC during reading. Participants included 30 chronic LH stroke survivors (LHSS) without VWFA lesions (Age=60.9(14.6); Gender=11F/19M; Months-since-stroke=56.7(56.1); Lesion Volume=67.2cm³(70.8); WAB-AQ=86.1(13.3)) and 38 demographically-matched controls. All participants completed three runs of a novel block-design fMRI task involving rapid serial visual presentation of words, pseudowords, false fonts, or fixation. Word > false font contrasts were analyzed for each individual, and then entered into a mixed-effects model. A LH VWFA mask was derived from Neurosynth, then subdivided into anterior and posterior regions, and mirrored onto the RH. For each ROI, the top 10% of activated voxels were used to calculate activation magnitude and center-of-mass location for each participant. Regression analyses assessed the effects of group (patient/control), hemisphere (left/right), and subregion (anterior/posterior) on activation magnitude and localization along the anterior-posterior axis. Covariates included age, education, handedness, and lesion volume. A main effect of hemisphere revealed that both LHSS and controls showed relatively less activation in the whole rVWFA relative to the lVWFA ($t(128)=-7.82$; $p<0.001$). This effect held for both anterior and posterior subregions ($p<0.001$). Further, LHSS demonstrated significantly reduced activity in the posterior lVWFA relative to controls ($p<0.001$), which drove significant group-by-subregion interactions when comparing posterior lVWFA vs posterior rVWFA ($p=0.01$), and posterior lVWFA vs anterior lVWFA ($p=0.001$). Regression analyses predicting y-coordinates of peak activation within the whole lVWFA confirmed that peak activation was farther anterior in LHSS relative to controls ($t(62)=2.48$; $p=0.015$). An exploratory analysis of five additional LHSS with lesions to the lVWFA provided preliminary evidence of both decreased activation in the lVWFA and increased activation in the rVWFA, relative to both control and non-VWFA lesioned LHSS. These findings provide new lesion-based evidence that top-down connections from the language network support typical VWFA function. LH strokes that spare the VWFA can result in a decrease in posterior lVWFA activation. We hypothesize that disconnections from specific language regions may underlie

these effects. Next steps include testing this hypothesis using lesion-symptom mapping methods, and determining how deactivation of posterior lVWFA affects reading outcomes after stroke. This information will be essential to understand adaptive reorganization of the VWFA, potentially including recruitment of the rVWFA.

B53 - Causal evidence of a temporo-parieto-frontal network supporting reading: An investigation in patients with gliomas

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Applying advanced neuroimaging and stimulation techniques in brain lesion research offers unique causal insights into the neural mechanisms underlying cognitive processes beyond studies in healthy populations. However, research on the brain network supporting reading, one of the most complex and uniquely human cognitive abilities, remains scarce. Addressing this gap, we conducted voxel-based lesion-symptom mapping (VLSM) and direct cortical stimulation (DCS), two complementary methodologies, alongside other MRI modalities, in a cohort of 278 glioma patients. Our findings highlight the critical involvement of well-established reading-related regions, including the left superior temporal gyrus, supramarginal gyrus, and inferior frontal cortex, as well as previously underreported areas such as the hippocampus. Notably, the left inferior frontal cortex, superior temporal gyrus, and supramarginal gyrus emerged as key convergent areas across both VLSM and DCS approaches. Further analyses incorporated diffusion MRI ($n = 131$) revealed that the arcuate fasciculus and corticospinal tract play pivotal roles in reading function. Additionally, resting-state function MRI data ($n = 118$) identified a distributed temporo-parieto-frontal network linked to reading performance, with the left precentral gyrus and right inferior frontal cortex involved, acting as potential compensatory hubs based on the past literature's interpretation. Together, these results provide compelling causal evidence for the involvement of specific brain regions in reading within glioma patients and offer a broader perspective on the distributed neural network underlying this essential cognitive function.

B54 - Reading Skill Predicts Variability in Pseudoword Pronunciation: An Experience-Dependent Basis for Neuroimaging Analyses

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In English, inconsistencies in spelling-to-sound mappings often yield multiple plausible pronunciations for a single pseudoword. While there have been neuroimaging studies investigating pseudoword reading and its relationship to reading skill, these studies are often limited by rigid binary definitions of pseudoword "accuracy" and overlook the variability in how pseudowords are actually pronounced. We propose that capturing this variability can offer a valuable behavioral anchor

for interpreting individual differences in brain activation patterns during reading, consistent with experience-dependent and statistical learning frameworks. Fifty-one participants completed the Word Identification and Word Attack subtests of the Woodcock Reading Mastery Test (WRMT). Age-adjusted Basic Skills Composite scores were used to divide participants into three reading skill groups. During an fMRI scan, participants read aloud 40 pseudowords; responses were recorded and phonetically transcribed. To better characterize pronunciation variability, we defined several accuracy thresholds based on sample-level response distributions of pronunciations where accurate was defined the following six ways starting with the most stringent and proceeding to the most lenient: (1) most frequently produced in the sample; (2) among the top two most frequently produced in the sample; (3-5) in the top 25%, 50%, or 75% of cumulative response probabilities, and (6) produced by at least one other participant. For each participant, the proportion of accurate pronunciations under each threshold was calculated and correlated with WRMT reading scores. All within-sample accuracy definitions showed significant positive correlations with reading skill (all p s < .05*), with the strongest association observed for the top 75% cumulative response ($r = 0.54$, $p < 0.001^{***}$). To assess how pronunciation variability differed by reading skill group, we calculated the mean Shannon entropy for each pseudoword spelling across groups. A linear mixed-effects model predicting entropy from reading group (with random intercepts for pseudowords) revealed a significant effect of reading skill group. Specifically, compared to the high-skilled reading group, both the average- and low-skilled groups demonstrated significantly higher entropy values (Average: $t(78) = 2.23$, $p = 0.02^*$; Low: $t(78) = 9.12$, $p < 0.001^{***}$). These findings demonstrate that readers with higher skill levels produce more consistent pronunciations of pseudowords, as indexed by group-based probability thresholds and entropy. Capturing this behavioral variability may provide a foundation to interpret more granular individual differences in neural responses during decoding, moving beyond binary notions of accuracy for pseudowords, and enhance our understanding of sublexical processing.

B55 - Greater fidelity of neural patterns during reading is associated with lower frequency and concreteness ratings, and higher orthographic distance

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Lexical and semantic features are represented across a set of language cortical regions. Previous work has used representational similarity analyses (RSA) to determine that specific regions encode lexical and semantic features in a set of individuals. However, such work does not address whether the representational patterns are more or less likely to be reproduced across individuals in relation to these psycholinguistic variables (e.g., orthographic neighborhood). To address this, here we used fMRI and an RSA approach to quantify the representational fidelity (RF), which is the degree to which stimulus-evoked multivoxel patterns are reliably structured across individuals. Although traditionally used to define the noise-ceiling in RSA, here we used it to examine the representational signal-to-noise ratio for individual words in an

fMRI study of reading. We hypothesize that there will be a relationship between RF and both lexical and semantic features within brain regions associated with language processing. 32 participants underwent fMRI scanning while reading 160 words presented 4 times. For each participant, an RSM was generated by cross-correlating the activation patterns within a region of interest (ROI) elicited from each word stimulus. RF was then calculated for each word by correlating each participant's RSM with the group average RSM while leaving that participant out (e.g., the correlation between RSM1 and the mean of RSM2-RSM32). This results in an RF value for each word, or 160 RF values total for each ROI. 38 individual ROIs representing left-hemisphere regions previously associated with lexical and semantic processing were generated using the Yeo 17 – Schaefer 400 parcellation atlas. Word frequency (log-transformed), length, concreteness, and orthographic distance (OLD20) measures were also obtained for each word. Multiple regressions with RF as the dependent variable were then performed for each ROI using word frequency, length, concreteness, and orthographic neighborhood as covariates of interest, and corrected for multiple comparisons using FDR ($q = 0.05$). Additional whole-brain analyses were also conducted (voxel thresholded at $p < .005$, cluster corrected to $p < .05$). ROI analyses revealed negative associations between word frequency and RF in parcels corresponding to the inferior frontal gyrus (IFG), supramarginal gyrus (SMG), the ventral occipito-temporal cortex (vOTC), and posterior portions of the middle temporal gyrus (pMTG). Additionally, there were negative associations between concreteness and RF in parcels corresponding to the angular gyrus, anterior temporal lobe, posterior cingulate cortex, and pMTG. That is, words with lower frequency or concreteness values correspond to higher RF within regions associated with language and semantic processing. In contrast, there was a positive association between orthographic distance and RF in parcels corresponding to the inferior frontal and supramarginal gyri, vOTC, and pMTG. That is, words with higher orthographic distance had higher RF within language regions. Whole-brain analyses revealed similar results. This suggests that words with a sparser orthographic neighborhood, lower concreteness, lower frequency, and longer words are associated with higher representational SNR. Overall, this body of work provides a novel approach for examining the neural components of the reading system based on the fidelity of neural patterns.

B56 - “Tactile word form” responses in parieto-occipital cortices of proficient blind braille readers

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Reading recruits specialized neural populations in the lateral ventral visual stream (vOTC), including the so-called ‘visual word form area’ (VWFA). The VWFA neighbors other visual object recognition regions, including the fusiform face area and parahippocampal place area, but is functionally and anatomically distinct. One hypothesis for the consistent location of the VWFA across individuals is that it is optimized for connectivity between visual and language networks. Here we test the hypothesis that, analogously, blind braille readers to develop braille specialization in anatomical regions that interface between touch and language. Posterior parietal

cortices (PPC) participate in high-level tactile perception (Saadon-Grosman, Arzy, & Loewenstein, 2020; Rolls et al., 2023). Moreover, neurobiology of language is changed in blindness and blind individuals recruit 'visual' cortices during spoken language processing. Here we report that posterior parietal/dorsal-occipital regions (PPC-DOC), at the border of tactile and occipital language networks, are functionally specialized for braille in people born blind. Congenitally blind braille readers ($N = 20$) participated in two experiments. In Experiment 1, participants read braille words and consonant strings, touched shapes made from braille dots, and listened to spoken words and backwards speech. In Experiment 2, blind participants touched small 3D models of faces and small maze-like 'places.' Sighted participants ($N = 20$) performed analogous visual experiments. We tested whether blind readers develop responses to braille in PPC-DOC that prefer braille over speech and over tactile face and scene perception. An individual-subject leave-one-run-out analysis identified voxels in PPC-DOC that respond more to braille words than shapes made of braille dots ($t(19) = 4.6$, $p < 0.001$). These voxels also prefer braille words to spoken words ($t(19) = 4.7$, $p < 0.001$). Consistent with a specialized-for-braille hypothesis, braille-preferring voxels also failed to distinguish between faces and scenes ($t(19) = 0.3$, $p = 0.79$). By contrast, separate neural populations in parietal cortices responded preferentially to tactile faces and tactile places, respectively (p 's < 0.001), and these voxels did not prefer braille or spoken words over the associated controls. In fact, face-preferring neural populations responded more to tactile shapes than to braille words ($t(19) = 2.4$, $p = 0.028$), mirroring the functional profile observed in vOTC of sighted readers. Overlap maps of the voxel populations across subjects revealed bilateral responses to braille, with a different anatomical distribution from face and scene responses. Braille responses were relatively consistently localized across blind readers (up to 50% of subjects overlap), peaking on the parieto-occipital border, in area V3a. In sighted participants, this parieto-occipital region is retinotopic and motion-sensitive (Tootell et al., 1997; McKeefry et al., 2008.) We also observed variation of braille response peaks along the anterior/posterior axis across individuals. Our results suggest that tactile reading recruits a differently localized orthographic processing circuit. We hypothesize that development of modality-specific orthographic representations is shaped by connectivity to the language network and sensory input systems.

B57 Sandbox Series - Combing accelerated theta burst simulation with reading instruction: A RARE treatment model for persistent dyslexia

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Developmental dyslexia (DD) is a neurodevelopmental disorder that results in poor reading proficiency due to atypical neurobiological attributes. Despite many opportunities to learn, the most resistant cases of DD can still have severe reading problems that persist into adulthood. Although there are several remediation techniques that can be effective for children with DD, there are no additional treatment options for adults with persistent, treatment-resistant DD. In addition, making changes in reading behaviors in adults with DD is challenging due to their age-related decreased potential for neuroplasticity in neural circuits that support reading. This population may be ideally

suited for a neuromodulatory adjunct to traditional education-based treatment. The current study aims to assess the impact of a combined accelerated theta burst stimulation (aTBS) and an individualized educational intervention paradigm to improve reading outcomes in young adults with persistent DD. Specifically, we utilized aTBS as a tool to modulate cortical excitability to enhance reading outcomes in response to reading intervention. This multiple baseline, single-subject design is the first to assess the effectiveness of combining aTBS and an individualized reading intervention program for the treatment of DD. The current, ongoing pilot study included native English speakers between 18 and 30 years of age (mean age = 21.25) with a documented or suspected history of DD or other reading disability. All subjects met study-based criteria for reading impairment as identified by scoring below age-norm expectations on at least one subtest of a standardized reading measure (TOWRE-2, WJ-IV) and tested into the study reading intervention curriculum (level B2 or C on SRA Corrective Reading Decoding Placement Test). Two to four subjects were run concurrently in a cohort design. Each cohort participated in 10 nonconsecutive treatment days over five weeks, with two to three treatment days per week, each with two treatment sessions per day (20 sessions). Treatment days consisted of two sessions that included an aTBS session immediately followed by a one-on-one 30-minute reading intervention administered by a trained reading specialist. Each subject received a minimum of two baseline days which included sham aTBS plus reading intervention. Subjects were then randomized into active stage start day which included active aTBS plus reading intervention. Daily oral reading fluency assessments, completed at the beginning of each treatment day, included a selection of passages from the Texas Middle School Fluency Assessment designed to measure growth in reading. Passages were identified to be consistent with subjects' Lexile reading level (mean = 1120.5). Words read per minute and total errors were calculated as measures of oral reading fluency and accuracy. Preliminary results indicate that combined aTBS and behavioral reading intervention improves oral reading fluency and accuracy above reading intervention alone. Those with more active aTBS sessions showed great gains in reading. Additionally, those subjects with a lower reading level at baseline (SRA B2) showed greater gains than those who tested at a higher reading level. As such, increasing neuroplastic potential with aTBS may help to improve reading in those with persistent DD, when used as an adjunct to behavioral intervention.

B58 - Modeling Sign Language Production in Light of Neurological Impairment

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Conduction aphasia resulting from a traumatic brain injury typically presents with deficiencies in linguistic production. Patients with spoken language conduction aphasia have fluent speech production with good auditory comprehension, but show a disproportionate inability to repeat, with frequent phonemic errors in production. These patterns are typically explained as resulting from damage to the interface between separate linguistic sensory and motor systems. However, there are no known cases which examine how a person who uses a visual-

modality language may be affected by this disorder. We present a unique case study of a 59-year-old native Deaf ASL signer "D.K." with bilateral lesions in the right and left temporal-parietal lobes. She shows well-preserved ASL comprehension, but with formational errors in sign production and fingerspelling, and significant disruption in the repetition of signs and non-sign manual actions. In the case of DK, we present evidence that the observed sign language and manual errors implicate impairment of somatosensory feedback in hierarchical motor plans underlying sign production. Specifically, at the broadest-level, we posit that an arm-based ballistic gesture is guided by a specification for a body or spatial target configuration (i.e. a postural target, see Corina 2021). Proprioceptive knowledge in the superior-parietal regions is a robust signal that drives the execution of location-specified path movements. Superimposed upon this broad movement is a finer-grained somatosensory-based specification for handshape configuration. In the present case, the loss of somatosensory knowledge of the fingers, thumb positions, and palms leaves D.K. vulnerable to phonetic formational errors. This could reflect an underspecified forward model of handshape information and/or impairment in the evaluation of error signals between the intended target handshape and her actual production. The compositional nature of signed languages may expose the interactions between somatosensory and proprioceptive signals in skilled manual actions. This case study is unique, and is, to our knowledge, the first description of a conduction-like aphasia in a signed language user. Corina, D. P. (2021). Articulatory postures and forward models in American Sign Language: Linguistic and neuroscience evidence. *FEAST. Formal and Experimental Advances in Sign language Theory*, 4, 61-73.

B59 Sandbox Series - Perceptual categorization in the visual domain: evidence from three sign languages

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Category is a fundamental feature of language architecture. Perceptual categorization (PC) has been widely studied for spoken languages, but only a few studies have been conducted in sign languages (see Baker et al., 2005; Best et al., 2010; Emmorey et al., 2003; Mertz, 2024). Previous studies have shown mixed results and were limited by types of stimuli used (e.g. still images, disembodied hands or unnaturally synthesized signs). In this study, we use realistic avatars signing four handshape contrasts to examine PC in users of Catalan Sign Language, Spanish Sign Language and Sign Language of the Netherlands. To explore whether differences in categorization depend on the type of phonological feature, contrasts involved changes in selected fingers or in finger position (curving and spreading of the fingers). The contrasts included existing and non-existing feature values (i.e. handshapes) in the phonological repertoire of the sign languages to examine the role of linguistic knowledge in the perception of categories. Finally, we test signers and non-signers to examine how much PC in sign language is driven by familiarity with this linguistic modality. We present pseudosigns as name signs of members of a family. Stimuli were recorded by a signer using motion capture and then synthesized on a metahuman avatar. For each contrast, we created a set of eight stimuli equally distributed

between the two target signs. Participants perform an ABX (categorization) task and a same-different (discrimination) task in two orders (ABX-BAX, AB-BA), and provide confidence ratings for the responses on the ABX task. For each contrast, the ABX task has 64 trials (8 contrast variants x 4 repetitions x 2 orders), and the same-different task 96 (6 contrast variants x 4 repetitions x 2 conditions (same-different) x 2 orders). If the sign contrasts are perceived categorically, the categorization task should show the typical sharp between-category shift on the continuum, and discrimination should be greater at the category boundary. The confidence ratings will reflect tolerance to (phonetic) variability in the feature value. Based on previous findings and pilot data, we expect results to depend on contrast type. For changes in selected fingers, we expect to find evidence of PC, while changes in finger position may be a matter of degree rather than category. Category may depend on anatomical features that serve as reference points: change in spread is contrastive between +/- contact between fingers. We will examine group and individual differences to probe whether experience with a specific sign language alters one's categorical boundaries. By including non-signers, we will be able to test whether any PC effects are due to (sign) language experience or to more general visual-domain classification of the human body. Data collection is under way, and we will present the results at the conference. The findings will reveal commonalities and differences in the auditory and visual linguistic domains. This work contributes to understanding better how PC of phonological contrasts is processed in our minds and paves the way to investigating how linguistic categories are represented in the brain across different modalities.

B60 Sandbox Series - Localizing visual mismatch responses by hearing signers of American Sign Language (ASL) using Magnetoencephalography (MEG)

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Mismatch responses (MMR) provide a window into the brain's automatic detection of stimuli changes, which have been used to study pre-attentive linguistic processing at various levels. While many auditory MMR (aMMR) studies have reported automatic phonological and lexical processing localized to the fronto-temporal networks, only one EEG study has looked at visual MMR (vMMR) in a sign language. They found enhanced responses by deaf Hong Kong Sign Language (HKSL) signers to lexical signs (vs. non-signs) around 230ms compared to hearing non-signers, suggesting a similar automatic lexical processing in the visual modality but with topological differences. Using Magnetoencephalography (MEG), the current study established a vMMR paradigm in American Sign Language (ASL) to better localize vMMR and to examine the role of sign language experience on visual processing among hearing signers and non-signers. We used a visual oddball paradigm where deviants are interspersed within standards about 15% of the time. Each block includes one standard-deviant pair that differs only in the handshape. Two ASL lexical signs (BOY: flat-O handshape at forehead; KID: horn handshape at nose) were selected, and two non-signs were created by switching the handshapes of the real signs (BOY-

fake: horn handshape at forehead; KID-fake: flat-O handshape at nose), creating four standard-deviant pairs, two with real-signs as deviants and two with non-signs as deviants. Static sign pictures were presented in peripheral visual fields, and the participants were instructed to focus on the change of central fixation cross as a distraction task. We are aiming for 16 participants in each group. Here we report preliminary group findings from 13 hearing signers (mean age = 32; average years of signing = 13.8; ASL-CT score = 23.8) and 10 age-matched hearing non-signers. The vMMR is calculated by subtracting the evoked standard response from the evoked deviant response for each standard-deviant pair. When lexical signs served as deviants, non-signers showed a ventral stream processing pattern with activations in primary visual areas and inferior/middle temporal regions. In contrast, signers showed earlier vMMR responses (140-180ms) primarily involving the dorsal stream, with activations in superior/inferior parietal regions, sensorimotor cortex, and Broca's area and insula, which indicates a role of sign language experience on the automatic visual processing of the lexical signs. When non-signs served as deviants, both groups showed more distributed activation patterns, though signers still showed earlier vMMR responses. These findings suggest that sign language experience shapes pre-attentive visual processing for ASL lexical signs. Specifically, non-signers predominantly rely on the ventral visual pathway for object recognition, whereas signers recruit the dorsal pathway for both visual and language processing, integrating visual, spatial, and motor information crucial for sign language representation. This study provides novel MEG evidence for modality-specific adaptations of automatic language processing in the brain. We will use whole-brain permutation cluster tests as well as ROI-based analyses to statistically test group differences once the data collection is complete.

B61 - Visual language experience modulates the perception of sublexical iconicity

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Iconicity refers to the perceived similarity between the form and meaning of a linguistic unit. Signed languages display more iconicity than spoken languages due to their visual modality and relatively young age. Prior work comparing ratings by signers of different languages has shown that the perception of iconicity is modulated by linguistic experience (Occhino et al. 2017). This study compares how signers and hearing non-signers perceive iconicity in two signed languages to examine the effect of experience with a language modality. Iconicity ratings by American Sign Language (ASL) signers and US non-signers were drawn from the ASL-LEX database for 300 ASL signs and by Spanish Sign Language (LSE) signers and Spanish non-signers from the LSE-sign database for 300 LSE signs. Each set contained a similar distribution of high and low iconic signs and 184 signs were translation equivalents. Ratings by signers and non-signers showed strong correlations in both languages: $r(298) = .81, p < .001, r(298) = .74, p < .001$. To examine whether discrepancies in ratings were systematic, we classified the iconic mechanisms at play in each sign. All signs were annotated for their iconic strategy using a phonological

decomposition approach (adapted from Pietrandrea 2002). Each parameter – handshape, location, and movement – was categorized as either non-iconic or representing one of several iconic mappings. For handshape: SELF (hand as itself), REF (hand represents another entity), OUTLINE (outlining object shape). For location: SELF (body part represents itself), REF (body part represents another object), SPACE (marked location in space). For movement: SELF (movement reflects actual movement of referent), TRACE (movement traces shape of object), ABSTRACT (movement contributes to meaning in a more abstract way, e.g. movement forward to denote 'future'). Importantly, within the set of translation equivalents, the distribution of iconic mechanisms did not differ significantly between ASL and LSE: both languages had the same most frequent combinations and nearly all logically possible combinations showed up in the annotations. Comparing signs with different combinations of iconic strategies confirmed that individual phonological parameters contribute separately to overall iconicity ratings. For instance, signs where handshape alone is iconic are consistently rated as less iconic than signs where multiple parameters contribute iconically (in both languages). Comparing ratings by signers and non-signers as a function of types of iconic mechanisms revealed different sensitivities to different combinations of iconic parameters. Signs with abstract movement and signs in which the hand or body represented itself were rated as more iconic by non-signers, whereas signs in which handshape represented an entity were rated more iconic by signers. These results suggest that non-signers identify direct iconic mappings more readily, while their experience with co-speech gestures may make abstract movements accessible to them. In contrast, signers (whether of LSE or ASL) rely on their linguistic knowledge, and consider signs with the most frequent and systematic combinations of mechanisms to be most iconic. In conclusion, iconicity can be decomposed into the contributions of different phonological parameters and experience with a signed language selectively tunes sensitivity to these iconic mechanisms.

B62 - Brain areas involved in speech motor learning in altered auditory feedback in Mandarin speakers

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In speech communication, auditory perception plays a crucial role in encoding, monitoring, and adjusting speech to ensure accuracy and effectiveness. When speaking, the brain continuously compares the planned speech outcome with auditory feedback. If there is a mismatch between the intended auditory target and the actual perceived speech output, the brain initiates corrective adjustments to minimise errors. One effective method to investigate speech motor control is using altered auditory feedback tasks. In these tasks, participants are exposed to real-time perturbations in pitch, loudness, or formant frequencies. Participants generally respond by adjusting their speech production in response to feedback perturbation. Such adaptive responses occur implicitly and involuntarily. Previous neuroimaging studies using unpredictable altered auditory feedback tasks revealed increased activity in right speech motor cortex and auditory cortex bilaterally. However, unpredictable

altered auditory feedback does not involve the feedforward control system as feedback returns to normal after each perturbation. In the current MRI study, we adopted a whole-brain analysis to reveal the brain areas involved in speech adaptation during sustained altered auditory feedback in native Mandarin speakers. A behavioural study showed that Mandarin speakers adapt to formant perturbations by offsetting the shift in the first vowel formant. The extent of adaptation is similar to that seen in speakers of non-tonal languages. We scanned 48 native Mandarin Chinese speakers while they read the syllable “dē” out loud. Speech was recorded and fed back to them either normally (baseline) or with a 110-Mel increase in the frequency of the first vowel formant (adaptation). Speech production and feedback occurred during a short (1200 ms) silent interval between echo-planar volume acquisitions (800 ms, voxel size = 2.4 mm isotropic). We compared brain activity between baseline and adaptation phases of the feedback paradigm. Brain activity was greater during adaptation compared with baseline in the right inferior frontal, supramarginal and angular gyri, and posterior lobe of the left cerebellum. Learning-related linear decreases in brain activity were seen in the primary motor cortex and somatosensory cortex, at the level of the lip and tongue representation, bilaterally. Two 10-minute resting-state MRI scans were collected before baseline and after adaptation. We then looked for changes in resting-state networks that reflected acquisition of the adapted state. We found increased connectivity between right Heschl’s gyrus and the rest of the bilateral auditory network. For the resting-state network involving the parietal cortex bilaterally, we saw increased connectivity with primary motor and supplementary motor cortex in the adapted resting state. These results are consistent with a role for a right lateralised frontal and parietal brain network of feedback control (task data) and a feedforward control/learning system within the motor, auditory and somatosensory cortex (resting-state data).

B63 Sandbox Series - Different Speech Styles Involve Distinct Auditory-Phonetic Planning Targets

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Speech production is typically modeled as a process in which speakers use auditory targets to guide motor speech planning (Hickok, 2014; Houde & Nagarajan, 2011; Tourville & Guenther, 2013). But what are these targets — abstract, categorical phonological codes or more specific representations tied to the phonetic details of an utterance? For example, previous research has shown that formant values of the same vowels systematically differ between casual and clear speech styles (Smiljanic & Bradlow, 2005; Leung et al., 2016). Are there distinct auditory-phonetic targets within a sound category for casual and clear speech, or a single prototypical target serving both styles of motor articulation? Here we use the centering effect to test this hypothesis. Centering refers to the tendency to correct ongoing utterances that are initially articulated off target, e.g., “centering” an initially off-target vowel toward a speaker’s prototypical formant values (Niziolek et al., 2013). This is argued to reflect error correction via feedback control, where discrepancies between the prototypical target and actual speech are detected and corrected over time. The centering effect, then, provides a means to identify targets in speech planning. In this

study, we asked whether speakers center to different auditory-phonetic targets during casual vs. clear speech production. Participants produced English monosyllabic vowel-initial words app(/æ/), up(/ʌ/), and ebb(/ɛ/) in two speech styles: casual (as in everyday conversation) and clear (as if speaking to a hearing-impaired listener). Data collection is ongoing. For each trial, we calculated the average first and second formant values (F1 and F2, in mels) over two time windows — an early (first 50 ms) and middle (middle 50%) window — for each vowel production. For each speaker, we computed median F1 and F2 values during the early time window for each vowel and speech style to represent distinct phonetic targets for casual and clear speech. Using Euclidean distance from each trial to the relevant medians in the early time window, we classified trials as “center” (on-target; closest third) and “periphery” (off-target; farthest third) productions (Niziolek et al., 2015). We then focused on periphery productions to compare their Euclidean distances during the middle time window to the casual vs. clear vowel medians, assessing whether formant trajectories in casual and clear speech shift toward distinct phonetic targets. A linear mixed-effects model on the pilot data revealed a significant interaction between Speech Style (Casual vs. Clear) and Phonetic Target (Casual vs. Clear vowel median) on Euclidean distance ($\beta = -0.554$, $p < .01$). This result suggests that periphery vowel productions shifted toward different directions in the acoustic-phonetic space over time: casual speech moved closer to the casual vowel medians, while clear speech moved closer to the clear vowel medians. Our findings provide evidence that speakers have distinct auditory-phonetic targets depending on speech style, indicating that there are planning processes operating within sound categories to account for systematic phonetic variation in speech production. Moving forward, our goal is to understand the neural mechanisms underlying auditory feedback control in this within-category planning process through speech-induced suppression in auditory-evoked neural responses.

B64 - Differences in the timing of action preparation in people who stutter

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Stuttering involves interruptions to the smooth flow of speech. Accordingly, speech fluency can be induced in people who stutter using external cues to time speech production. From this and related observations, stuttering has been proposed to be related to differences in the internal timing of speech. Recent studies have reliably shown differences in people who stutter in mu/beta (8-30 Hz) frequency M/EEG (magnetoencephalography and electroencephalography) activity patterns prior to speech production. Whether this difference is speech-specific or reflects a more general anomaly in motor control remains unknown. Also uncharted is the extent to which the temporal coordination of action preparation is affected in people who stutter. Here, we developed a working-memory task in which participants shifted between hand-action plans as a function of internally driven temporal expectations. Participants held the orientation of two tilted bars, each linked to an action (left or right button press) in working memory. At the end of each trial, participants were probed to report the

orientation of one of the bars. In most trials (80%), an informative retro-cue prompted participants to prioritize one visual item and its associated action plan. In half of those trials, participants were probed to report the orientation of the cued item following a short delay (1 s). In the other half, the delay between the cue and the probe was long (3 s) and participants were probed about the opposite (uncued) item. In this task, the passage of time prompted participants to shift their focus from the cued item to the other item and associated response plan. The dynamic prioritisation of action plans was mirrored by an action-specific and temporally tuned lateralised modulation of mu/beta (8-30 Hz) frequency activity as measured using MEG in both people who stutter ($n = 20$) and typically fluent speakers ($n = 20$). Source-reconstruction of the MEG signal localised the lateralised mu/beta modulation to the primary motor cortex (M1). Intriguingly, people who stutter differed from typically fluent speakers in the temporal pattern of mu/beta activity modulation when shifting between action plans. Specifically, lateralised mu/beta activity modulation was weaker in people who stutter relative to typically fluent speakers around the time of shift between action plans. In contrast, lateralised mu/beta activity modulation was similar in both groups during the later part of the delay, as participants prepared to respond in long trials. While people who stutter were less accurate in their orientation reports than typically fluent speakers in all conditions, we observed no difference in reaction time between the groups. The weakened lateralised mu/beta modulation around shift time in people who stutter may reflect differences in action preparation under uncertainty. It could also reflect differences in the temporal coordination of action preparation. Furthermore, the observed differences in manual action preparation between the groups indicate that stuttering may be linked to differences in action preparation across several motor systems.

B65 Sandbox Series - Self-Monitoring through Rhythm: Probing Prosodic Planning with Delayed Auditory Feedback

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Introduction: The role and integration of prosodic information in speech self-monitoring remain underexplored. Delayed auditory feedback (DAF) is a procedure where speakers hear their own voice with a time delay, which provides a valuable tool for investigating the respective roles prosodic and segmental cues. Prior study have shown that DAF around ~200 ms induces maximal stutter-like disruption in fluent speakers (MacKay, 1968). Although the effects are traditionally attributed to articulatory or phonetic-level issues, stress pattern manipulations appear to drive DAF disruption more than phonemic content (Kaspar & Rübeling, 2011). The 200 ms delay also aligns more closely with syllabic than segmental timing. Based on Hickok's recently updated dual-stream model (2023), which describes dorsal streams that support auditory-motor coordination and timing, we would expect prosodic processing to heavily engage this dorsal stream pathway during speech production. Interestingly, Ozker et al. (2022, 2024) showed via ECoG that dorsal precentral gyrus (dPreCG) exhibits DAF-scaled error signals tightly coupled with auditory cortex. We therefore propose that prosodic frames serve as critical components for self-monitoring and motor-time alignment in speech planning. To the best of our knowledge, no study has directly attempt to isolate prosodic from segmental error sources

under DAF condition with sentence level production, or examined classical envelope-tracking metrics during DAF tasks. This proposed experiment aims to address current research gap by testing prosodic contributions to speech production during auditory feedback perturbation, with future plans for neural investigation. **Methods:** We will use a 2x3 design comparing natural speech (normal prosody) to monotonous speech (reduced prosody) across three DAF delays: 0 ms, 100 ms, and 200 ms. Ten adult native English speakers without speech or hearing disorders will be recruited for the pilot. Speech tasks will include phonetically balanced sentences, rhythmic chants (e.g., Mother Goose), and iambic poetry. A contrastive counting task ("one two one two" vs. "ONE one ONE one") will be employed to isolate prosodic from segmental contributions. Behavioral metrics will include disfluencies, speech rate (syllables/s), and mistimed syllables. A proposed EEG version of the study will aim to assess neural responses under identical conditions. Planned analyses include stimulus-brain envelope tracking in delta (0.5–2 Hz) and theta (4–8 Hz) bands across STG, dPreCG, and ventral articulatory areas including posterior inferior frontal gyrus (pIFG)/BA44 and Spt. Connectivity will be analyzed between STG and both (a) dPreCG and (b) the pIFG–Spt complex to test whether prosodic frame scaffolding relies more on dorsal stream mechanisms. **Implications:** The study will facilitate our understanding of the role of prosodic frames in temporal alignment during speech production. We predict greater DAF-induced disruption during natural prosody than monotonous speech, reflecting temporal cue tracking and mismatched feedback sensitivity. Based on Hickok's dual-stream framework, STG–dPreCG connectivity and envelope tracking in delayed conditions are expected to be impacted, especially at 200 ms delay. Examining behavioral and neural responses to DAF will have significant implications for psycholinguistic models by clarifying the role of prosodic domains, and for clinical practice by exploring the venue of temporal processing interventions for speech disorders.

B66 - Hierarchical lateralization of the speech production network at rest

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Introduction: The dorsal stream for language is putatively strongly left-lateralized. We used resting-state fMRI to investigate the lateralization of functional connectivity (FC) in three bilateral pairs of regions engaged in the functional progression from higher-order articulatory planning to direct motor neuron output for speech. Regions included the ventral portions of primary motor cortex (MC, A4), premotor cortex (PMC, A6), and pars opercularis (pOp, A44). **Methods:** Data came from the publicly available dataset on cognitive aging from the Cambridge Centre for Ageing Neuroscience (Cam-CAN). Participants ($n=118$) were included if they were right-handed (EHI>40), obtained the maximum score on cognitive screening, and had >6 minutes of usable resting-state data. Data were preprocessed using the established Cam-CAN pipeline followed by analysis with AFNI/FSL. Residual time series were obtained by regressing motion parameters and WM/CSF signal, then band-pass filtering (0.01-0.1 Hz). We extracted the eigenvariate time series from each ROI (identified using the Brainnetome

atlas) and performed whole brain correlations across all other brain regions in the atlas ($n=274$), converting to z-scores to permit inter-subject comparison. We used three t-tests to identify significant FC differences for homologous regions, including covariates (age, sex, education, handedness, duration of usable data) and applying FWE multiple comparison correction (3dClusterSim, voxelwise $p=0.001$, corrected $p=0.01$). For each region, we present results indicating which regions were more correlated with LH and RH. Results: L_vMC vs. R_vMC: LH greater FC with L sensory/motor regions (primary auditory, ventral somatosensory, posterior insular cortices), and thalamus, as well as R dorsal angular gyrus and ventral precuneus/posterior cingulate. RH exhibited greater FC with R sensory/motor regions (primary auditory cortex, ventral pOp) and L caudal supramarginal gyrus. L_vPMC vs. R_vPMC: LH greater FC throughout L frontal and parietal lobes, anterior/posterior ITG, fusiform gyrus, precuneus, and posterior cingulate; also noted for R cerebellum. RH significantly greater FC with R sensory/motor regions and additional higher-order association cortices (MFG, IFG, pMTG, STS, IPL, SPL, anterior/posterior cingulate, precuneus); also basal ganglia and thalamus. L_vpOp vs. R_vpOp: LH significantly greater FC with wide swath of bilateral regions (much of PMC, SFG, medial OrbG, anterior/posterior cingulate, precuneus, anterior/posterior MTG and STS, anterior ITG). Additional bilateral connectivity included SMA, amygdala, hippocampus, parahippocampal gyri, and visual regions (including lateral and medial occipital cortices and fusiform gyri). Strict lateralization for IFG, MFG, and IPL, and the R cerebellum. RH significantly greater FC with multiple R regions (dorsolateral SFG, MFG, IFG, lateral OrbG, vPMC, vMC, anterior insula, posterior cingulate, precuneus, IPL, SPL, posterior ITG, entire MTG). Significant left FC present only in SMG and cerebellum. Conclusions: Overall, vMC, vPMC, and vpOp show an expanding pattern of whole-brain FC from modality-specific sensory/motor regions to higher-order cognitive, linguistic, affective, and integrative networks. Left hemisphere regions tend to exhibit broader connectivity patterns than their right homologues, with greater cross-hemispheric FC at the lowest and highest levels. Findings are consistent with the hierarchical roles of these regions in articulatory planning and execution, supporting a central role for the left hemisphere in the speech network even at rest.

B67 - EEG evidence for acoustic cue weights in speech perception

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Introduction. A core principle in phonetics is that phonemes are identified based on acoustic cues. For example, previous research has shown that voice onset time (VOT) is the primary cue for stop voicing in English, allowing listeners to distinguish perceptually between [b] and [p] in words like “beach” and “peach.” EEG studies support this finding, demonstrating that in mapping an acoustic signal to phonological categories, the P3 component is sensitive to VOT, such that P3 amplitude is greater when VOT is more prototypically “voiced” or “voiceless” as opposed to ambiguous. However, listeners rely on multiple cues with different perceptual weights. For example, in English stop voicing, the fundamental frequency (f0) plays a secondary role in phoneme identification, co-occurring with VOT and

compensating for masked primary cues. While secondary acoustic cues are central in speech perception, it is still unclear whether they are processed similarly to primary acoustic cues, and whether neurological data reflects phonetic theories that cues exist in a weighted relationship. The present study addresses this gap by considering (1) whether P3 is sensitive to secondary acoustic cues such as f0, and (2) whether P3 can be used as an assay of acoustic cue weights. **Methods.** An EEG study was designed using the oddball paradigm with stimuli varying along two stop voicing continua: beach–peach [b~p] and dear–tear [d~t]. Each continuum was manipulated in Praat for VOT (5 steps) and post-stop f0 (3 steps), yielding 15 stimuli per continuum. In each of the four blocks one of the words is the target word, and in each trial, participants hear a stimulus and press one button if it is the target and another if it is not. Each stimulus is presented 10 times in each block for a total of 1200 trials. ERP analyses were carried out with statistical validation via linear mixed-effects models. Data collection is ongoing ($n=12$, target=30). **Results.** Behavioral results show that both VOT and f0 contribute to the perception of a sound as voiced or voiceless, with a logistic mixed-effects model showing significant results for both VOT ($\beta=0.83$, $p<0.01$) and f0 ($\beta=0.37$, $p<0.01$), but a greater effect for VOT. The ERP analysis confirms that more prototypically voiced and voiceless VOTs elicit greater P3 amplitudes, and demonstrate the novel finding that more prototypically voiced and voiceless f0s also elicit greater P3 amplitudes. Finally, when we compare VOT and f0, results suggest that cue weighting is playing a role, with prototypical VOTs showing a larger P3 than prototypical f0s, and mid-continuum/ambiguous cues eliciting a smaller P3. **Conclusion.** Preliminary results paint a picture of the neural processing of phonemes that is largely in line with phonetic theory. Behavioral and ERP data demonstrate that both VOT and f0 contribute to the perception of a phoneme as voiced or voiceless, but VOT plays a stronger role. When considering the interaction of the two cues, we see evidence for cue weights, suggesting that EEG data could be a tool for determining acoustic cue weights in future research.

B68 - Effects of emotional prosody on sentence intelligibility and emotion recognition in vocoded speech

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Effective human communication requires a listener to decode not only the content of speech, but also the emotional state of the speaker. Importantly, human communication rarely takes place in optimal listening environments. Listeners typically face various acoustic challenges, such as background noise, that can exert distinct effects on the intelligibility and recognizability of different vocal emotions. Furthermore, the emotional intonation of a speaker influences the cognitive and neural function of the listener, with consequences for attention, lexical access, and memory. Thus, some vocal emotions may require greater decoding effort in certain contexts. This may be particularly true for individuals with cochlear implants (CI), who perceive speech with significantly reduced spectral detail. While CI users are generally less accurate than listeners with normal hearing in identifying both the content of speech and its emotional inflection, limited prior research has investigated whether such

disadvantages are emotion-dependent or, conversely, exist for all vocal emotions. Here, we investigated the effects of emotional prosody on sentence intelligibility and emotional valence recognition across two levels of noise vocoding: 4-channel and 8-channel. Participants (N=35) transcribed semantically-neutral sentences produced in neutral, angry, and happy prosodies that were spectrally degraded using a vocoder to retain the target number of spectral bands. Participants then categorized the emotional valence (neutral, negative, positive) of each sentence at the same two levels of spectral detail, as well as the full-spectrum versions of each stimulus. Sentences produced with happy prosody demonstrated reduced intelligibility (linear mixed-effects: $ps < .001$) in vocoded speech. While emotion recognition accuracy was high for happy prosody in full-spectrum speech, recognizability of happy prosody dropped as spectral detail decreased (logistic mixed-effects: $ps < .001$). Multidimensional scaling of categorization behavior revealed that extreme degradation of spectral information (4-channel vocoding) leads to a contraction of the perceptual dimension supporting the separation of happy and angry prosodies (linear mixed-effects: $ps < .004$), and this contraction is associated with greater uncertainty when categorizing happy speech (logistic mixed-effects: $ps < .023$). These findings suggest that the disruption of acoustic features crucial to speech intelligibility and emotion recognition, such as natural F0 contours, has a more deleterious impact on speech produced in a happy prosody than speech produced in neutral or angry prosodies. Given that speech intelligibility and emotion recognition are influenced by challenges in the listening context, and given that these challenges do not have an equivalent effect on all vocal emotions, we extend our above findings to investigate the neural correlates of emotional speech perception in vocoded speech. Participants (anticipated N=15) transcribe 498 unique sentences, equally distributed across the same three emotional prosodies studied behaviorally and presented at either full-spectrum or 4-channel vocoding. The strength of the cortical encoding of the auditory signal is measured by speech-brain coherence, and possible attention effects are investigated via alpha power dynamics. Findings may lead to an enhanced understanding of how cognitive systems process vocal emotions in challenging listening conditions and elucidate factors that help explain why speech intelligibility and emotion recognition are disadvantaged for some prosodies over others. Data collection is currently underway.

B69 - Pre-attentive phonological encoding does not track phonetic cue weighting

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Understanding how the brain encodes phonological categories requires insight into how it weighs different phonetic cues. For instance, voicing contrasts in English stops (e.g., /g/-/k/) are primarily cued by voice onset time (VOT), with fundamental frequency (F0) as a secondary cue (Kapnoulas et al., 2017). While larger mismatch negativity (MMN) responses have been linked to pre-attentive encoding of phonological—as opposed to phonetic—contrasts (Kazanina et al., 2006) and to more robust phonological category encoding (Díaz et al., 2008), it remains unclear whether a) secondary cues pre-attentively engage in phonological encoding, and b) MMN responses reflect participant-level variation in cue-weighting differences. Thus, we

conducted a behavioural task followed by an MMN experiment to address these questions. Methods: English syllables were resynthesized to vary between the dorsal stop [ga] and [ka] along VOT (short: 5, 8, 11ms; long: 47, 50, 53ms) and F0 (low: 74, 79, 83Hz; high: 132, 140, 148Hz). English speakers (n = 37) were assigned to either the VOT group (i.e., varying short and long VOT; fixed low F0) or the F0 group (i.e., varying low and high F0; fixed short VOT). Participants first completed a two-alternative forced-choice identification task, categorizing stimuli as [ga] or [ka]. The MMN experiment used the same stimuli, along with glottal [ha] syllables that varied in aspiration (“VOT”, short: 80, 83, 86; long: 122, 125, 128ms) and F0 (phonetic values identical to dorsal stimuli). Each participant completed two oddball blocks for both dorsal and glottal stimuli: one with short VOT or low F0 as standard and long VOT or high F0 as deviant, and another with the reverse configuration. We expected the VOT group to show an MMN in dorsal conditions (phonological contrast). If F0 also supports pre-attentive voicing contrasts, it should elicit a larger MMN in dorsal (phonological) than glottal (phonetic) conditions. If MMN reflects individual cue weighting, amplitudes should correlate with behavioral cue weights. Results: Behavioural results were submitted to a mixed-effects logistic regression. Coefficients for VOT and F0 were extracted for individual participants to index cue weights. Significant VOT and F0 coefficients confirmed that both cues can be utilized for the voicing contrast. The MMN amplitude was computed using temporal cluster-based permutation tests and averaged across frontocentral electrodes. In the VOT group, a significant MMN emerged only for short VOT deviants in the dorsal condition, consistent with featural accounts (Lahiri & Reetz, 2002; Hestvik & Durvasula, 2016; Monahan, 2018). In contrast, the F0 group elicited a significant MMN in both dorsal and glottal conditions with comparable amplitudes, suggesting that F0 was not engaged in pre-attentive encoding of voicing contrast. No significant correlations were observed between MMN amplitudes and individual cue weights across all conditions. Conclusion: Secondary phonetic cues can support phonological contrasts in behavioral categorization but are not engaged pre-attentively. Moreover, individual differences in cue weighting are not captured at the level of the MMN, which aligns with previous findings that fine-grained phonetic details degrade along the subcortical-cortical auditory pathway (Toscano et al., 2010; Ou et al., 2023).

B70 - Non-semantic speech decoding in the hippocampus

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The hippocampus has been recognized for its role in processing episodic and, more recently, semantic memory (Duff et al., 2020). However, evidence suggests that its function extends beyond memory to include speech and language processing, as demonstrated by hippocampal responses to sentence-level semantics (Piai et al., 2016), pronoun identity (Dijksterhuis, Self et al., 2024), and word boundaries (Ramos-Escobar et al., 2022). These responses to higher-level language processes may reflect overlaps with memory-related functions or indicate language and speech-specific processing. To further clarify the hippocampus' role in speech processing, we investigated its involvement in speech perception and production. We collected data from intracranial electroencephalographic (IEEG)

electrodes implanted in patients undergoing inpatient epilepsy monitoring for surgical resection at the Duke Comprehensive Epilepsy Center. In each trial, participants listened to an audio recording of a single word (or non-word; duration 0.5 ± 0.1 s) and spoke the word (or non-word) after a cue with 0.5-1.25s delay. Preprocessing included line noise filtering, muscle channel removal, outlier removal ($>3SD$), and common average referencing. The high gamma power (HG, 70-150Hz), which was shown to correlate with local neuronal firing, was then extracted using a multi-band band-pass filter. We first assessed whether there was word specific information in the hippocampus in Study 1 ($N = 17$, age = 33.6 ± 12.5 y, 7 Female). Of the 139 electrodes recorded in the hippocampus, 68 (49%) responded significantly during the listening or speaking epoch (cluster-corrected, time-resolved non-parametric shuffle test against baseline, FDR-corrected $p < 0.05$). We then trained a 4-way linear discriminant classifier with 5-fold cross validation to decode the target word from dimensionality-reduced HG activity ($>80\%$ variability retained after principal component decomposition) in a time-resolved manner (200ms window). The linear classifier achieved significantly above-chance decoding within 0.5s of onset in both listening and speaking (peak decoding = 36%, chance = 25%). This successful decoding suggests that the hippocampus processes speech related information. We then sought to validate and extend the findings to see if semantic information was necessary for hippocampal involvement in speech. In Study 2 ($N=31$, age = 30.9 ± 10.9 y, 16 Female), participants performed the same task with non-words. Using a similar decoding approach as the first experiment, we decoded the constituent phonemes within these non-words from neural signals in the hippocampus. Of 191 electrodes in the hippocampus, 66 (35%) responded significantly during listening or speaking. Our results showed significant decoding (peak decoding = 23%, chance = 11%), with a similar time-course of activation, providing further evidence for lower-level speech processing in the hippocampus. Together, these findings deepen our understanding of neural speech circuitry and establish the continuum of hippocampal involvement from sentence-level semantics to non-semantic phonemes to pure tones (Gillig et al., 2022).

B71 Sandbox Series - Adaptation in an uncertain environment: Pupil dilation as a proxy for locus coeruleus-norepinephrine activity and error-based learning

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INTRODUCTION Listeners regularly encounter unfamiliar talkers, noisy places, and idiosyncratic pronunciations of phonemes. Amidst this ocean of novelty and variability, there must be a system in place that allows each listener to rapidly adapt when necessary while simultaneously balancing the stability of existing representations (Friston et al., 2020; Kleinschmidt & Jaeger, 2015; Sohoglu et al., 2012). This problem becomes ever more complex in scenarios where listeners must contend with multiple concurrent challenges to perception and comprehension, such as when encountering a new talker with rapidly fluctuating noise occurring in the background. Pupillometry, or the measure of pupil area over time, has grown in popularity as a method by which to measure online effort allocation during speech perception and other demanding tasks (Brown et al., 2020; Zekveld & Kramer, 2014). Pupil dilation, modulated via the norepinephrine system (Poe et

al., 2020), is also thought to index “arousal states” which are linked to the receptivity and reactivity of a given population of neurons wherein a highly aroused state is proposed to lead to greater plasticity and ability to adapt to a changing environment (Aston-Jones & Cohen, 2005). The proposed project tests predictions from a novel hypothesis of adaptation, wherein subcortical error signals—including those originating in the locus coeruleus—to first alert the listener of a challenging listening scenario and then iteratively, and specifically, tune the relevant cortical regions to achieve improved perception and/or comprehension. Using pupillometry as a proxy for the LC-NE system, this project seeks to test how listeners enter into an adaptive state, thus allowing for the recruitment of mental resources to improve their ability to pull a talker’s voice out from background noise. **METHODS.** In the proposed study, participants adapt not only to short, spoken sentences in different noise levels (Low, Medium, Hard) but also three different talkers (Female 1, Female 2, Female 3). By having only 42 trials for each novel talker, the task maximizes the amount of time spent in an adaptive state. Each block features a different talker, and the order of talkers was counterbalanced across participants. Within each block, there are 14 sentences embedded in each Low noise (+5dB SNR), Medium noise (+0dB SNR), and High noise (-5dB SNR) condition, which were presented in 12 different fixed, pseudorandom orders. Participants are tasked with listening to the sentences embedded in noise and verbally repeating what they heard. We hypothesize that we will replicate findings that there will be larger overall pupil dilations in high noise compared to low noise (e.g., Van Engen & McLaughlin, 2018), but, critically, we expect to find larger pupil dilations early in a block, when uncertainty is highest which then reduce as listeners improve their ability to understand the talker in noise. We have also included an exploratory cue manipulation, which may further capture whether the LC-NE system is proactive and flexible during adaptation to speech. **CONCLUSION.** The results of this project will create new avenues for future research into the role of error-driven adaptation, and an integrated LC-NE system.

B72 Sandbox Series - Hemispheric differences in speech perception: The role of right temporal regions in talker-specific learning

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The ease of everyday conversation belies the difficulty of low-level speech perception. Processing a speech signal requires the listener to repeatedly map a complex array of continuous acoustic cues onto a set of discrete phonetic category representations quickly and consistently. This challenging process is less effortful and more accurate when the listener’s language system is able to adapt to the talker’s unique phonetic space. Studies of talker-specific learning show that listeners not only are sensitive to the idiosyncratic phonetic details of a talker, but also use that information to recognize both who is talking and what is being said. Talker-specific perceptual learning is supported by a bilateral network of brain regions in temporal and frontal cortex. While left and right superior temporal gyri (STG) both show sensitivity to phonetic detail, there are two competing hypotheses regarding the division of labor between the two

hemispheres. One proposal argues that the hemispheres differ in what information is represented, with left STG specializing in shorter spectral sweeps (e.g., stops) and right STG specializing in longer spectral sweeps (e.g., vowels). The other proposal is that the hemispheres differ in how information is represented, with the left being more categorical and the right being more gradient. More gradient representations of phonetic detail may also be related to more flexible processing, allowing right temporal regions to adapt more readily to novel talkers. In the present study, we test the hypothesis that right temporal regions are critical for talker-specific learning. We will investigate the role of the right hemisphere in representing talker-specific phonetic detail with a sparse sampling fMRI design. Participants will complete two different 1-back tasks in the scanner: in the 1-back talker identification task, participants will indicate whether two tokens were spoken by the same talker or not, and in the 1-back phonetic task, participants will indicate whether two tokens were the same word or not. The stimuli for this task will comprise tokens drawn from four five-point phonetic continua. These continua form a VOT-vowel matrix from “deal” to “teal” (VOT), “teal” to “till” (vowel), “till” to “dill” (VOT), and “dill” to “deal” (vowel). The tokens will be produced by four female talkers of Mainstream US English. Participants will complete three blocks each of the two 1-back tasks, with all six blocks comprising the same 64 tokens (16 stimuli x 4 talkers). We will use representational similarity analysis (RSA) to decode token information as a function of task. We hypothesize that attention to talker identity will enhance sensitivity to phonetic information in right temporal regions and diminish sensitivity to phonetic information in left temporal regions. Attention to phonetic categories should show the opposite pattern, with more fine-grained phonetic encoding in the left hemisphere. In other words, if right temporal regions are responsible for linking talker and phonetic information, then tokens will be represented more uniquely in these regions during talker identification than during word identification. This work will provide critical insight into the division of labor between the two hemispheres for speech perception.

B73 Sandbox Series - Information dynamics underlying speech perception

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The analysis of the speech signal unfolds rapidly within a distributed network of brain regions. These (often functionally specialized) brain regions extract critical acoustic and linguistic features. An important question concerns how the brain (spatially and temporally) orchestrates the processing of the various kinds of information for successful speech perception, that is what the underlying information dynamics in the speech and language network are. We use information theoretical measures to characterize and quantify these dynamics (Francis et al. 2022). First, we validate our methods by applying them to fMRI data from a binaural integration task (Preisig et al. 2021). In this task, an ambiguous speech sound (a CV syllable midway between /da/ and /ga/) is presented to the right ear while a disambiguating spectral feature (third formant, F3) is presented to the left ear. Because the successful completion of this task (i.e., the integration of unique acoustic features presented to either ear) is fully reflected in a listener's behavior (i.e. the correct identification of a CV syllable), the task allows us to

accurately characterize how the dynamics of information processing inform perception. Binaural integration was disrupted in half of the trials by means of transcranial direct current stimulation, giving us additional insight into the (in)dispensability of this relationship. Next, we expand our focus of inquiry to investigate the information dynamics underlying the perceptual classification of a fundamental linguistic feature, i.e. sentence type. Acoustically, the distinction between a question and a statement is strongly cued by a rising or a falling fundamental frequency (f0) contour, respectively (Studdert-Kennedy and Hadding 1973). We analyze source-localized magnetoencephalography data from a recent experiment in which participants listened to and classified single words according to sentence type (Oderbolz, Orpella, and Meyer, submitted). The words' f0 contours were manipulated to create a continuum between a prototypical question and a prototypical statement. In a forthcoming paper, we show that the behaviorally- and perceptually-relevant representation of the sentence type distinction lies in the left frontocentral operculum and anterior insula (Op/aINS). We now reveal that the left Op/aINS receives a high degree of unique information from the right hemisphere, especially regions in the frontal and temporal cortex, in line with its well-established functional specialization for slowly changing acoustic signals (Oderbolz, Poeppel, and Meyer 2025). In turn, the left early auditory and inferior frontal cortex contribute redundant as well as synergistic information. Together, these information dynamics interact to produce the neural representation of sentence type that informs participants' behavior and perception. Conceptualizing information as a dynamic and decomposable entity by means of information theory provides the necessary level of nuance to better understand how complex cognition and behavior arise. Although we apply these measures to questions relevant to speech and language, we emphasize their potential for the assessment of information dynamics in both basic and clinical research and in a wide range of fields.

B74 - Neural Tracking of Auditory and Lexical Processing in Bilingual Children and Adult L2 Learners under Simulated Cochlear Implant Listening Conditions

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This study investigates auditory and lexical processing in Spanish–English bilingual children and adult second language (L2) English learners by applying multivariate temporal response function (mTRF) to analyse the electroencephalography (EEG) recordings. Participants listened to audiobooks in both languages, presented either in their original form or processed through a cochlear implant (CI) simulation, to compare their auditory encoding and lexical processing mechanisms. This work is of special interest because applying EEG/mtrf at the lexical level remains relatively novel, particularly in children. Furthermore, developmental differences in early versus late stage lexical measures have rarely been explored under CI simulation, making this study well placed to shed light on how maturation shapes semantic processing in challenging auditory conditions. The sample included 23 early bilingual children (ages 7–12) and 40 adult L2 learners (ages 18–50). Participants listened to the same narrative materials across both languages. During the listening

tasks, EEG equipment recorded neural activity, and mTRFs tools were applied to model auditory and lexical tracking. Lexical properties, such as frequency, predictability, concreteness, arousal, and neighbourhood density, were estimated using a large pre-trained language model (GPT-4) based on the narrative content. Results revealed developmental differences in how degraded speech was processed. While both groups demonstrated cortical sensitivity to acoustic and lexical features, children exhibited greater difficulty with lexical prediction under vocoder conditions compared to adults. Adults' lexical tracking remained stable across degradation, indicating a more mature and adaptable prediction mechanism. In contrast, children significantly declined the lexical predictability measure when the signal was vocoded, suggesting underdeveloped strategies for semantic prediction in acoustically compromised environments. Theta-band activity, associated with fast temporal modulations and lexical access, was significantly enhanced in children under vocoder conditions, possibly reflecting a compensatory cognitive effort. However, this enhanced activity did not correspond to improving lexical tracking, pointing to inefficiencies in integrating lexical content under perceptually demanding conditions. Adults demonstrated stronger lexical frequency and neighbourhood density tracking across conditions, consistent with more mature and interconnected lexical networks. Likewise, adults exhibit a significant 'language effect' when processing lexical frequency, with some evidence supporting better Spanish tracking than English. This suggests that adults can leverage their broader exposure and experience with language when recognising words. Nevertheless, children's responses to these variables were weaker, showing a noticeable gap in lexical tracking capabilities. This suggests that their vocabulary and experiential basis for word frequency are less developed, which limits predictive processing during speech comprehension. The study concludes that while children's auditory tracking is largely comparable to that of adults, significant differences remain in higher-order lexical processing, particularly under vocoded conditions. Spectral degradation impacts children and adults differently, with children demonstrating less mature and less efficient lexical prediction. These developmental differences highlight the need for age-appropriate auditory training and language instruction strategies. These findings contribute to our understanding of lexical development in bilingual populations and stress the need for tailored training approaches that address linguistic and perceptual challenges, especially for children with hearing impairments. Future research should explore how lexical processing develops across ages in challenging auditory contexts.

B75 - The Role of Context Gating in Predictive Sentence Processing

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Humans predict upcoming language input based on the preceding sentence context and their prior knowledge of the language and the world (Altmann & Mirkovic, 2009; Dell & Chang, 2014; Federmeier, 2007; Levy, 2008; Ryskin & Nieuwland, 2023, *inter alia*). For example, the N400 event-related potential (ERP) component is more negative in response to a word that is less predictable from the preceding sentence context compared to one that is more predictable (e.g., Frank et

al., 2015; Kutas & Federmeier, 2000). The predictability of a word can be estimated using surprisal, the negative log probability of a word in context, from a language model (Levy, 2008; Hahn et al., 2022). However, human memory is imperfect. How do humans maintain the linguistic context for prediction over multiple timescales (e.g., immediately preceding words as well as the larger discourse) and optimize working memory resources such that elements that are most informative for prediction are maintained while others are not? Working memory processes associated with prefrontal cortex (PFC) have been proposed to perform such functions (O'Reilly et al., 1999) and have been modeled via neural networks with gating mechanisms which learn when to maintain important information and when that maintained information needs to be updated (Servan-Schreiber & Cohen, 1992; Hochreiter & Schmidhuber, 1997). Yet, past fMRI work suggests that the prefrontal regions associated with non-linguistic working memory (the multiple demand network; Fedorenko et al., 2013) are not meaningfully engaged during listening comprehension tasks (Blank et al., 2017; Diachek et al., 2020; Shain et al., 2019). To shed light on this, we collected EEG data while participants listened to stories from the Natural Stories corpus (Futrell et al., 2020) and extracted ERPs for each word in the stories. We replicate findings from previous literature that words that are low in predictability based on preceding context (high in surprisal) elicit larger N400 effects than predictable words (e.g., Frank et al., 2015; Michaelov et al., 2020; Szewczyk & Federmeier, 2022). To study how gating may play a role in next-word prediction, we use a performance difference metric between language models with and without gating, which we show is sensitive to word-by-word working memory demand. Long-short term memory (LSTM) networks include these PFC-like gating mechanisms while recurrent neural network (RNN) models do not. We derive a residual measure that captures the extent to which the LSTM models outperform the RNN models (Aurnhammer & Frank, 2019). We show that this residual measure is associated with the word-by-word engagement of WM (as operationalized by multiple theories), suggesting that a language model's ability to gate words in the context is particularly helpful in the same situations where WM appears to be taxed in humans. This tentatively suggests that the PFC structures which have been associated with gating (Braver & Cohen, 2000) may support adaptive memory for context during language comprehension. Finally, we explore the neural timecourse of these gating effects, finding that they appear to have most predictive power in a time window following the N400.

B76 Sandbox Series - Adapting to Foreign-Accented Speech: ERP Evidence of Interactions Between Phonetic and Semantic Processing

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Language comprehension is guided by expectations; however, perceptual input in noisy linguistic environments may deviate strongly from one's expectations, leading to a need to correct for perceptual errors or to reconstruct meaning. Two distinct mechanisms have been proposed to shape the processing of error-prone noisy linguistic signals. On the one hand, altered or degraded phonetic input may disrupt bottom-up mapping to categories and cascades to affect the retrieval of the intended

lexical item, resulting in increased N400 (Romero-Rivas et al., 2015). On the other hand, prior top-down expectations may be favored over bottom-up information given a noisy signal. Comprehenders often tolerate or ignore perceptual errors and interpret the sentence as a more plausible alternative, resulting in reduced N400 (Hsin et al., 2023, Goslin et al., 2012). Both predictions have found empirical support in the literature, suggesting that listeners may engage in both strategies depending on various factors. We hypothesize that listeners can dynamically adjust bottom-up and top-down strategies, but over distinct timescales. The discrepant evidence may arise due to different studies capturing different stages of the adaptation processes. Specifically, listeners are predicted to adapt to the perceptual input rather rapidly, overcoming initial difficulty in phonetic processing. Over a slower timescale, listeners may gradually switch to a strategy that upweight top-down prior expectations to counteract the low-level perceptual noise; this strategy may persist even after the bottom-up driven difficulty to lexical access is resolved. To test this hypothesis, we track N1/P2 (phonetic encoding) and N400 (semantic processing) to examine how comprehenders adapt strategically over time to Foreign-accented speech (FAS)—compared to native speech (NS)—in an exposure-test paradigm. Method. In an Exposure phase, participants will hear only native or foreign-accented speech, depending on group assignment (NS vs. FAS; $n = 24$ each). Critical items consist of 128 high-constraint sentences predicting a specific word (e.g., “He played the trumpet in the school...”), completed by the expected word (“band”), a cohort competitor (“bank”), a rhyme competitor (“sand”), or an unrelated word (“mist”). In the Test phase, all participants hear 40 novel FAS sentences, 30 of which ending with an expected word and 10 with a phonological competitor. Comprehenders will answer yes/no comprehension questions following 1/3 of trials in both phases. Predictions. Baseline perception: NS group will exhibit large N1/P2 responses and graded N400 amplitudes (expected < competitors < unrelated). FAS group will show an initial attenuation or delay of N1/P2 responses compared to the NS group due to increased phonetic uncertainty. We predict that bottom-up perceptual errors may increase lexical access difficulty, which in turn may lead to increased N400 for expected words, yielding less differentiation between expected words and other conditions. Adaptation: FAS group will adapt to phonetic variation in FAS rapidly, as indexed by increased N1/P2 over exposure. At the same time, we predict that the FAS group will gradually adapt their strategy to rely more on top-down prior, resulting in reduced or more selective N400s (driven by upweighted top-down prior) over the course of exposure.

B77 - Phonological neighborhood density effects in prefrontal cortex when listening to speech in noise

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Phonological neighborhood density—the number of words that sound similar to a target word—has long been considered in the context of spoken word recognition. However, the neural mechanisms through which listeners deal with increased competition are unclear. Some studies suggest neighborhood density effects are present in the temporal lobe, potentially relating to representations of acoustic features in competing

words. Other studies suggest frontally-mediated mechanisms to handle ambiguity and resolve conflicts. Furthermore, how such processes might change in the context of normal aging are unclear, and of particular importance given older adults' challenges understanding speech in noise. We conducted an fMRI study of a speech-repetition task in which we presented single spoken words in background noise to both young and older adults. Words varied in lexical competition demands, being selected to have either few neighbors (i.e., from a sparse phonological neighborhood, low competition) or many neighbors (i.e., from a dense phonological neighborhood, high competition). Participants were both young ($n = 46$; aged 19-30 years) and older ($n = 30$; aged 65-81 years) adults. To measure recognition accuracy, each trial was scored as either a correct or incorrect repetition. Accuracy was generally good ($M = .81$, $SD = .12$), and we restricted further analyses to correct responses only. As expected, at the whole brain level, spoken word recognition in noise was associated with activity in the left and right superior temporal gyrus. Supporting our hypothesis about DLPFC involvement in spoken word recognition, a region near the left inferior frontal sulcus showed a significant density effect, with Dense words eliciting more activity than Sparse words. To further characterize this effect, we extracted parameter estimates from each participant. Notably, the density effect did not significantly differ by age [$t(72.4) = 0.87$, $p = .387$, $d = -0.20$] and was not significantly correlated with hearing ability (better-ear pure-tone-average) in either the younger [$r(44) = -.18$] or older [$r(28) = .10$] group. These findings support a role for DLPFC in resolving lexical competition during spoken word recognition. Interestingly, DLPFC involvement was not related to either age or hearing sensitivity, suggesting a degree of stability in the neural systems underlying spoken word recognition outside the temporal lobe.

B78 - Cortical representation of quantification: The role of the left anterior temporal lobe

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Quantifiers like ‘all’ and ‘some’ are fundamental to how we construct meaning in language. They appear in all known languages and even emerge in the first generation of new ones (Kocab et al., 2022), suggesting they reflect a core aspect of human cognition. Yet how quantifier meanings are computed in the brain remains unclear. A major challenge in studying the neural basis of quantifiers is that, while language processing is rapid, quantifier interpretation spans the full sentence. Neural activity tied to the quantifier's composition must be separated from serial prediction effects. Using MEG, we addressed this by presenting full sentences in parallel, giving the system access to both quantifier arguments simultaneously. Prior work shows this method evokes sentence-level effects as early as 130ms (Fallon & Pykkänen, 2024; Flower & Pykkänen, 2024). 24 native English-speaking participants read 4-word English sentences flashed for 300ms using parallel presentation. The sentences contained quantified phrases as in “all cats are nice,” using either the Aristotelian quantifiers all, some, or no or the definite determiner the. Participants reported whether an immediately following stimulus was the same or different as the first stimulus, with mismatches created by swapping out one word (e.g., all dogs are nice). MEG data were analyzed from the

first stimulus only. We focused on the left anterior temporal lobe (LATL), broadly implicated in semantic processing (Pylkkänen, 2019). Generalized Quantifier theory (GQ) posits that quantifiers encode set-theoretic relations between two sets (Barwise & Cooper, 1981). The LATL has been linked to Boolean set intersection (Poortman et al., 2016), and could therefore participate in quantifier interpretation under GQ. If so, LATL should compute quantifier meaning via set intersection of its arguments, predicting: all > some > no. A second hypothesis is that LATL activity reflects quantifiers' referential properties. Restricted Quantifier theory (RQ; Knowlton et al., 2022, 2023) posits that all and no involve plural definite semantics, unlike existential some. Given LATL sensitivity to unique entities (Grabowski et al., 2001) and to domain-restricting determiners (Leffel et al., 2014), RQ predicts stronger responses for all and no than for some. A spatiotemporal clustering test over the LATL showed a significant main effect of determiner type at 210–410ms after sentence onset. Pairwise comparisons revealed two patterns: the elicited more activation than all Aristotelian quantifiers; and all and no both elicited more activation than some, consistent with RQ. A generalized linear model confirmed these effects weren't driven solely by bigram frequency. In sum, our findings suggest that the LATL contributes to computing quantified meaning, with activity patterns supporting the Restricted Quantifier theory. Whole-brain analysis revealed no other significant quantification effects after correction. These results align with prior evidence of LATL involvement in referential processing (e.g., unique entities like celebrity names; Damasio et al., 1996) and inform representational theories of quantification.

B79 - Exploring sensory qualia relations and implicit syntactic structure in a semantic Odd-Word-Out task for Brazilian Portuguese: a normative study

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The odd word out task is designed to visualize and test the integrity of verbal semantic processing, and is often included in language batteries. There is a significant lack of standardized stimuli in Brazil, which, although of continental proportions, maintains relative linguistic homogeneity. Moreover, linguistic differences between Brazilian and European Portuguese (BP vs. EP) make relying on generalized datasets developed for EP or direct translation undesirable. Deficits in semantic processing can result from brain lesions and during awake brain surgery when direct cortical stimulation is applied to several cortical and subcortical regions and pathways (e.g., Duffau et al., 2005; Richardson et al., 2011; De Witte et al., 2015). Furthermore, lesions in different areas have been associated with trouble recognizing thematic relations between words (e.g. apple-worm) versus taxonomic relations (e.g. pear-apple) (Schwarz et al., 2011; Mirman & Graziano, 2012). In this study conducted in BP, we examined how two types of sensory-semantic relations as proposed within the qualia framework (Pustejovsky, 1995), as well as implicit syntactic relations, mediate cognitive processes involved in the context of the odd word out task. Our first

hypothesis was that these relations would be indeed seen as highly related, and our second hypothesis was that word position would influence the incremental manner in which semantic relatedness is constructed, such that memory and semantic (re)analysis would be burdened relatively more when target words are in first (but even more so in second) position, and especially so in the implicit syntactic condition, which is subject to the directionality of the linguistic structure of the language being tested. Healthy participants (n=210) performed the odd word out task on an online platform (PCIBEX). Stimuli were three-word sequences with one unrelated target word, related by (i) constitutive qualia: in "lençol fronha prato" (sheet pillowcase plate), both sheet and pillowcase are made out of cloth-like materials distinct from the plate; (ii) telic qualia: in "xícara caneca prato" (tea-cup mug plate), both tea-cup and mug are for drinking, distinct from the plate; and (iii) implicit syntactic relations, as in "bolso calça prato" (pocket pants plate), where the relation between "bolso" and "calça" can be established by the phrasal structure "bolso de calça". Accuracy was equally high (mean 94.6%) across semantic relation types (Accuracy~relation_type: $X^2(2)=4.98$, $p>0.05$) and reaction times were fastest for syntactic, followed by constitutive and then telic relations (RTs~relation_type: $X^2(2)=15.33$, $p<0.001$). Thus, semantic processing seems to be facilitated by syntactically mediated relations. Target word position also affected performance: odd words in the third position were identified more quickly and accurately than those in first or second positions (RTs~relation_type + target_position: $X^2(4)=137.37$, $p<0.001$). For syntactic relations, only 3rd position seemed to yield faster RTs, but interaction between factors was not significant. These data provide a much-needed baseline for different populations of BP speakers. Moreover, they highlight the importance of considering semantic relation types and word position when designing language assessment tools.

B80 - Structure building is more incremental during comprehension of spontaneous speech than during audiobook listening

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The naturalistic revolution in cognitive neuroscience has led to increased interest in the study of language use in naturalistic contexts. However, previous studies have primarily focused on audiobook listening, which is not the most natural mode of language use. Spontaneous speech, in contrast, comes closer to how language is used in daily life, and it has a number of features that affect the neurobiology of sentence processing, including incomplete sentences, disfluencies, and restarts. While neural signatures of syntactic structure building are found with both types of stimuli, the incrementality of structure building is found to be modulated by properties of the input across different studies. Against this background, we compare neural activity for structure building when people listen to coherent audiobooks versus spontaneous speech, in order to investigate how people's sentence-processing strategy is affected by the properties of the linguistic input. In a within-subjects design, 30 Dutch-speaking participants listened to 25-minute audiobook

stories and to 25-minute recordings of a person spontaneously answering general questions (e.g. "What is your favorite food?") while their brain activity was measured with fMRI. The syntactic structures of the sentences in both the audiobooks and the spontaneous recordings were semi-automatically annotated by a constituency parser for Dutch. We then used the syntactic structures to quantify structure building at each word via an incremental 'top-down' strategy, which builds syntactic nodes at phrase opening, and a less incremental 'bottom-up' strategy, which builds nodes at phrase closing. Using forward encoding models, these metrics were regressed against fMRI time courses in three brain regions linked to sentence-level processing: the left inferior frontal gyrus (LIFG), posterior temporal lobe (LPTL) and anterior temporal lobe (LATL). All models included the control regressors sound power, word onset, frequency, surprisal and entropy, and model fit was quantified via linear mixed-effects models. Spontaneous speech elicited stronger brain activity than audiobooks, suggesting overall higher effort and/or engagement for comprehension of spontaneous speech. Moreover, the results showed a striking asymmetry between the effects of top-down and bottom-up node count: the top-down regressor significantly captured increased activity in the LIFG and LPTL, which was larger in spontaneous speech than in audiobooks. The significant effect of bottom-up node count, in contrast, was consistently negative in all ROIs and in both types of stimuli, suggesting that brain activity decreased at phrase closing. Taken together, the data suggest that the neural response to syntax is strongly driven by phrase-opening words, which allow structure to be built incrementally. This effect was enhanced for spontaneous speech, suggesting that structure building is more incremental during comprehension of spontaneous speech. More generally, the results confirm the idea that the type of linguistic input has an effect on the mode of syntactic processing, in line with previous studies showing language-specific differences in processing strategy. This result has important implications for the neurobiology of language, because it suggests that experimental findings might not be the same when more natural and ecologically valid input is used.

B81 - Oscillatory signatures of Sentence Processing under varying Working Memory Conditions

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Recent work on neural oscillatory correlates of sentence processing suggests power decreases in alpha and beta can be associated with the processing of syntactic and semantic violations (Kielar et al., 2014). Some findings also suggest changes in alpha may reflect neural processes underlying Working Memory (WM) (Wianda & Ross, 2019). More recently, Rossi & Prystauka (2020) found that when individuals process linguistic information in their second language (L2), alpha and beta oscillations decline earlier in time than in native speakers. The authors hypothesized that processing in the L2 taxes WM resources, and that this reduction might be at the basis of the observed shortening of the oscillatory duration. Goal: The present study tests this hypothesis by manipulating WM itself in native, monolingual English speakers to create a 'taxing condition' while processing in their native language. Method: Fifty-seven monolingual English college aged students

participated in the study ($f = 28$; mean age = 19.5). Participants were randomly assigned to one of two groups: A NonMemory group ($N = 28$) completed a single-task version of a Sentence Judgement Task (SJT) while EEG was recorded. The Memory group ($N = 29$) completed a dual-task version of the SJT with an additional ongoing working memory task which required participants to memorize a sequence of three words at the beginning of each sentence, monitor the sentence for those words, and randomly recall if a specific word was present in the sentence. The SJT consisted of 60 correct sentences, 60 items with syntactic violations, and 60 items with semantic violations. Results: Time-frequency representations (TFRs) of EEG data were computed using the FieldTrip toolbox. Continuous data were epoched (-750 to 1800 ms) and TFRs (2-30 Hz, 2 Hz steps) were computed using the *mtmconvol* method with a 500 ms Hanning-tapered sliding window in 10 ms steps. Relative baseline correction (-0.5 to -0.1 s) was applied. Statistical analysis was conducted using a cluster-based permutation test, for the two memory groups separately. Following Rossi & Prystauka, three time-windows: 450-750 ms, 750-1050 and 1050-1300 – were analyzed within the 4-30 Hz frequency range. Sentences with a syntactic violation elicited an increase in theta power (4-6Hz) and a decrease in alpha-beta power (10-22 Hz) in both groups in the first time window. The decrease in alpha-beta power continued in the second, and third time window for both groups alike. Sentences with a semantic violations elicited an increase in theta power (4-6Hz) in both groups in the first-time window. In the second time window a decrease in beta power was observed for both groups, but it was maintained only in the third time window for participants who completed the task without memory load. Discussion: These results provide preliminary support for the idea that shorter oscillatory reverberations might reflect reduced working memory resources during sentence processing.

B82 - Neurophysiological mechanisms of phrase compression at the phrase boundary

Sophie Inchyna¹, Christophe Smith, Jacob Odeh, Jenna Hooper, Bryant Barrentine, Nicole Bentley, Matthew Nelson;
¹University of Alabama at Birmingham

In previous work, we developed the node-tracking framework of how the activation of neuronal populations in the brain might be construct tree-structure representations during sentence comprehension. We derived this from observations that while reading a sentence, population-level neural activity measured by high gamma power (70-150 Hz) in the left Middle Temporal Gyrus (MTG) builds up word-by-word within a phrase but declines sharply after the phrase boundary. Concomitantly, left Inferior Frontal Gyrus (IFG) activity increases transiently only at phrase boundaries, proportionate to the amount of decline in MTG activity. Here we refer to this activity pattern as the phrase compression activity profile. This framework has been highly impactful, but as of yet, the evidence behind it is merely correlational. Self-paced reading tasks have long been employed in the field as a way of measuring the dynamic processing requirements at each word in a sentence. In these tasks, longer Response Times (RTs) on a given word are interpreted as reflecting more processing required for that word. However, these tasks have seldom been paired with

simultaneously recorded neural activity of any kind, and never with intracranial neural activity. We hypothesize that when doing so, participants will show longer per-word RTs at phrase boundaries, reflecting processing related to the phrase compression activity profile. This leads to a prediction that pauses at phrase boundaries will co-occur with the phrase compression activity profile. To test this, we recorded intracranial activity (sEEG and ECoG) in 43 epilepsy patient volunteers while they performed a self-paced reading task. Participants read 3 types of sentences: Object-relative sentences, Subject-relative sentences, and control sentences. After each sentence, participants saw an array of 4 pictures, and they were tasked with choosing the picture that matches the sentence they just read. Across patients, the neural activity in the left IFG around the time of the phrase boundary showed a trial-by-trial correlation with per-word RT's at the phrase boundary that flipped it's sign between before versus after presentation of the word. Higher IFG activity before the phrase boundary word onset correlated with faster response times at the phrase boundary word, suggesting that this anticipatory activity on these trials lead to shorter word RTs. However, higher IFG activity after the word onset correlated with slower word RT's, suggesting that the lack of preparatory activity on these trials created a need for this area to "catch up" and perform these processes after the word onset, leading to a longer word RT. This effect was specific to the object-relative sentences, suggesting a particular role for the IFG for comprehension of these sentences, consistent with many other findings in the field. Neural activity in the left STS also correlated with longer pauses at the phrase boundary of object-relative sentences. Moreover, we also observed Ramping-up neural activity through-out the first phrase of the sentence, which is explained by and consistent with the node-tracking framework. Altogether, this shows a causal link between phrase comprehension measured by self-paced reading pauses at the phrase boundary, and the phrase compression neural activity profile.

Poster Session C

Saturday, September 13, 11:00 am - 12:30 pm, Field House

C1 Sandbox Series - Hemispheres are identifiable based on connectivity; but handedness is not

Trevor Day¹, Peter Turkeltaub¹, Elissa Newport¹, Andrew DeMarco¹; ¹Georgetown University

Broadly speaking, the hemispheres of the brain are structurally and functionally very similar, but some functions are lateralized, notably including language processing. After a left hemisphere (LH) perinatal stroke, the right hemisphere (RH) can reorganize to assume the language functions of the LH (Newport et al., 2022), but this is no longer possible in older children or adults. There are also some differences in the organization of the brains of left and right-handers (Li et al., 2014), with reversed laterality for language being more common (but still the minority) in left-handers. We hypothesized that we could classify a hemisphere as a LH or RH and as belonging to a left- or right-hander, based on its intrinsic organization. While task activation is certainly suitable for this problem, resting-state (RS) is generalizable between studies. Finally, we also asked which brain regions are most important for classifying the hemisphere. We investigated

whether a hemisphere can be identified as a LH or RH based on RS connectivity within that hemisphere. Using data from 935 healthy young adults from the Human Connectome Project (HCP), we created "hemiconnectomes:" partial connectomes created from ipsilateral connections. We asked if these hemiconnectomes are identifiable as belonging to an LH or RH and to a right- or left-handed individual. We tested three kinds of classifiers (Hannum et al., 2023) on RS data from HCP: a linear discriminant analysis (LDA), support vector classification, and a neural network. Each model was trained on pairwise correlations ($n = 16,110$) between all ipsilateral regions, and was asked to predict a four-way class, hemisphere X handedness. Each connection receives a value reflecting its importance to the LDA classifier. To understand what regions were most important for classification, we computed weighted node centrality, a summary value of the strength of all connections to a given region. All three models perfectly identified hemisphere chirality in both handedness groups. However, none of the models were able to discriminate between handedness groups (Matthew's correlation coefficient [MCC]: $-.07 - .33$). The small proportion of left-handers in HCP poses a class-imbalance problem. However, oversampling the left-handers did not improve the models (MCC: $-.15 - .23$). None of the model types performed reliably better than the others (post hoc Tukey adjusted p-values $> .08$). The networks with the highest node centrality (i.e. those that are most distinguishable between the hemispheres) are the cingulo-opercular (mean strength: 5.48), somatomotor (5.8), and language networks (5.28; Ji et al., 2019). Other high-strength regions are found throughout the temporal lobe. The next analytic step is to use hemiconnectomes calculated during the HCP language task, which may magnify differences between the handedness groups. The long-term goal of this project is application of the technique to the intact hemispheres of patients who suffered a perinatal or adult stroke, to measure how (and whether) their intact RH has reorganized to function more like a LH.

C2 - Neural tracking of semantic and rhythmic information under temporal compression

Zhengwu Ma¹, Qimiao Gao, Nan Wang, Jixing Li; ¹City University of Hong Kong

Introduction. Understanding how the human brain processes time-compressed auditory input is fundamental to revealing the limits and flexibility of temporal encoding across different cognitive domains. While both speech and music rely on temporally structured sequences—semantic and syntactic in speech, rhythmic and harmonic in music—the extent to which the brain can preserve and integrate these representations under temporal compression remains unclear. Recent advances in large-scale language and music models offer a novel opportunity to probe the encoding of semantic and rhythmic information in the brain. By aligning neural signals with model-derived embeddings, it is now possible to quantify how representational fidelity changes under different listening conditions. In this study, we leverage state-of-the-art neural language and music models to extract high-dimensional representations of words and music beats from AI-synthesized Mandarin songs. We then examine how these embeddings are tracked by EEG responses under varying levels of temporal

compression. This approach enables a fine-grained comparison of speech and music processing limits, providing new insights into the neural basis of auditory comprehension under time pressure. **Methods.** We recorded 256-channel EEG from 36 right-handed native Mandarin speakers (19 females, mean age = 24.8 years, SD = 6.9), all undergraduate or graduate students in Shanghai with no self-reported neurological disorders. Participants passively listened to a 2-minute AI-synthesized Mandarin song presented at four playback speeds (4×, 3×, 2×, and 1×, in that order). For each word and music beat in the stimuli, we extracted semantic and rhythmic embeddings using a large language model (LLaMA3-8B; Grattafiori et al., 2024) and a large music model (MusicLM; Agostinelli et al., 2023), respectively. Source-localized EEG epochs were then extracted from -100 ms to 500 ms relative to the offset of each word and beat at each speed condition. For each subject, we regressed word and beat embeddings against EEG signals sampled every 10 ms throughout the epoch, across all playback speeds. The regression was performed for each source within a bilateral language network mask. To assess the impact of temporal compression on speech and music processing, we compared the coefficient of determination (R^2) at the faster speeds (2×, 3×, and 4×) against the baseline (1×) condition. Significant spatiotemporal clusters for group-level speech condition contrasts were identified using a cluster-based permutation t-test (Maris & Oostenveld, 2007) with 10,000 permutations. **Results.** For speech processing, we observed significantly reduced activity in the left anterior temporal lobe (LATL) at 2×, 3×, and 4× playback speeds compared to the original (1×) speed. A similar pattern was found for music processing at 2× and 3× speeds, with decreased LATL activity. However, at 4× speed, music processing elicited a distinct significant cluster in the superior temporal regions relative to the 1× condition. These findings suggest reduced semantic comprehension and integrative processing for both speech and music at moderately compressed rates (2× and 3×). At the highest compression (4×), music processing appears to engage more low-level auditory regions, potentially reflecting diminished processing of acoustic detail.

C3 Sandbox Series - First steps towards simulating aphasia in the EARSHOT model of human speech processing

Ihntza Malharin^{1,2}, M. Belén Saavedra^{2,5}, Linkai Peng³, Simona Mancini^{1,4}, James S. Magnuson^{1,3,4}, ¹BCBL, Basque Center on Cognition, Brain and Language, ²University of the Basque Country UPV/EHU, ³University of Connecticut, Storrs, CT, USA, ⁴Ikerbasque, Basque Foundation for Science, Bilbao, Spain, ⁵Université de Lorraine, France

EARSHOT is a model of human speech processing that learns to map real speech to semantic representations (Magnuson et al., 2020). We report first steps towards simulating aspects of aphasia with EARSHOT by damaging increasing proportions of randomly selected weights in different model layers. Although the model is purely receptive, we simulated naming/identification tasks by presenting spoken words to damaged models and measuring the cosine similarity of the output to every word in the lexicon. We operationalized the model's naming/identification response as the word with highest cosine similarity. For errors, we evaluated phonetic and semantic similarity of the response to the target vector. We were interested in how robust EARSHOT would be to damage, and

whether we might observe systematic patterns of phonetic vs. semantic deficits following damage to different model components. **Method:** We trained the model on 1000 high-frequency English words spoken by one talker. The inputs were 256-channel spectral slices. The model's task was to activate the defined semantic vector (SkipGram) for the current target word at each frame. The model has 512 hidden nodes (long short-term memory nodes, or LSTMs), and 300 semantic output nodes. As each word was presented, we identified the word with peak cosine similarity to the output at any time step, and operationalized this as the model's response. The undamaged model reached 95% accuracy. We randomly masked progressively larger proportions of connections in 3 different model layers to emulate damage. We tested damaged models by presenting all 1000 words and assessing both accuracy and error patterns by measuring semantic (cosine) similarity and phonemic similarity (1 - Levenshtein distance normalized by the length of the longest word in a pair) of responses and targets. **Results:** At all levels of damage for all three locations, we observed mainly mixed errors: items with fairly low phonetic similarity and modest semantic similarity, as well as fewer items with high phonetic and semantic similarity. Relatively pure phonetic errors occurred at all damage locations, but were most prevalent for input-to-hidden damage. Relatively pure semantic errors were rarer but occurred at all damage locations. As we increased damage, the mixture of error types was fairly stable for input-to-hidden damage, but at other locations, errors became less similar to targets phonetically. **Conclusions:** We can consider the input-to-hidden transformation a primarily encoding step, where EARSHOT learns to convert spectral inputs to a complex distributed code with significant phonetic structure (despite not being trained on phonetic targets; see Magnuson et al., 2020), and the hidden-to-output step as a primarily decoding step, where the intermediate hidden code is transformed to a semantic representation. We might expect the hidden-to-hidden layer to play a combined or intermediate role, but in fact it patterns with the hidden-to-output layer. This division of labor is apparent in the persistence of phonetic errors at higher levels of damage only for the input-to-hidden layer. Our next focus will be examining to what degree these patterns relate to patient data.

C4 Sandbox Series - Modeling hemodynamic responses to the speech envelope in STG

Arielle Moore¹, Tyler Perrachione², Emily Stephen³, ¹Boston University

The amplitude envelope of speech provides important information about its underlying phonetic content, and behavioral evidence suggests these amplitude variations are critical for speech recognition. Measuring neural tracking of the speech envelope is an increasingly popular method for investigating the brain bases of speech recognition and how these may vary across individuals and conditions. However, studies of neural tracking of the speech envelope come almost exclusively from electrophysiological methods like EEG, MEG, or ECoG (Oganyan and Chang 2019; Keitel, Gross, and Kayser 2018), which have excellent temporal resolution to capture neural responses on the relevant timescales of the speech envelope (1-8 Hz). However, inferences about functional neuroanatomy from these techniques is limited, whether due to

the limited spatial resolution in EEG and MEG or limited coverage of recording sites in ECoG. Consequently, little is known about which local brain regions differentially track the speech envelope and other rapid speech features. While fMRI provides much better spatial resolution, this technique has been thought to have limited temporal resolution because it measures slow hemodynamic responses that unfold on the order of 0.05 Hz and samples (at best) at 1-2 Hz. However, recent evidence suggests that the BOLD signal has surprising temporal precision for rapid neural events (Lewis et al. 2016). The only extant fMRI study of speech envelope tracking performs classic voxelwise modeling using a convolved standard hemodynamic response function (Hausfeld, Hamers, and Formisano 2024), which may not effectively capture the BOLD hemodynamics of rapid neural events (Polimeni and Lewis 2021). Here, we are using data from a prior block-design fMRI study of participants listening to 18-s samples of dynamic, natural speech stimuli (obtained at 3T, 3-mm voxels, TR = 0.75s) to examine three different approaches to modeling neural responses to the speech envelope. Specifically, we compare a novel data-driven multivariate regression analysis approach against two classic univariate fMRI data analysis methods (FIR and HRF-convolution OLS models) with respect to their accuracy and precision in identifying latent patterns of neural activation specifically in response to the speech envelope. The models will be evaluated using cross-validated model significance measures to determine how effectively each captures speech envelope tracking responses across the superior temporal gyrus (STG). Univariate analysis of fMRI data measures differences in response magnitudes at the level of individual voxels, but its assumption of independence between voxel activities contradicts what we know about the functional relationships among voxels within similar regions and tissue types (Weaverdyck, Lieberman, and Parkinson 2020). Voxels often share temporal response patterns that may be obscured by traditional univariate approaches. This is particularly relevant for features like the fast and dynamic speech envelope which may elicit temporally coordinated responses across regions that univariate models are ill-equipped to capture. With advances in faster fMRI imaging techniques and growing evidence that BOLD signals can reflect rapid changes in neural activity, data-driven multivariate models offer an exciting opportunity to uncover novel aspects of speech processing using fMRI that have previously only been the purview of other recording techniques like EEG or ECoG.

C5 - Neural Effects of Attention Capture by Comprehensible Background Speech

Jessie Rademacher^{1,2}, Marc Schönwiesner¹; ¹Leipzig University, ²Max Planck Institute for Human Cognitive and Brain Sciences

Aims: In our daily lives, selective auditory attention allows us to focus on relevant information while filtering out distractions. Background stimuli can, however, shift the focus of attention if they are surprising or inherently relevant to the individual. While attention capture by deviant, surprising stimuli is well-examined, the role of background speech in this process remains less clear. Specifically, the extent to which unattended speech is semantically processed and to which degree its intelligibility and semantic content drive attentional shifts remain debated. To address these questions, we developed a novel experimental

approach to isolate comprehension effects by using background speech in a constructed micro-language, both before and after participants acquired fluent listening comprehension. **Method:** We examined auditory attention capture mechanisms in healthy individuals by employing electroencephalography (EEG) during an auditory task with background speech in a micro-language. Participants performed this task both before and after training in this micro-language, allowing us to isolate the effect of speech comprehension on attentional processes. Additionally, we included deviant environmental sounds and phoneme deviations in the background speech to compare attention capture mechanisms elicited by different auditory stimuli. Neural responses were analyzed using the multivariate temporal response function approach. **Results:** We show behavioral differences and neural correlates of attention capture before and after participants acquired comprehension of the background language. Specifically, differences in timing and topography of neural encoding for both target and distractor streams, compared between attention-capturing comprehensible and incomprehensible background speech, deviant sounds and phoneme deviations are shown. Additionally, we highlight differences in behavioral and neural responses to phoneme deviations in the distractor stream before and after comprehension, and contrast these effects with mere exposure to the language. **Discussion:** By clearly isolating comprehension effects, this research advances our understanding of attention capture effects by comprehensible background speech. Our findings highlight the role of intelligibility in guiding attentional shifts and provide insights into the neural underpinnings of selective auditory attention in complex listening environments.

C7 - Transformer-based LLM (WhisperX) vs Clinician Performance for Transcribing Speech Errors in People with Aphasia

Shreya Parchure¹, Harris Drachman¹, Leslie Vnenchak¹, Denise Harvey¹, Olufunsho Faseyitan¹, Roy Hamilton¹, H. Branch Coslett¹; ¹University of Pennsylvania, Philadelphia, PA

Introduction: Speech samples from people with post-stroke aphasia (PWA) offer rich markers of cognitive and linguistic status essential for diagnostics and treatment. However, the utilization of said data has been limited by the need for time- and labor-intensive manual transcription. Recent advances in artificial intelligence- (AI) based speech transcription, particularly transformer-based large language models (LLMs) like OpenAI's Whisper, hold potential for automating these processes. Despite their utility in healthy naturalistic speech, their ability to recognize impaired speech is understudied. **Aim:** Here, we examine the ability of LLMs to transcribe speech samples from the Philadelphia Naming Test administered to PWA, compared with systematic IPA transcription by experienced speech-language pathologists (SLPs). **Methodology:** We transcribed 3660 trials of PNT speech samples from 21 PWA using WhisperX in Python (model type: small.en, batch size: 32, learning rate: 5e-5, maximum sequence length: 512 tokens), which is a transformer-based model developed by Erium on OpenAI's Whisper. Each trial-level transcription was compared to that of an experienced SLP who previously scored the PNT; then marked as human-AI match or mismatch. Since ~56% of all PWA responses had been

off target with either semantic or phonemic errors, we also classified whether AI accurately retained these different types of errors in transcription. Lastly, we benchmarked AI performance at transcribing each given PWA's speech by subcategory of the aphasia severity and type as measured by the Western Aphasia Battery. Results: SLP transcriptions took 2-4 hours on average for each PWA (~175 trials), whereas automated pipeline required 20-25 mins per subject (2-3min AI transcription + ~20 for a human annotator to align the transcript with each trial). Comparing to SLP transcription with >80% inter-rater match, the AI-assisted transcript achieved 73.63% overall match rate (75.43% with leniency for homophones, spelling and pluralization errors). The model correctly transcribed 96.36 % of semantic errors however only 20.17% of phonemic errors. WhisperX commonly erred by introducing phonemic errors (38.65% of mismatches, i.e. by substituting a phonologically similar word, e.g. "base" for "vase"); by lexicalizing erroneous utterances (29.95% of mismatches, i.e. substituting the target word even when PWA made a phonemic error); or by skipping the trial (23.62 % of mismatches). Discussion: WhisperX reliably transcribes semantic paraphasias but is less reliable in detecting phonemic errors, likely because its lexicalization of impaired speech matches desired processes from its training to auto-correct or interpolate lower quality recordings of healthy speech. Future models should be explicitly trained on impaired speech samples to overcome this issue. Overall, our work is the first to benchmark and implement transformer-based models in automating aphasic speech transcription that may increase clinical and research efficiency. Conclusion: We provide a benchmark of LLM-based real time transcription for speech in PWA. Future algorithmic refinement for phonemic intricacies using input data of impaired speech is necessary. WhisperX offers a scalable alternative to manual transcription, potentially streamlining clinical workflows and research assessments.

C8 - Developing Research Briefs as Tools for Science Communication with Broader Audiences

Rachel Pizzie¹, Rachel Sortino¹, Christina Kim¹, Casey Spelman¹, Bradley White, Ilaria Berteletti¹, Lorna Quandt¹, Melissa Malzkahn¹; ¹Gallaudet University

The Visual Language and Visual Learning (VL2) Research Center at Gallaudet University has studied the effects of visual language on the development of cognition, language, and literacy for nearly two decades. Because this research focuses on American Sign Language (ASL) and d/Deaf, DeafBlind, and hard of hearing (DDBHH) individuals, science communication is a top priority through materials developed across spoken, written, and signed language modalities. One dissemination tool is research briefs that can be widely shared with the general public. The goal of the briefs is to make research findings accessible and applicable by creating digestible summaries. Scientists also make recommendations that educators and caregivers can use to best support healthy development for DDBHH children. Thirteen VL2 research briefs have been written in English for a non-academic audience and then summarized into bite-size ASL videos that highlight key takeaways from each brief. Many of the briefs have been translated into written Spanish and Mandarin. The VL2 team, with colleagues and partners, has developed research briefs on a wide range of topics, from the importance of fingerspelling in reading development to supporting DDBHH children's socio-

emotional development. Each research brief is authored by a team of scientists and science communicators, with unique citations to reference in future publications. VL2's most recent brief focuses on math anxiety and numeracy, spotlighting novel content related to quantitative skill development in DDBHH learners. Math anxiety is a significant challenge for math achievement. Highly math anxious DDBHH individuals show poorer STEM outcomes, a pattern observed in hearing students. Whereas math anxiety and numerical skills might seem to be a departure from prior briefs that focused primarily on supporting language acquisition, for many DDBHH children, language skills are key to developing numerical skills. Some DDBHH students are at risk of falling behind their hearing peers with numerical skills, and there is evidence that delayed exposure to accessible language, rather than hearing loss, explains delays in DDBHH children's math skills. In the brief, the authors focus on evidence-based strategies for remediating math anxiety, and emphasize the importance of accessible language for DDBHH children in developing language and quantitative skills. Importantly, the authors provide examples of what strategies could look like at home and in the classroom so educators and caregivers can immediately apply what they have learned. The research brief utilizes figures and infographics to convey information, and recommendations for activities and tips for key stakeholders. This research brief was developed in collaboration with trainees and members of the VL2 research team, using an iterative review process and consideration of best practices in science communication. In addition, the research brief has been summarized in ASL videos, making content accessible and friendly to DDBHH community members. Neuroscience research must prioritize making science more accessible to a general audience, encouraging stakeholders to engage with evidence-based practices for education, and cognitive and language development. By making science communication more accessible, neuroscientists create vital connections for everyone to understand the links between scientific findings and benefits for society.

C9 Sandbox Series - The Animated Sentence Production Test (AnimSPT) for Aphasia: Pilot Study of Test Development and Preliminary Validation

Zeinab khoshhal molasaraei¹, Dirk Den Ouden¹, William Matchin¹; ¹university of south carolina

Sentence production deficits are a key challenge for individuals with aphasia. Since communication occurs primarily in sentences, effective treatment depends on understanding breakdowns in sentence production. These impairments can arise during message formation, lexical retrieval, syntactic encoding, or articulatory planning. However, existing assessments have limitations. Spontaneous speech tasks, such as story retelling, allow individuals to avoid complex structures and do not clarify the source of observed errors. Constrained tasks, like single-picture descriptions, often rely on metalinguistic prompts (e.g., arrows), adding cognitive demands that can obscure true linguistic deficits. This study aims to develop and evaluate the validity and reliability of a novel sentence production test for aphasia. The test progresses systematically from object naming to action naming, then to active sentence production (with verb tense inflection), and

finally to passive sentence production—all using a consistent set of lexical items. It is designed to efficiently identify specific areas of breakdown, minimize reliance on extralinguistic prompts, and be quick to administer and score. Animated scenes are used to enhance ecological validity and provide a naturalistic context for assessing verb retrieval and sentence formulation. The AnimSPT consists of four subtasks: object naming, action naming, active sentence production (past, present, and future tenses), and passive sentence production. Animated stimuli were used to elicit structured responses with minimal prompting. In the pilot phase, 23 healthy adults named 30 verbs (15 transitive, 15 intransitive) to identify those with the highest naming agreement for test inclusion. The full AnimSPT was then administered to 9 healthy individuals and 5 individuals with aphasia. The stimuli successfully elicited target sentence structures in most cases, particularly among healthy participants, who required only a brief practice phase. Healthy individuals consistently outperformed participants with aphasia across all tasks. Within the aphasia group, the greatest impairments were observed in producing past tense and passive constructions. Performance varied across individuals, with those showing milder impairments producing more accurate and complete responses. The pilot confirmed the feasibility and diagnostic potential of the test. Next steps include refining stimuli and administering the AnimSPT to a larger sample of both individuals with aphasia and healthy controls.

C10 Sandbox Series - Prosody processing after stroke: evidence from a classification and an imitation tasks

Giada Antonicelli^{1,2}, Karen Arellano^{1,2}, Nerea Gorostiola^{1,2}, Pia Hembach³, Simona Mancini^{1,4}; ¹Basque Center on Cognition Brain and Language (BCBL), Donostia-San Sebastián, Spain, ²University of the Basque Country (UPV/EHU), Bilbao, Spain, ³RWTH Aachen University, Aachen, Germany, ⁴Ikerbasque, Basque Foundation for Science, Bilbao, Spain

Prosody comprehension is a complex process that requires to perceive sound, extract relevant acoustic features and integrate them into a coherent percept to be compared with stored intonation representations. Superior temporal areas, basal ganglia, and frontal regions are crucial interconnected hubs for intonation processing. While temporal areas are the locus of acoustic perception and semantic representations, the role of other implicated regions is less clear, as is hemispheric lateralization. Prosody comprehension impairments have been observed after brain damage to either hemisphere, although the right temporal cortex seems to be especially sensitive to slow spectral modulations involved in prosody. To contribute evidence to such debate, we recruited 16 stroke survivors (days post-stroke = 34.81 ± 9.24), presenting with either a right-hemisphere (N=7, involving frontal areas, basal ganglia, thalamus and temporal and parietal regions) or a left hemisphere lesion (N=9, involving frontal areas, basal ganglia and thalamus). They were tested on a prosody classification task with two conditions, sentences and sequences of monosyllables. Their responses were compared to those of 15 healthy controls. To better characterize possible prosody classification deficits, we also analyzed responses from an imitation task on the same stimuli, in which participants mimicked the intonation they heard. Classification performance was measured based on response accuracy (correct, incorrect), while imitation quality was operationalized as the acoustic

distance from the target, determined via both human rating and dynamic time warping. Crawford's tests revealed that seven stroke survivors had average accuracy below three standard deviations from the controls' mean in both conditions, accompanied by significantly poorer imitation performance. Of these, three of them had a lesion in left frontal regions, one in the left thalamus, one in the left basal ganglia, one in left fronto-parietal and one in right frontal regions. Seven brain-damaged participants showed anomalous responses only in the imitation task. Out of those, five had right hemisphere lesions (one temporal, one parietal, two frontal, one in the basal ganglia), while two had damage in the left basal ganglia and the thalamus, respectively. One stroke survivor with a small right thalamus lesion was not different from controls. These results suggest that left frontal lesions were associated with reduced performance in both prosody classification and imitation, while right frontal regions only in one out of three cases. As for condition effects, all basal ganglia lesions were linked to deficits in the monosyllabic condition, while poor performance in the sentence condition was evident in individuals with frontal, temporal and parietal lesions, regardless of hemisphere. Our observations support left frontal regions as a 'control panel' of prosody processing that integrates percepts during comprehension and plans intonation modulations during production. In line with existing findings, basal ganglia might support lower-level motor representations, such as the ones involved in rhythm perception/generation. In our results, they were particularly linked to the monosyllabic condition, characterized by a more rhythmic profile compared to the sentence condition. Future work should include a wider sample of participants and lesions and explore the relationship between prosody comprehension/imitation and meaningful prosody generation.

C11 - Lesion Mapping of Language Deficits in Acute Stroke Patients: An Analysis of NIHSS Best Language Scores and Clinical Neuroimaging

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Introduction Lesion characteristics and initial severity of language deficits are critical prognostic indicators for long-term recovery in post-stroke aphasia.^{1,2} However, lesion anatomy associated with acute aphasia remains poorly understood.³⁻⁶ One approach to examine lesion-symptom relationships in acute stroke without jeopardizing patient care is to leverage existing clinical tools and patients' medical records in retrospective analyses. Here, we combined clinical neuroimaging and language measures from the National Institute of Health Stroke Scale (NIHSS)⁷ to investigate lesion anatomy associated with acute aphasia severity in a large, non-selective cohort of stroke cases admitted to the Prisma Health-Upstate hospital in Greenville, South Carolina, between January 2019 and

December 2020. Method Eligible participants were drawn from the Stroke Outcome Optimization Project8 dataset, which includes basic demographic information, NIHSS scores, and neuroimaging data. A total of 478 participants with NIHSS Best Language scores and neuroimaging were included in data analyses. The Best Language subscale is a widely used clinical assessment that relies on visual stimuli to assess acute language impairment. Aphasia severity is assessed on a 4-point scale ranging from '0' (no aphasia) to '3' (global aphasia). Since only 6 individuals presented with global aphasia, ratings of '2' and '3' were considered indicative of severe aphasia in statistical analyses. Clinical MRI scans were completed within 48 hours of stroke onset for most participants and within 30 days for all participants. Stroke lesions were manually demarcated on the structural images (T1-/T2-weighted, FLAIR) available for each participant using MRICroGL.8 We performed voxelwise and region-of-interests whole-brain analyses to identify lesion correlates of acute aphasia severity across three group contrasts: no ('0') vs. mild-to-moderate ('1') aphasia, no ('0') vs. severe ('2'/'3') aphasia, and mild-to-moderate ('1') vs. severe ('2'/'3') aphasia. Lesion-symptom mapping was performed using the NiiStat software and analyses included voxels or regions damaged in at least 10 participants. Overall lesion volume was treated as a covariate in all analyses and permutation thresholding was applied to correct for multiple comparisons ($N=5,000$, corrected $p<.05$). Results Participants with severe aphasia ($N=102$) were older ($68.0\pm14.4y$) and had larger lesion volume ($49.9\pm51.5cc$) than participants with mild-to-moderate aphasia ($N=149$; $66.1\pm13.9y$; $24.6\pm39.9cc$) or no aphasia ($N=227$; $64.1\pm14.4y$; 16.2 ± 27.4) ($p<.05$). Our primary analyses revealed that mild-to-moderate aphasia was associated with dorsal, superior temporal, and deep white matter lesion in the right hemisphere (RH) relative to no aphasia, whereas severe aphasia was associated with lesion to frontal, temporal, and basal ganglia anatomy, and fronto-temporal white matter connections exclusively in the left hemisphere (LH). Comparison between mild-to-moderate vs. severe aphasia mirrored these findings, with the strongest effects observed in the RH frontal lobe (mild-to-moderate>severe, $Z>3.0$) and LH frontal, superior temporal, and fronto-temporal connections (severe>mild-to-moderate, $Z>4.0$). Discussion As expected, our results revealed that damage to the canonical perisylvian language network in the LH is associated with severe acute aphasia. However, somewhat surprisingly, we found that lesion affecting homolog regions in the RH was robustly associated with milder acute language deficits. These findings are clinically relevant and inform our understanding of the neural mechanisms underlying language impairment in post-stroke aphasia.

C12 - Residual language activation modulates naming error types in chronic post-stroke aphasia

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Introduction: Lexical retrieval is commonly impaired following left-hemisphere stroke. The prevalence of resultant naming errors – such as semantic errors, phonological errors, and perseverations – varies considerably across individuals. Prior research has identified key neural regions where lesion damage impairs lexical retrieval subprocesses that might contribute to

different error types, including the left inferior frontal gyrus (IFG), middle temporal gyrus (MTG), and anterior/posterior inferior temporal gyri (a/pITG). Yet, error types likely also rely on functional language activation or disfunction beyond the lesion boundary. The current study analyzes error production in picture naming (1) as a function of anatomical lesion damage and (2) fMRI language activation in a large cohort of left-hemisphere stroke survivors with aphasia. Methods: 80 individuals with left-hemisphere stroke-induced aphasia participated in an adaptive fMRI semantic decision task with two alternating conditions: semantic decision (e.g., CALENDAR-DATE) versus pseudofont matching (e.g., 505dD-505dD). Four regions of interest were identified based on peaks of activity in 15 controls. Naming was assessed on a set of 120 line drawings and scored for overall accuracy, semantic errors, phonological errors, and perseverations. For each ROI, two sets of Spearman partial correlations examined overall accuracy and errors as a function of (1) the proportion of the ROI lesioned (covariates: age, education, lesion volume, and apraxia severity) and (2) the language activation (covariates: age, education, lesion volume, apraxia severity, and proportion of voxels lesioned in that ROI). The analyses were corrected for multiple comparisons using the Benjamini-Hochberg method. Results: Overall naming accuracy decreased with lesion damage to the STS/MTG, aITG, and pITG and increased with higher activation of the STS/MTG and the aITG. Higher activation in the IFG and aITG correlated with fewer semantic errors. Greater lesion damage to the STS/MTG, aITG, and pITG correlated with an increase in phonological errors, whereas greater lesion damage to the IFG correlated with fewer phonological errors. Higher activation in the STS/MTG and aITG correlated with fewer perseverations. Discussion: These results link specific error types in picture naming to both lesion location and functional activation in individuals with aphasia. Lexical retrieval thus appears to rely on a distributed network of regions, with frontal and temporal regions contributing to different stages of the naming process. Activation in the aITG correlated with a decrease in every error type, suggesting it plays a general role in semantic processing and lexical retrieval. IFG activation suppresses semantic errors, likely reflecting its role in semantic interference resolution during naming. The findings for posterior temporal regions are most consistent with a role in lexical phonological retrieval. These findings demonstrate that combining lesion and activation data may better characterize the neural mechanisms underlying naming impairment. In turn, this approach may inform more individualized, brain-based approaches to aphasia treatment.

C13 - Neural Decoding of the Semantics of Silently Imagined Answers

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Strokes that damage phonological brain systems at the core of the middle cerebral artery territory can leave people permanently incapable of finding the words to convey their thoughts as speech or writing, despite remaining intellectually intact and able to understand language. As verbal recovery prospects in severe cases of such phonological retrieval deficits are often low, and current Augmentative and Alternative Communication technologies have limited utility (e.g. synthesizing pre-scripted speech via a tablet), there is a need to

develop new methods to assist communication. Recently introduced semantic brain decoding models that transcribe the gist of comprehended language and imagined speech from fMRI data may present a foundation for new communication technologies for aphasia. However, because decoding models have been tested on either comprehension or imagined speech in isolation, it is unknown how well they can distinguish the semantics of imagined language production from comprehension when the two processes overlap, as would be essential for a conversational application. It is also unknown how semantic decoding approaches generalize to people with aphasia. Here we present work in progress that seeks to address these questions. The overarching hypotheses are: (1) The semantics of imagined answers can be selectively decoded from fMRI activation, and: (2) This ability will generalize to people with aphasia when semantic cognition is preserved despite phonological damage. Six neurotypical participants and one participant with phonological impairment from stroke were recruited to date. To enable the objective evaluation of the ability to decode imagined answers, all participants attended a visit where they memorized the profiles of five distinctive fictional characters, which would form the basis for questioning. Profiles were presented as memorable AI-generated videos e.g., introducing Mary from NYC, who is a policewoman, paints as a hobby and has a pet chameleon. Participants' ability to memorize the profiles was confirmed via a card arrangement task (matching a "Mary" card to "Painting" not "Cycling"). Participants later underwent fMRI as they imagined the answers to questions on the characters' profile features, e.g. Stimulus: "What is Mary's job?", Silently Imagined Answer: "She's a police lady". To evaluate whether the semantics of imagined answers could be distinguished from questions in fMRI data, a partial correlation-based Representational Similarity Analysis was deployed. To model the semantics of Q&A's, the corresponding texts were processed through GPT-2-medium. A single vector for each question and each answer was derived as the pointwise average of word embeddings extracted from Layer 16 (of 24). The representational geometry of fMRI activation extracted from the Default Mode Network was then correlated against the Answer model, controlling for the Questions. Statistical significance was evaluated via permutation tests. Significant positive RSA coefficients were detected for 4/6 neurotypical participants. In the participant with aphasia, RSA coefficients reflecting the semantics of the question, but not answer were detected with ~5sec delay relative to neurotypical adults. This study provides early evidence that the semantic content of imagined answers can be selectively decoded from fMRI data independent from comprehension processes and identifies challenges that surround adapting decoding approaches for aphasia.

C14 Sandbox Series - Vocabulary learning and regularity extraction in dyslexia: Dynamics of consolidation and benefit of sleep

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Sleep benefits memory consolidation, and a reduced benefit could at least partially explain the impaired learning of regularities (e.g., morphology) reported in dyslexia. In the current study we assessed the involvement of sleep in learning

of novel vocabulary and novel plural inflections based on implicit morpho-phonological regularities. We considered the temporal dynamics of these learning types and tested their association with sleep spindles and with slow-wave sleep – two types of neural activity that have been shown to benefit vocabulary consolidation. Participants were trained in the evening on the inflection of 36 novel words, in which morpho-phonological regularities were embedded, and were presented either frequently or infrequently during training. Training was followed by an immediate test of acquisition and generalization, a night in a sleep lab with a polysomnography, and three additional tests across nine days. For controls, we found that accuracy on the vocabulary test improved across the first night following learning, and the change was positively associated with slow-wave sleep duration. Memory for infrequent words declined towards Day 9, but greater spindle density during the first night was associated with a smaller decline. Mean group accuracy on trained inflections did not change overnight, but individually, the change was negatively correlated with spindle density. Accuracy on generalisation showed no change over time and no correlations with sleep characteristics. These results demonstrate that in typically developing young adults, vocabulary and grammar learning have different temporal dynamics of consolidation and distinct patterns of association with sleep metrics, and emphasise the potentially protective role of spindles for long-term memory retention. We are now analysing the data of young adults with dyslexia, comparing both their behavioural performance as well as their sleep characteristics, and the association between neural activity during sleep, and memory consolidation.

C15 - Synchronized perception, asynchronous processing: Differing neural synchrony to social attribution animation in autistic and non-autistic adolescents

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There is a near-universal tendency for people to attribute humanlike characteristics to simple geometric shapes animated to enact a social plot. These types of social attribution animations have been used to investigate whether autistic and non-autistic people differ in the extent to which they attribute humanlike intentions, suggesting that autistic people identify fewer social elements and are less likely to afford social reasoning to the shapes. Here, we collected fMRI data from 53 adolescents (28 autistic) while they watched a social attribution animation. We investigated group differences in brain synchrony using inter-subject correlation (ISC) to capture shared neural responses over time. Specifically, we addressed: (1) group similarities/differences in neural synchrony, (2) which brain regions exhibited differences, (3) how synchronization fluctuated across movie duration, and (4) stimulus features associated with neural engagement. METHODS: We computed pairwise ISC within and between groups of autistic and non-autistic adolescents by correlating each participant's voxelwise time course with every other participant's (Pearson correlation). First, we computed whole-brain ISC, comparing within- and between-group values. Second, we performed a time-resolved ISC analysis using sliding windows to generate ISC time series,

at each voxel, across the movie. Third, we adapted a component-based ISC analysis, where for each participant we decomposed voxel time courses into global (non-selective) and region-specific (selective) components. We used a ventral occipitotemporal seed (Brodmann areas 19/20/37) to extract and regress out the non-selective signal, and computed selective components corresponding to language, theory-of-mind, and motor networks. **RESULTS:** The non-autistic group ($r=0.022$) exhibited higher whole-brain ISC ($p = 0.001$) than the autistic group ($r=0.0166$). Both groups demonstrated strong synchronization in occipital cortex, while non-autistic participants additionally showed elevated synchronization in anterior medial temporal lobe. Time-resolved analysis revealed that when there were differences, non-autistic participants generally exhibited higher ISC, in areas such as Brodmann 8, 17, 21, 25, and 40, suggesting group differences in visual, cognitive control, semantic, emotional, and multisensory synchronization. For the stimulus features analysis, in both groups the theory-of-mind selective component exhibited the greatest frequency of synchronization compared to language and motor selective components, although to different movie events: in non-autistic participants, theory of mind peaks occurred during both broad social contexts and discrete social events, while autistic participant peaks occurred during interactions between two key characters. **CONCLUSION:** Autistic and non-autistic people both show robust synchronization in early visual regions during naturalistic movie viewing, but they do so more strongly within than across groups, and they diverge in higher-order network engagement over time. Non-autistic synchronization was broader and more consistent suggesting that recruitment of cognitive control, emotional regulation, and social reasoning networks was consistent across non-autistic people. Although selective component analysis showed that both groups exhibited theory of mind synchronization during socially meaningful moments, there were group differences in the frequency and distribution of synchronization. These results highlight shared perceptual engagement but different modes of higher-order social narrative processing in autistic and non-autistic adolescents.

C16 Sandbox Series - Examining Intrinsic Brain Variability and Neurotransmitter Balance in Adults with Dyslexia Using fMRI and MRS: Implications of the Neural Noise Hypothesis of Dyslexia

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The Neural Noise Hypothesis (NNH) of dyslexia (Hancock, Pugh, & Hoeft, 2017) posits that their core deficits in phonological awareness (PA), grapheme-phoneme mapping, and multisensory integration may arise from imbalances in cortical excitation and inhibition (E/I), mediated by neurotransmitters such as gamma-aminobutyric acid (GABA) and glutamate. Such an imbalance can substantially elevate neural noise beyond levels optimal for cognition, thereby affecting brain variability. Recent electroencephalogram (EEG)–magnetic resonance spectroscopy (MRS) study (Glica et al.,

2025) found that the Glu/GABA+ ratio (indicator of E/I balance) in the left superior temporal sulcus were associated with multisensory integration in dyslexia. However, as that study focused on a single region, it remains unclear whether other brain regions also contribute to E/I imbalance. At the microscale, neural noise can disrupt synchrony through E/I dysregulation, potentially manifest at the macroscale as abnormal brain variability—moment-to-moment fluctuations in neural activity detectable via functional magnetic resonance imaging (fMRI) (Garrett et al., 2013). Brain variability has theoretical foundations (e.g., stochastic resonance theory) explaining how optimal variability enhances neural communication. Once regarded as random noise, brain variability is now understood to reflect meaningful cognitive processes, and its implications in neurodevelopmental conditions such as autism spectrum disorder (ASD) (Uddin, 2020). Despite its relevance, brain variability has received little empirical attention in dyslexia particularly during resting states, and has mostly been studied using between-session brain variability (Malins et al., 2018). Building upon the NNH framework, this study presents a conceptual model integrating neurotransmitter balance and intrinsic brain variability to better understand dyslexia in adults, an often-overlooked population (Vender & Delfitto, 2025). We will examine within-session intra-regional brain variability during resting-state fMRI in young adults with reading disability (RD, aka specific reading disability or developmental dyslexia; $N = 45$) and typical readers ($N = 45$), classified via the Test of Word Reading Efficiency - Second Edition and Adult Reading History Questionnaire. Brain variability is assessed using validated metrics: standard deviation of BOLD (SDBOLD) and mean squared successive difference (MSSDBOLD) (Wehrheim et al., 2024). This study addresses two primary questions: (1) Do individuals with and without dyslexia differ in intra-regional brain variability? Whole-brain voxel-wise and reading-related region-of-interest (ROI) group comparisons will assess whether intrinsic brain variability distinguishes the groups, reflecting either domain-general disruptions (as seen in ASD) or dyslexia-specific mechanisms. We hypothesize group differences particularly in regions related to PA (e.g. temporal cortex), grapheme-phoneme mapping (temporoparietal cortex), and multisensory integration (e.g. temporal cortex and frontal lobe). The Partial Least Squares (PLS) analysis will further identify specific regions where the brain variability correlates with reading-related skills, followed by an examination of spatial overlap with group-level differences. (2) How are neurotransmitter concentrations related to brain variability? Using MRS, we will measure GABA and glutamate concentrations in key reading-related regions (left/right temporoparietal cortex, left precentral gyrus) and a control region (vertex). We hypothesize that indicators of E/I balance—Glu/GABA+ imbalance and the Glu/GABA+ ratio in reading-relevant regions will correlate intra-regional brain variability, with no such associations expected in the control region.

C17 - Orthographic Amnesia in Developmental Dysgraphia

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Introduction Hepner et al. (2017) reported on multiple cases of developmental spelling dysgraphia in which individuals with

normal/superior cognitive skills exhibited highly selective, severe difficulties in learning the spellings of irregular words in the face of normal pseudoword spelling accuracy. Despite extensive testing, it has been challenging to identify the stage at which these selective learning difficulties arise. Here we report on an investigation that builds on Tao et al. (2024) which examined the neural bases of the initial stages of orthographic learning as neurotypical adults learned spellings for novel pseudowords during fMRI scanning. We found a distinctive bilateral hippocampal increase in BOLD response with the increasing memory strength of learning trials. Currently, we administered the same orthographic learning paradigm to two individuals with severe acquired spelling dysgraphia. To evaluate the selectivity of the effects, we also administered a similar paradigm involving in-scanner learning of complex visual patterns (Law et al., 2005). Methods Participants are a father (RBT, 56 years old) and son (TBT, 19 years old) diagnosed with severe developmental surface dysgraphia. Both are native English speakers and right-handed, with no history of neurological disease. They exhibit severe difficulties specifically in spelling irregular words (TBT: 0.7%ile and RBT: 4%ile) compared to normal performance in pseudo-word spelling. Nonetheless, both demonstrate normal-to-superior: spoken language vocabulary (PPVT), digit span, learning (verbal, visual and face), working memory (span), and executive functions (card sorting). Participants were administered two learning tasks during fMRI scanning: (1) Orthographic learning: Participants learned the mapping between 10 Auditorily presented pseudowords and their target spellings, with 16 repetitions of each item; (2) Visual pattern learning: Participants learned the mapping between 8 kaleidoscopic patterns and one of four button presses, with 18 repetitions of each item. In-scanner accuracy was recorded and used to bin learning trials into different levels of memory strength (based on Smith et al., 2004), for later analysis. Results Behavioral results. Orthographic Learning: TBT and RBT had in-scanner accuracies of 45% and 38%, respectively, significantly below the control mean of 78% ($p < 0.04$ and 0.02). Visual pattern learning: TBT and RBT had in-scanner accuracies of 78% and 56%, comparable to controls ($p = 0.58$; $p = 0.39$). Neuroimaging results. Orthographic Learning: Neurotypical controls showed increasing BOLD response with increasing memory strength of the learning trials in bilateral Hippocampi ($p < 0.001$). In contrast, TBT and RBT did not ($p = 0.74$), with a significant interaction between groups ($p < 0.03$). Visual Pattern Learning: TBT and RBT exhibited the expected increase in BOLD response with increasing memory strength of the learning trials, in bilateral Hippocampi. Conclusions The profound and highly selective nature of the difficulties these individuals experienced in learning word spellings can be described as selective “orthographic amnesia”. In fact, we report a lack of responsiveness of the bilateral Hippocampi during orthographic learning, despite appropriate Hippocampal responsiveness during other similarly structured complex visual pattern learning. Future work is needed to understand whether the abnormal Hippocampal responses are primary or derivative.

C18 - Longitudinal changes in cortical grey matter in adolescents with developmental language disorder

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Introduction: Developmental language disorder (DLD) affects approximately 7% of children, leading to persistent difficulties in learning language without a known cause. Cross-sectional neuroimaging studies have found atypical grey matter morphology in peri-sylvian regions bilaterally in DLD, but the developmental trajectories underlying these findings remain unclear. Longitudinal studies are needed to determine whether the grey matter differences in DLD persist over time, therefore “lagging” the changes in typical development, or if they reflect a delay that eventually reaches the same level of maturation. A third possibility is that the trajectories of cortical change in DLD deviate from those in typical development. Methods: In a longitudinal investigation, we collected T1-weighted structural MRI scans and extensive neuropsychological data from 53 children and adolescents, who were first assessed between ages 10–15 and followed up between 14–20 years old, with a mean interval of 4 years 6 months. Participants included 20 who met our criteria for DLD, 22 typically developing (TD) controls, and 11 with a history of speech-language difficulties (HSL) who did not meet DLD criteria. Using FreeSurfer-derived cortical metrics, we estimated changes in cortical surface area and thickness in 84 structural scans collected at two time points from the DLD and TD groups. Results: Behaviourally, at initial assessment, participants with DLD performed poorer than their TD peers on all measures of language, memory, reading, nonverbal reasoning, and motor control. At follow-up, the gap in performance between DLD and TD persisted, despite similar rates of gain in both groups on most tests. The performance of HSL participants typically fell between the other two groups. Brain imaging analyses indicated reductions in surface area in the superior temporal sulcus and ventromedial prefrontal cortex bilaterally in both DLD and TD groups over time. Additionally, the TD group showed surface area reductions in the left ventral postcentral gyrus, which remained unchanged in DLD. The DLD group, on the other hand, showed an increase in surface area in the left pars opercularis and anterior insula, and in the temporal pole bilaterally. These regions were not significantly changed in the TD group. Cortical thickness reductions (thinning) were observed in both groups in association cortex, consistent with previous longitudinal studies of typical development. Discussion: The behavioural results indicate that individuals with DLD have qualitatively similar but quantitatively lower performance on a range of cognitive skills that continues into adolescence and early adulthood. This pattern reflects a persistent lag in development of language and other skills. The imaging results suggest dynamic and region-specific patterns of cortical maturation in DLD, likely reflecting complex interactions between synaptic pruning, myelination, and experience-dependent plasticity. Regional differences aligned with distinct maturational profiles; the left ventral postcentral cortex showed evidence of lagged development in DLD, while the left frontal opercular cortex appeared more consistent with a delayed maturation trajectory. However, with the current two time-point design we were sensitive to linear changes only. Longitudinal data spanning a wider age range and incorporating multiple time points from larger samples will be required to characterise brain trajectories in this population.

C19 - Neural representations of speech sounds in children who stutter

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Stuttering is a speech disorder characterized by involuntary repetitions, prolongations and blocks that disrupt the flow of speech. While stuttering is primarily characterized by speech production deficits, previous studies have reported considerable evidence that children and adults who stutter exhibit behavioral and neural patterns of speech perception divergent from fluent controls of the corresponding age group. Here, we hypothesized that neural representation of phonemes may be less distinct in children who stutter than controls of same age. Participants were composed of three groups -- children who stutter (age 7-12 years), their age-matched control peers and adults without speech, language or hearing disorders. As the participants listened to 15 minutes of naturalistic, continuous speech from the public domain audiobook Alice's Adventures in Wonderland in quiet, we acquired their electroencephalographic (EEG) responses. We analyzed the preprocessed EEG data time-locked to 0 – 500 ms after the onset of phoneme instances (phoneme-related potentials; PRPs) in order to examine cortical representations of phonemes. For each participant, we analyzed the separability of their PRPs among different phonemes and among different manners of articulation (stop, fricative, nasal approximant, vowel) by computing the F-statistic on the PRPs over time. These F-statistics were compared between the groups of participants. Also, we trained neural network classifiers using EEGNet to predict phonemes from the PRPs. Over the duration of the PRPs, the F-statistics were generally lower for children who stutter than the control children and adults, showing that there is a less distinct separation between phonemes as well as between manner categories in the PRPs of children who stutter than fluent peers. Also, the classifiers trained to decode phonemes from the PRPs predicted phonemes less accurately and with more uncertainty in children who stutter than controls, further demonstrating that cortical representations of phonemes are less distinctive in children who stutter. The pattern of group differences in PRPs also varied between the manner categories, not only in terms of the magnitude but also timeframes within the duration of the PRPs when the difference was more pronounced. These differences suggest that the developmental trajectories of how different phonemes are represented in the brain real-time while listening to continuous speech vary between children who stutter and their fluent peers.

C20 - Poor sleep hygiene in adolescence is associated with disrupted encoding and consolidation of newly learned words

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Sleep supports memory by restoring hippocampal encoding capacity after wakefulness (Cirelli & Tononi, 2020) and by redistributing newly acquired information from the hippocampus to long-term neocortical memory stores during memory consolidation (Klinzing et al., 2019). Both functions of sleep facilitate word learning. Sleep before word learning leads to better memory for the words (March et al., 2023). Sleep after word learning allows for lexicalisation whereby new words form integrated networks with similar words in the mental dictionary (Davis & Gaskell, 2009). While the impact of sleep on word learning is well documented in adults and young children, little is known about these mechanisms in adolescence, despite adolescence being a developmental period of considerable disruption to sleep patterns. Adolescence is marked by biological changes, such as shifts in circadian rhythms, that delay sleep timing, alongside behavioural factors like increased device use before bed that further disrupts sleep. Together, these changes often lead to chronic sleep restriction (Gradisar et al., 2011). We therefore hypothesised that the transition from pre-adolescence to adolescence would lead to poorer sleep and worse encoding and consolidation of new words. To test this, the AdSleep project has an accelerated longitudinal design to track sleep and word learning across three years in two adolescent cohorts: younger adolescents aged 11-12 and older adolescents aged 13-14. Here, we report findings from the first year of data collection (N = 490). Participants completed a word learning task across two sessions spaced 24 hours apart, designed to assess both initial encoding and overnight consolidation. During session 1, participants learned the word forms, meanings, and sentence contexts of 16 rare English words via transcription, memorisation and production. Memory was tested immediately for half of the words and 24 hours later for the remaining words using cued recall tasks. Sleep was assessed via self-report questionnaires as well as a 2-week sleep diary prior to testing. Objective measures of sleep were derived from actigraphy in a subsample of participants. Bayesian mixed effects models confirmed a substantial difference in sleep patterns between the two age groups. Older adolescents exhibited a stronger evening chronotype and fell asleep 41 minutes later on average than younger children, leading to insufficient sleep relative to age-based recommendations (mean = 7 hrs, 28 mins). They also reported poorer sleep hygiene, notably more frequent afternoon/evening napping, and more frequent device use close to bedtime. In the word learning task, older adolescents outperformed younger adolescents at encoding, but underperformed at delayed recall, suggesting age-related improvements in encoding capacity were offset by weaker overnight consolidation. Sleep hygiene significantly predicted both encoding and consolidation performance across all tasks (β s = 0.10 - 0.56), with better sleep hygiene associated with improved performance. These findings suggest that poor behavioural choices around bedtime may contribute to the trade-off between improved encoding capacity and reduced consolidation efficiency in the transition from pre-adolescence to adolescence. This supports theories of word learning that assign a key role for sleep and suggest that interventions targeting modifiable sleep behaviours could benefit word learning in adolescence.

C21 - Developing by predicting: neural representations of naturalistic linguistic prediction mature with age and support language development

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Introduction: The human brain is classically conceptualized as a prediction machine. In the domain of language, convergence between the adult brain and large language models (LLM) highlights that prediction is a core mechanism supporting language comprehension, with LLMs that are better at predicting upcoming words also more accurately capturing human brain responses to natural language. Behavioral studies further indicate that children rely on predictive coding abilities to acquire linguistic knowledge, such as words and sentence structure. However, the neural mechanisms underlying predictive coding in the developing brain, whether domain-general or domain-specific, in supporting language acquisition, remain largely unknown. The current study explored these questions by combining the predictive power of LLMs with a large-scale pediatric neuroimaging dataset. **Methods:** This study included 1,383 participants aged 5-22 years from the Healthy Brain Network dataset. All participants had usable fMRI data collected while watching a 10-minute clip from the movie *Despicable Me*. GPT-3 model was used to calculate the log probability of each spoken word given its preceding context in the clip. These probabilities were then converted into surprisal values, quantifying linguistic predictions during movie-watching. A voxel-wise encoding model using banded ridged regression was implemented to estimate the linear mapping from movie features onto brain activity. Model features included GPT-3 surprisal, lexical frequency, emotional valence, presence of words, bodies, and faces, and low-level audiovisual features. Model performance was evaluated on held-out test sample through 5-fold cross-validation by correlating the actual and model-predicted time series, using either the full model or individual features. One-sample t-tests at both voxel and regions of interest (ROI) levels were used to identify regions that significantly predicted by GPT-3 surprisal. Support vector regression (SVR) with 10-fold cross-validation then tested whether encoding performance in these regions could predict age and language development, controlling for motion, sex, scan location, and handedness, and significance was determined after permutation ($n=1000$). **Results:** (1) Both univariate and ROI-level analyses revealed that regions within a bilateral extended language network, including inferior frontal gyri (IFG), middle frontal gyri, superior temporal gyri and middle temporal gyri, were significantly predicted by GPT-3 surprisal feature ($t_s > 9.05$, $p_s < 1e-19$). (2) SVR model showed significant associations between encoding performance of GPT-3 surprisal and chronological age in the left-hemisphere language network only (left: $r = 0.21$, $p < 0.001$, mean squared error (MSE) = 12.73, $p < 0.001$; right: $r = 0.11$, $p < 0.001$, MSE = 16.08, $p = 0.661$). (3) When additionally controlling for age and nonverbal IQ, SVR revealed that only encoding performance of GPT-3 surprisal in the orbital part of right IFG significantly predicted individual differences in language development ($r = 0.11$, $p < 0.001$, MSE = 19.49, $p = 0.001$). **Conclusion:** This study demonstrates that linguistic predictions generated during naturalistic movie-watching are selectively encoded in the language network, highlighting the domain specificity of predictive language processing. Moreover, neural

representations of linguistic predictions predict both age and individual difference in language skills, further emphasizing the role of predictive coding in supporting language development.

C22 Sandbox Series - Exploring the role of episodic memory consolidation in predicting existing L2 vocabulary in proficient learners

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INTRODUCTION: Vocabulary acquisition is critical for second language (L2) learning. The Declarative/Procedural (DP) model posits that the declarative memory system supports the learning and retention of lexical information (Ullman, 2001). However, the long-term contribution of the episodic memory subsystem, which supports declarative memory for specific events, to L2 vocabulary remains debated. While the Complementary Learning Systems model suggests episodic memory's contribution may decline as L2 proficiency advances (Davis & Gaskell, 2009), the Episodic L2 Hypothesis argues for its persistent contributions even at high proficiency levels (Jiang & Forster, 2001). Empirical findings on the link between episodic memory and L2 lexical development are mixed (Ruiz et al., 2018; Walker, 2020), potentially due to methodological limitations. Notably, prior studies have often overlooked the crucial role of memory consolidation by measuring only immediate, single-time-point episodic memory performance. Furthermore, these studies often used artificial language paradigms, focusing on early-stage learners new to the specific language. Therefore, evaluating episodic memory consolidation efficiency in proficient learners is essential to clarify its lasting contribution to their established L2 vocabulary and to test competing theoretical claims about its role. This study addresses these gaps using an immediate and overnight delayed testing design to examine the relationship between episodic memory consolidation efficiency (relative memory performance change over 24 hours) and established L2 vocabulary knowledge in proficient L2 learners. **METHODS:** Fifty native Cantonese-speaking young adults completed the LexTALE (Lemhöfer & Broersma, 2012), a yes/no lexical decision test assessing existing L2 English vocabulary knowledge. As for episodic memory, the participants performed a nonverbal scene recognition task for intentional encoding followed by 10-minute immediate (Day 1) and 24-hour delayed (Day 2) recognition tests. Recognition sensitivity (d') was calculated for both tests. An episodic memory consolidation efficiency index was then calculated as the relative change rate in d' : $(d' \text{ of Day 2} - d' \text{ of Day 1}) / d' \text{ of Day 1}$. Three regression models examined the relationship between the LexTALE scores (controlling for age and gender) and different episodic memory measures: immediate recognition (d' of Day 1), delayed recognition (d' of Day 2), and the consolidation efficiency index. **RESULTS:** Neither immediate ($\beta = -0.06$, $p = .674$) nor delayed ($\beta = 0.14$, $p = .333$) recognition sensitivity significantly predicted LexTALE scores. However, the consolidation efficiency index, reflecting the relative d' -prime change over 24 hours, demonstrated a marginally significant positive relationship with

the participants' LexTALE scores ($\beta=0.27$, $p=.056$, partial $R^2=0.077$, corresponding to a partial $f^2=0.08$). Furthermore, a 10000-iteration simulation-based priori power analysis recommends a sample size of approximately 108 to achieve 80% power in future investigations using the consolidation efficiency index, given the effect size observed here. **CONCLUSION:** Episodic memory consolidation efficiency might offer unique predictive value for existing L2 vocabulary, demonstrating a marginal positive relationship not observed for immediate or delayed recognition performance in this study. Future studies with a larger sample size should further verify the results here. The preliminary findings offered some tentative support for the Episodic L2 Hypothesis which posits persistent episodic memory involvement and the DP model.

C23 - Developmental Changes in the Dynamic Neural Connectivity During Semantic and Syntactic Processing: Insights from EEG Analyses in Typically Developing Individuals

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Purpose: Efficient language comprehension involves rapid communication among brain networks, a dynamic process that continues developing beyond childhood. Behavioral research indicates that during language comprehension, younger children predominantly rely on semantic cues, gradually incorporating syntactic information as they mature (Schneider & Maguire, 2019). Brain networks and connections, particularly those involved in language comprehension, mature progressively over childhood. EEG connectivity analyses, with their high temporal resolution, can capture rapid communication between different brain networks more nuanced than traditional ERP and TFR analyses. This study aimed to identify developmental changes in neural connectivity during semantic and syntactic processing in middle childhood and adulthood. **Method:** Sixty typically developing participants, 30 middle-childhood (ages 8–9) and 30 adults (ages 18–32), listened to sentences containing semantic errors, syntactic errors, and correct sentences (Schneider & Maguire, 2019). Errors always occurred at the verb position to ensure precise temporal alignment and control for sentence-level confounding factors. Semantic violations involved noun-verb mismatches (e.g., "the lock should be burning in the fireplace"), while syntactic violations involved verb-form errors of intrusion and omission (e.g., "should be burn" or "should burning"). EEG data preprocessing included filtering and ICA-based artifact removal. Imaginary coherence (iCoh) measured connectivity in theta (4–8 Hz) and beta (13–30 Hz) bands. These frequency bands have been chosen as they have been shown to be more prominently affected by the presence of semantic and syntactic error processing, respectively (Bastiaansen, 2015). Connectivity differences were statistically assessed via permutation tests ($p < .05$) with Bonferroni correction for multiple comparisons. **Results:** Adults exhibited increased theta coherence between left frontal and bilateral parieto-occipital regions at 350–450 ms following semantic errors (left: $t(29)=2.71$, $p=0.014$; right: $t(29)=2.68$, $p=0.013$). Children

showed delayed theta coherence increases between left frontal and right parieto-occipital regions at 450–550 ms ($t(29)=3.17$, $p<0.01$). Theta connectivity between frontal regions and occipital regions was present in both groups, with a delayed timing in children. This shows the ongoing development of the coordination between higher-order processing networks in frontal regions, such as executive function, and the semantic representation network in occipital regions. Syntactic errors triggered decreased beta connectivity in adults between left temporal and frontal electrodes between 200 and 300 ms ($t(29) = -2.79$, $p < 0.01$). Around 600 msec, adults demonstrated a decrease in connectivity between left temporal and frontal regions ($t(29) = -2.752$, $p = 0.011$). In children, the connectivity decrease was observed between left temporal and central regions between 200 and 300 ms, similar to adults ($t(29) = -2.84$, $p < 0.01$). The early decrease in connectivity seems to be associated with distortion in the early stages of syntactic processing (Friederici, 2016). The effect around 600 msec, which only happens in adults, is associated with the reanalysis and repair process of the syntactic error, and it engages both memory and unification hubs of the brain. The absence of this effect in children is similar to past reports (Schneider & Maguire, 2019), adding further evidence that the neural substrates supporting syntactic processing are still developing in middle childhood

C24 - Neural Efficiency in Adult Word Learning: Evidence for overlap across language, cognitive control, and flexibility networks

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The ability to derive the meaning of a novel word from linguistic context is crucial for vocabulary growth and draws on several cognitive faculties, including retrieving the meanings of known words (semantics), integrating sentence structure (syntax), maintaining potential meanings (cognitive control), and continuously revising interpretations as new information emerges (cognitive flexibility). Accordingly, novel word learning likely recruits a broad network of brain regions associated with language processing, cognitive control, and cognitive flexibility; however, the extent to which these systems overlap remains poorly understood. Overlapping neural activation may reflect neural efficiency, whereby the brain repurposes existing circuits to support rapid vocabulary acquisition. While prior work has characterized visual word learning networks (e.g., Mestres-Missé et al., 2008), little is known about auditory word learning—the primary modality through which adults typically acquire new words. The present study addresses this gap by examining the neural basis of auditory word learning in adults and its overlap with language, cognitive control, and cognitive flexibility networks. Eighteen young adults (Mage = 19.40, SDage = 1.64) completed an auditory word learning task (Momsen et al., 2022), an auditory language localizer (Scott et al., 2016), a domain-general executive control task (Duncan, 2010, 2013; Fedorenko et al., 2013), and a cognitive flexibility task (Engelhardt et al., 2019; Nugiel et al., 2020, 2023) during fMRI scanning. All participants scored within the normal range on the NIH Toolbox Picture Vocabulary Test (Mage = 103.47, SDage = 8.26, range:

89–120). Using Group-Constrained Subject-Specific (GCSS) analysis, we identified individualized regions of interest (ROIs) engaged during the language localizer, domain-general executive control, and cognitive flexibility tasks separately (thresholded at $p < 0.001$; Scott & Perrachione, 2019). We then applied Local Pattern Similarity Analysis (LPSA) to compare activation patterns (Pearson's correlations) between word learning and each task within these ROIs. Correlation values were compared to zero via one-sample t-tests (positive correlations only) to assess co-activation. Within the subject-specific language network, word learning and language processing co-activated the Left Temporal Pole ($t(17) = 2.60$, $p = 0.019$), consistent with its established role in semantic memory and conceptual integration (Patterson et al., 2007; Lambon Ralph et al., 2017). Within the domain-general cognitive control network, word learning and cognitive control moderately co-activated the Left Inferior Frontal Gyrus (IFG)/Middle Frontal Gyrus (MFG) ($t(17) = 1.86$, $p = 0.079$). This significance trend aligns with prior findings linking the Left IFG to controlled semantic retrieval and conflict resolution (Badre & Wagner, 2007; Novick et al., 2005). Within the cognitive flexibility network, word learning and cognitive flexibility co-activated the Left Lateral Occipital Cortex ($t(17) = 2.86$, $p = 0.011$) and Left Supramarginal Gyrus/Angular Gyrus ($t(17) = 2.12$, $p = 0.049$). These regions are associated with higher-order conceptual integration and flexible semantic processing (Grill-Spector et al., 2001; Seghier, 2013; Binder et al., 2009). Together, these findings suggest that successful auditory word learning relies on the coordinated engagement of language, cognitive control, and flexibility networks, supporting dynamic integration of new words into existing semantic frameworks.

C25 - Left and right hemisphere language network functional connectivity across development

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Language processing in healthy adults relies on a left-lateralized network. When the critical left hemisphere (LH) language network (LN) is damaged early in life, e.g., in perinatal stroke, language can develop in the right hemisphere (RH) without deficits (Newport et al., 2022). In contrast, stroke in adulthood is associated with limited recovery and persistent aphasia. What allows for such RH reorganization early in life but not later? How does communication between language-related areas within the LH and RH change over age? We hypothesized that strong LH language connectivity was not well-established in early life, and that its development over age should align with when RH reorganization after stroke can occur. We analyzed LN functional connectivity (FC) across four healthy age groups: infants ($N=54$, mean age=4 months), toddlers ($N=61$, mean age=38 months), children ($N=111$, mean age=10 years), and adults ($N=71$, mean age=61 years). Infant and toddler data was extracted from the Baby Connectome Project, children data from the Human Connectome Project Development. Adult data were collected at Georgetown University. Participants were scanned during rest or movie watching. After standard preprocessing, we computed FC between 246 regions defined by the Brainnetome atlas (Fan et al., 2016). We used the Neurosynth database to generate an activation map of studies that report a key phrase 'language comprehension'. The LH parcels that overlapped with

the map, and their RH homotopes were defined as the LN. All the parcels outside the LN were defined as a non-language network (NLN). To analyze the differences in FC between RH and LH we ran paired-sample t-tests at each edge value within the LN (91 total) and between the LN and NLN (2071 total). All results were corrected for multiple comparisons. Within the LN, adults showed a LH bias: of 91 LN edges, 26 were stronger in the LH and 9 in the RH ($\chi^2(1)=10.9$, $p=.001$). Similarly, children had 24 edges stronger in the LH and 9 in the RH ($\chi^2(1)=6.82$, $p=.009$). As hypothesized, this pattern of LH connectivity was not present in early life. Infants had no significant difference in the proportion of strong connections (4LH and 9RH, $\chi^2(1)=1.9$, $p=.17$). Similarly, toddlers showed no significant differences (6LH and 16RH, $\chi^2(1)=4.6$, $p=.033$; Bonferroni-corrected α -level across groups was .01). For the between-network FC, all age groups had a higher number of strong RH than LH connections (infants: 44LH, 112RH; toddlers: 49LH, 124RH; children: 238LH, 345RH; adults: 103LH, 174RH). This LN-to-NLN stability suggests that our LN changes are not due to methodological differences in FC data collection across samples and ages. Our results suggest a developmental shift in the number of strong LH LN connections. Early in life, LN connectivity is not yet adult-like: infants and toddlers have no difference in the strength of RH and LH LN connections. As the brain matures, FC within the LH LN increases, forming a more specialized and efficient network for language processing. We speculate that this changes the ability of the RH to develop language after stroke, a hypothesis we are pursuing in ongoing work on childhood stroke.

C26 Sandbox Series - Synergistic Predictive and Reinforcement Mechanisms Drive Language Learning Success

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Language learning in adulthood presents significant challenges, often resulting in proficiency that is far from native-like and exhibiting considerable individual differences at the population level. We hypothesize that these challenges arise from suboptimal synergization of different learning mechanisms, with varying levels of this synergy accounting for the individual differences in learning success. To test this hypothesis, we examined how predictive coding and reinforcement learning mechanisms work together contribute to language learning by training three transformer-based models to learn an artificial language (Brocanto2) with distinct learning tasks: a) next-word prediction (GPT-G), where the model updates its internal representations by comparing predicted text to real text; b) grammaticality judgments (GPT-C) involving reinforcement learning, where the model is updated based on corrective feedback; and c) an integrated approach combining both training methods (GPT-GC). We collected functional magnetic resonance imaging (fMRI) data from 102 adult participants during an artificial language learning paradigm, tracking neural activity on the first day of learning and measuring behavioral performance over seven training days. All three models learned the artificial language with high accuracy: GPT-G achieved 91%

in generating novel and correct sentences, GPT-C reached 100% in grammaticality judgments, and GPT-GC scored 95% for generation and 97% for judgment, surpassing human participants. Representational similarity analysis showed a strong alignment between the models and human brain activity patterns, indicating that these GPT models developed internal representations similar to those of the human learners, even though they were never explicitly instructed to predict words. The prediction-based and reinforcement-based models demonstrated complementary roles in explaining activation patterns in the human brain. GPT-G showed a predominant alignment, while both GPT-G and GPT-C exhibited an alignment that progressed from sensory-motor regions to language regions as their performance improved. Meanwhile, the integrated model offers an additive explanation for the brain activities observed, supporting the hypothesis that synergistic predictive and reinforcement mechanisms are essential for language learning. Additionally, the integrated model and its corresponding neural activation patterns predicted individual learning performance effectively, not only on day 1 but also in the generalization test performance observed on day 7. These findings suggest that human language learning relies on both predictive processing and reinforcement signals. Our results integrate computational modeling and neuroimaging to demonstrate how these learning mechanisms play complementary roles in developing and refining language knowledge. This study provides a new framework for understanding language learning as a synergistic interaction between prediction and reinforcement learning mechanisms, with implications for language education and rehabilitation.

C27 - Formation of Hierarchical Neural Representations in Auditory Category Learning

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Effective speech and music perception rely on the ability to transform continuously changing acoustic signals into meaningful auditory categories. Listeners can achieve this by learning to integrate various acoustic cues based on their immediate reliability and relevance while abstracting them to create generalizable sound-category mappings. At the neural level, learning a novel auditory category may be supported by forming gradient hierarchical representations that derive from integrating multiple acoustic representations in auditory pathways. To test this hypothesis and further examine how the acoustic cues are represented in the brain over learning to form new category representations, we asked 34 adults to complete a magnetoencephalography (MEG) experiment while they learned to categorize novel speech-like sounds into two categories with corrective feedback. These sounds differed in temporal and spectral modulation, falling into two categories divided by a boundary in the acoustic space. Successful categorization requires the integration of the two acoustic cues. We found that behavioral categorization accuracy increased significantly across blocks, indicating efficient category learning. We generated six representation models, including three acoustic models (temporal modulation, spectral modulation, and spectro-temporal similarity) and three higher-level category-relevant models (category-boundary distance, binary category, and behavioral accuracy). We found robust encoding of all three acoustic models in the brain from ~100 ms, with temporal

modulation emerging ~200 ms after onset across all training sessions. Category-relevant (i.e., boundary distance and category) and behavior decision representations emerged only in the later learning sessions, and these representations were maximal over left frontotemporal regions ranging from 250 to 500 ms. The higher-level representations correlate closely with the acoustic representations (i.e., spectro-temporal similarity model), computed by integrating their information. These findings reveal a two-layer structure of category learning: early, cue-specific encoding followed by the emergence of category-level and behaviorally decision codes, consistent with our gradient abstracting hypothesis of category learning. Our results provide neural evidence that auditory category learning is driven by progressive integration and abstraction of multiple acoustic cues. These findings refine models of human auditory cognition and highlight encoding modeling as a powerful tool for linking neurodynamics to the category learning process.

C28 - Neuro-behavioral Correlates of Statistical Learning in English Second Language Comprehension: The Specificity of Statistical Learning Modality

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Improving listening comprehension is a primary concern for many Chinese English second language (ESL) learners, whose listening skills often lag behind their reading comprehension. An individual's implicit statistical learning (SL) ability is considered a crucial mechanism for both L1 and L2 acquisition (Frost et al., 2013; Ren & Wang, 2024; Saffran et al., 1996), which helps to explore the possible mechanism underlying this listening-reading gap in Chinese ESL learners. Recently, the neural indices of online auditory statistical learning (ASL), specifically inter-trial phase coherence (ITPC) in the delta band at chunk-rate (1.1 Hz) and item-rate (3.3 Hz) (Batterink & Paller, 2017), were shown to significantly correlate with L1 phonological awareness (Zhang et al., 2021). However, the relationship between the neurocognitive mechanisms of SL and ESL comprehension, particularly listening comprehension, remains underexplored. Furthermore, it is unclear whether the modality of SL (auditory vs. visual) moderates the relationship between SL abilities and specific language skills. This study investigated the correlations between SL and English L2 comprehension in Chinese native speakers, examining the possible moderating effect of SL modality (Study 1), and explored the specific neurophysiological correlates of auditory SL and visual SL (Study 2). In Study 1, 38 Chinese ESL learners completed cognitive assessments including working memory, rapid automatized naming (RAN), visual perceptual skills (TVPS-4), and auditory/visual SL tasks. Their College English Test Band 4 (CET-4) listening and reading scores served as indices of ESL comprehension. The results indicated that listening scores, which showed greater variability, were significantly lower than that of reading and had a stronger association with total CET-4 scores than reading scores. VSL was significantly positively correlated only with CET-4 reading scores, whereas ASL was significantly positively correlated with both CET-4 listening and total scores. After controlling for other cognitive factors, ASL and VSL made unique contributions to English L2 listening and

reading, respectively. Study 2 further collected EEG signals during auditory and visual SL tasks from 27 Chinese ESL learners. The results revealed distinct correlation patterns between the ITPCs derived from ASL and VSL tasks and both ESL performance and behavioral SL measures. In summary, our findings indicate the importance of SL for ESL comprehension and suggest modality specificity, potentially informing approaches to narrow the listening-reading gap and enhance learning effectiveness. Moreover, the results support the domain specificity of SL (Frost et al., 2015), highlighting the necessity of examining SL across different modalities when investigating individual differences in the relationship between SL and second language learning among diverse second language learners.

C29 - A precision rehabilitation approach to naming treatment in aphasia: Retrieval practice versus errorless learning

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Naming impairment is a prevalent and debilitating issue in post-stroke aphasia, often resulting from lexical access disorder, specifically, difficulty mapping between semantics and words (Stage 1) and/or between words and phonology (Stage 2). Two established naming treatments, retrieval practice (RP) and errorless learning (EL), leverage distinct learning principles to support language recovery. RP prompts retrieval from long-term memory (e.g., naming an object from its picture), engaging both Stage 1 and Stage 2 mappings during naming. In contrast, EL emphasizes the practice of Stage 2 mapping (e.g., repeating the name of a picture after hearing it), relying less on semantics-driven retrieval. Little is known about how individual differences in major processing stages of naming influence the benefits of RP and EL. RP and EL differentially engage the two stages of naming and may selectively improve errors from different stages. Through the lens of precision rehabilitation, the present study investigates person-specific and item-specific factors that impact differential treatment outcomes. A naming treatment study was conducted with 30 participants with chronic stroke-induced aphasia. For item selection, a 660-item common objects picture corpus was administered twice for naming assessment. Responses were coded into correct, phonological errors (Stage 2 error), semantic errors (Stage 1 error), and others. Each participant's personalized 120-item set was evenly assigned to RP and EL treatment conditions in a matched fashion. Each item was treated twice after an initial learning trial, with treatment trials ending in correct-answer feedback. Naming performance for 120 treated and 30 untreated items was assessed the next day and one-week post-treatment. Six cognitive-linguistic variables were collected as person-specific factors, including input and output semantic and phonological processing abilities, naming severity, and verbal working memory (WM) capacity. For each treated word, the item-specific factor (item nature) was coded into six categories based on pre-treatment item selection performance: correct, pure Stage 1, blended Stage 1, pure Stage 2, blended Stage 2, and other. Naming accuracy at the next-day post-treatment test was used as the dependent variable. We used separate multilevel logistic mixed-effects models to investigate how the variability in

participants' characteristics and item nature impact naming treatments' benefits. Both models evaluated the interaction between treatment type (RP versus EL) and person-specific or item-specific factors. Both treatments significantly improved naming accuracy compared to the untreated condition. In the person-specific model, higher verbal WM capacity was associated with greater benefit from RP relative to EL. In the item-specific model, RP outperformed EL for pure and blended Stage 1 items and blended Stage 2 items one-day post-treatment. At the one-week follow-up, RP maintained its advantage for pure Stage 1 and previously correct items. Theoretically, person-specific results suggest that WM may contribute to the effectiveness of RP by supporting semantic-driven retrieval, integrating successful retrievals into long-term representations, and/or facilitating learning from feedback after unsuccessful retrievals. Item-specific findings indicate that RP's mechanism of action may be strengthening Stage 1 mappings. Clinically, these findings suggest that RP may be particularly effective for individuals with high WM and for items affected by Stage 1 (semantic) errors.

C30 - Generalizable Speech Somatotopy Revealed by Intracranial Stereo-encephalography

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Human language production requires coordinated control of the vocal articulators to generate distinct phonological units composing meaningful words. Speech brain-computer interfaces (iBCIs) have provided communication alternatives for those who lost speech due to motor system disorders by decoding preserved articulatory representations from surface grids and penetrating arrays (Bouchard et al. 2013, Metzger et al. 2023, Willet et al. 2023). However, the capacity of depth electrodes to capture neural representations of articulatory control remains poorly understood. Here, we characterized broadband high-gamma (BGA; 70–150 Hz) neural dynamics from depth electrodes in 42 patients performing naturalistic sentence production tasks. Multivariate temporal receptive field (mTRF) encoding models were fit to both phoneme sequences and articulatory kinematic trajectories (AKTs) derived from an acoustic-to-articulatory inversion (AAI) model. In the speech-related ventral sensorimotor cortex (vSMC), highly correlated sites ($r > 0.3$) were identified both in the precentral gyrus and along the sulcal portion of BA4 (primary motor cortex) and BA6 (premotor cortex). Hierarchical clustering and low-dimensional projection of encoding filter weights from highly correlated electrodes ($r > 0.3$) revealed a structured organization of phonemic encoding by primary articulators (vocalic, lingual, labial). A prominent somatotopic division along the ventral-dorsal axis of the ventral sensorimotor cortex (vSMC) was observed, distinguishing tongue and lip representations. Notably, vocalic representations were localized deeper within the central sulcus compared to other supralaryngeal representations. In two bilingual participants who performed the task in both English and Spanish, phoneme and AKT encoding

models successfully explained substantial cross-language neural variance. AKT models demonstrated superior cross-language generalization compared to phoneme-based models. At the single-electrode level, tuning to phonemic groups and articulatory gestures were preserved across languages. Low-dimensional projections of filter weights revealed a separable boundary between labial and lingual phones across both languages. Reconstruction of AKTs with seq-to-seq models preserved decoding fidelity despite models being trained on a different language, indicating a shared articulatory code across languages. These findings revealed a unifying articulatory motif underlying natural language production at the local field potential level and highlighted the capacity of depth electrodes for future speech iBCI applications. Furthermore, the demonstrated cross-linguistic generalizability suggests the potential for novel neural speech decoding strategies based on latent articulatory representations.

C31 - Enhancing Prefrontal Theta Activity Associated with Action Verbal Fluency in Parkinson's Disease

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Word retrieval deficits often present in patients with Parkinson's disease (PD). While invasive brain stimulation of subcortical structures improves motor symptoms in Parkinson's disease (PD), its effects on speech and language impairments in PD remain inconsistent. Therefore, it is crucial to develop novel brain protocols that could improve word retrieval deficits in PD. Accumulating evidence supports the application of transcranial alternating current stimulation (tACS) to improve motor and non-motor deficits in PD. We employed a sham-controlled non-invasive neurostimulation protocol that aimed to examine the effect of multisite 4 Hz HD-tACS over the left frontal aslant tract (FAT) on verb fluency performance in individuals with PD. FAT connects inferior frontal gyrus (IFG) to supplementary motor area (SMA) and play crucial role in speech and language. Abnormal activity has been shown in both IFG and SMA in individual with PD. Seventeen non-demented PD participated in this study. They were native speaker of English and had normal or corrected vision. They received actual and sham stimulations with a week apart. The order of sessions was counterbalanced across participants. Following actual and sham stimulations, EEG data were recorded while participants performed action fluency (AF), phonemic fluency (PF), and semantic fluency (SF) tasks. Patients generated significantly fewer items in AF compared to PF and SF, regardless of stimulation, suggesting a relative decline in action word retrieval in PD. Relative to sham, the power of prefrontal theta activity significantly increased following actual stimulation for AF; this effect was not observed for PF and SF. Moreover, AF elicited a significant increase in prefrontal theta activity relative to PF and SF following actual stimulation but not sham stimulation. Based on these findings, we propose that stimulation of the left FAT in PD modulates oscillatory markers of word retrieval for action-related words (i.e., action fluency). This selective modulation of prefrontal theta activity does not indicate a general improvement in cognitive control but rather suggests that stimulation specifically enhances the executive control required for action word retrieval in PD. These results suggest that 4 Hz stimulation of the FAT may serve as a non-invasive protocol to improve action semantics, which is typically compromised in PD.

C32 - Age-Related Changes in Resting-State Functional Connectivity and Executive Function Predict Specific Types of Speech Disfluency

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Speech disfluencies become more frequent with age, yet the mechanisms underlying this change are not well understood. One possible mechanism is age-related decline in executive function (EF), which has been linked to increased difficulties in maintaining fluent speech. Simultaneously, aging is also associated with intrinsic large-scale functional reorganization of brain networks such as the Default Mode Network (DMN) and Multiple Demand (MD) network which play important roles in EF. Moreover, prior work using Resting-State Functional Connectivity (RSFC) to capture these intrinsic changes has linked aging with reduced functional segregation—reflected in weaker within-network coherence and stronger between-network connectivity—which may impact the specialization of systems supporting language production (Zhang & Diaz, 2023). Building on this work, the present study ($n = 271$) examined a) whether RSFC within and between the Language, DMN, and MD networks predicts speech disfluency patterns and b) whether EF (measured via Stroop interference) and/or RSFC mediates the relationship between age and speech disfluency. Importantly, we distinguished disfluency types (e.g., repetitions, revisions, filled/unfilled pauses, and prolongations) to identify which are most sensitive to cognitive and neural factors. Behaviorally, aging was associated with more repetitions, revisions, and unfilled pauses, but was negatively associated with filled pauses. Age also significantly predicted worse Stroop performance, consistent with age-related declines in EF. In terms of RSFC, increasing age predicted significant declines in within-network connectivity and segregation across all three networks. Increasing age also predicted decreases in between-network RSFC between the Language and DMN. Notably, greater RSFC between the Language and DMN was associated with fewer revisions ($b = -1.26$, $p = .0095$) and fewer unfilled pauses ($b = -3.26$, $p = .0405$), while higher DMN segregation was associated with fewer total disfluencies ($b = -3.19$, $p = .042$) and repetitions ($b = -0.572$, $p = .0029$). Two significant Age $\times$ Connectivity interactions emerged. First, age moderated the relationship between DMN within-network connectivity and filled pauses ($p = .016$) such that among older adults, greater within-DMN connectivity predicted more filled pauses, suggesting that increased coherence in this network may not support fluent speech in older age. Second, age moderated the relationship between DMN segregation and repetitions ($p = .0098$) such that in younger and middle-aged adults, greater DMN segregation was associated with fewer repetitions, but this effect diminished in older adults. Lastly, causal mediation analyses revealed that Stroop performance partially mediated the effect of age on filled pauses (indirect effect: $B = -0.0057$, $p = .048$), suggesting that age-related declines in EF may contribute to increased use of filled pauses. Together, these findings suggest that age-related changes in both EF and RSFC within and between brain networks related to language contribute to specific patterns of speech disfluency in adulthood. Moreover, the distinct effects across disfluency types highlight that not all disfluencies are functionally equivalent—certain types may be more tightly linked to the breakdown of domain-general cognitive control or network modularity with age.

C33 - Toward Decoding Meaning: Single-Neuron Semantics in Natural Dialogue

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Current speech neuroprosthetic systems fall short of harnessing the brain's full capacity for language. Understanding the neural computations that translate thought into words—and do so seamlessly in multi-speaker conversations—is a formidable challenge. This project aims to accurately characterize the neural mechanisms underlying language production and comprehension using biostatistical modeling and network-level approaches. We analyze naturalistic conversations recorded from patients undergoing intracranial monitoring for epilepsy, enabling us to examine single-neuron activity in real-world social interactions. We demonstrate that a subset of neurons significantly encodes semantic features, as shown by their modulation by contextual word embeddings. By fitting Poisson ridge regression models to neural spike data, we identify neurons whose firing rates are reliably predicted by at least one semantic embedding dimension. Crucially, the naturalistic setting provides rich sampling of both spoken and heard words, allowing us to dissociate the neural subspaces involved in production and comprehension. In both hippocampus and anterior cingulate cortex, we observe semi-orthogonal subspaces for these two processes. Model-based tuning curve correlations reveal a positive—but not complete—overlap, suggesting shared yet speaker-sensitive representations. This speaker-sensitivity persists within semantic categories (e.g., places vs. body parts), indicating that the structure of neural encoding varies across linguistic domains. Together, these findings provide evidence for fine-grained, semantically grounded representations at the single-neuron level during conversation. By uncovering these neural computations, we lay the groundwork for neuroprosthetics that decode both language production and comprehension with greater fidelity.

C34 - Stimulus-response correlation space analysis dissociates spatiotemporal cortical networks supporting speech production

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Introduction: The spatiotemporal distribution of cortical activation during language production is a central question in cognitive neuroscience. High spatial/temporal resolution recording over multiple brain regions can help resolve this question. However, to interpret this electrophysiological data, specific psycholinguistic manipulations with testable behavioral

predictions are necessary to separate neural variance attributable to dissociable processing stages. Here, we combine a delayed visual naming paradigm in conjunction with intracranial electrophysiology to identify specific spatiotemporally separated cortical networks supporting specific stages of speech production. **Methods:** Subjects (20 healthy, 15 intracranial electrophysiology) are presented visual stimuli (pictures, words, pseudowords) to name but are instructed to delay response until a go cue at 0/400/1000ms. Behavioral analyses examine the effect of interaction of psycholinguistic factors (lexical frequency, phonological density, etc.) and delay on response time (RT). For electrophysiological analysis, we exploit the temporal variance induced by delay. We calculate stimulus/response-locked trial-to-trial correlation of high gamma (70-200Hz) activity at each contact/region and project this to a stimulus-response correlation space. We parcellate cortical networks in time and space by shifts in stimulus-response correlation space in response to psycholinguistic factors and compare these changes in RT induced by the same factors to validate separation of networks. **Results:** Behaviorally, the factor delay modulated the effect of lexical selection on RT in both populations ($F_{6,3176}=2.49$, $p=0.021$) but did not modulate temporal parameters of phonological planning ($F_{2,3182.6}=0.92$, $p=0.04$), confirming the paradigm separates processing stages. Stimulus-response correlation analyses revealed globally invariant structure across subjects. Certain regions showed strong stimulus-locking (occipital lobe) or response-locking (motor cortex), but most regions were intermediate. Distances in stimulus-response correlation space did not correlate with physical (Euclidean) distance between contacts in the brain ($R^2=0.013$), suggests that our approach was not simply capturing brain structure. Shifts in correlation space identified dissociated cortical networks that predicted substantial variance in RT from lexical selection ($R^2=0.64$) and phonological density ($R^2=0.75$). Using a leave-one-subject-out cross validation approach, these shifts explained 31.4% of variance in RT at the trial level. We then examined the activity of these networks in time for various stimuli categories and examined the shifts in cortical networks in amplitude and peak time. We find that there are sequential but overlapping stages of speech production widely distributed across the cortex. **Conclusion:** Stimulus-response correlation space reveals stable spatiotemporal signatures of psycholinguistic processing that generalize across individuals. Analysis in stimulus-response correlation space provides a way to leverage temporal variance in the task to separate processing stages temporally and across cortical locations. This approach also provides a functional space in which electrophysiological data from multiple subjects, each with different electrode coverage, can be directly compared. Using this approach, we identify a mixed serial and overlapping process of speech production.

C35 - Effects of syllable frequency in speech production: Replication and extension

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Speaking requires translating an intended message into a sequence of sounds. There is a noticeable difference in the ease with which frequently produced sequences of speech sounds are articulated compared to those rarely produced (see for

review, Laganaro, 2019). One explanation is that well-learned sequences form stable, automatized articulatory routines—syllable-sized chunks in a Mental Syllabary (Crompton, 1982)—while motor plans for infrequent sequences are assembled online, segment by segment. Empirical support for the Mental Syllabary hypothesis includes, for instance, shorter naming latencies for frequent syllables and diverging ERP waveforms for high and low frequency syllables before articulation onset. We aimed to replicate these findings and extend the data to articulatory duration which, so far, had remained untested. If motor plans for frequent syllables are automatized, this should yield shorter and less variable articulatory durations for frequent than infrequent syllables. In two naming experiments, adult native speakers of Dutch produced high- or low-frequency non-word syllables (e.g., 'kem' or 'kes'). Experiment 1 ($n = 26$) used immediate naming and visual presentation of the syllables. Materials were taken from Cholin, Levelt and Schiller (2006). Using linear mixed modeling and a backward step-wise model comparison approach, we found a main effect of frequency on naming latency: as expected, naming latency decreased with syllable frequency. We also observed an interaction between syllable frequency and the condition it was assigned to. Within the high-frequency condition, naming latencies decreased with frequency as expected. In contrast, within the low-frequency condition (0 to 3.1 occurrences per million), naming latencies slightly increased with frequency. This effect could reflect the effortful retrieval of infrequent, but putatively learned, syllables. Contrary to our prediction, articulatory duration increased with syllable frequency. Experiment 2 ($n = 20$) used delayed naming and auditory presentation of the syllables. Participants heard a target syllable, then an auditory distractor, and finally produced the syllable upon presentation of a visual cue. We recorded the EEG as in Bürki, Cheneval and Laganaro (2015). Preliminary results replicate their basic pattern of diverging ERP waveforms in the 200 ms time window before speech onset, suggesting that frequent and infrequent syllables differ in processing cost. As expected, there was no frequency effect for the delayed naming latencies. However, articulatory duration again increased with frequency. Experiment 1 is the first replication of Cholin et al.'s behavioral findings with identical materials and Experiment 2 is a conceptual replication of the study by Bürki, Cheneval and Laganaro (2015). The study adds novel results concerning articulatory durations. We speculate that high-frequency syllables will have been produced in more diverse contexts and so be associated with a wider set of permissible instantiations, from which speakers make a random choice in our task. This raises questions about the internal structure of motor plans—e.g. whether they involve gestures or phonetic features or differ in their articulatory targets. Future research should examine how motor plans interact with the prosodic demands of connected speech, including how frequency shapes articulatory duration in fluent, continuous production.

C36 - Decoding words during sentence production: ECoG reveals syntactic role encoding and structure-dependent temporal dynamics

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Language production research has primarily focused on single-word tasks, such as picture naming. In contrast, the neural

underpinnings of sentence production remain less studied due to experimental challenges and limitations of traditional neural measures (e.g., fMRI, MEG), which are sensitive to motor artifacts and offer limited spatial/temporal resolution. Even the assumption that isolated word production mirrors sentence contexts remains largely untested. To address this, we used electrocorticography (ECoG) to record brain activity in 10 awake neurosurgical patients during an overt production experiment. In a picture naming block, participants repeatedly named six characters (e.g., chicken, nurse). They then completed a sentence production block, describing cartoon scenes in response to questions in active (Who hit whom?) or passive (Who was hit by whom?) forms, resulting in active ("Dracula hit Frankenstein") and passive ("Frankenstein was hit by Dracula") sentences. Using machine learning classifiers, we identified neural patterns uniquely associated with each word during picture naming. Models were trained for each of seven ROIs, 20 time windows (-750 to 250ms from speech onset), and for each patient, resulting in ~1,400 classifiers. We validated these models using held-out picture naming trials, where they successfully decoded word identity in the time window that the model's training data came from, consistent with feedforward models of lexical access. Next, to test generalizability, we used these classifiers to predict word identity throughout sentence production. For active sentences, we successfully decoded each word in the order of production – i.e., subject then object. Because the classifiers were trained only on picture naming data, this constitutes strong evidence for shared representations between single word production and sentence production. Intriguingly, applying this same procedure to passive sentences revealed a different pattern. While we again successfully decoded word identity with above chance accuracy, across models, both the subject and the object remained active throughout the entire sentence. This was driven by sustained representations in prefrontal cortex, which has previously been implicated in the processing of non-canonical sentences like passives, but its particular function has remained a topic of debate. Here, we show not only that it plays a role in sustaining word representations, but furthermore that it encodes words' sentence position, with inferior frontal gyrus (IFG) selectively encoding subjects and middle frontal gyrus (MFG) objects. In contrast, sensorimotor cortex, which encodes articulatory information, patterned with active sentences, encoding words in the order in which they were produced. Our findings reveal a previously uncharacterized division of labor within the language network. Sensorimotor cortex encodes lexical information robustly and in a task-agnostic way, while prefrontal regions are sensitive to syntactic structure, likely reflecting flexibility under varying task demands. Furthermore, we unexpectedly uncovered a means by which the brain tracks syntactic roles: a spatial code whereby subjects are selectively encoded in IFG and objects in MFG. We propose that the complex temporal dynamics of word processing in prefrontal cortex may impose a subtle processing pressure over the course of language evolution, offering a possible explanation for why nearly all the world's languages place subjects before objects.

C37 - Enhancing Pragmatic Abilities in Autism through Reading Intervention: Insights from fMRI

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Autism Spectrum Disorder (ASD) is associated with difficulties in processing and using pragmatic language¹, the use of language in social contexts². Delayed language is an early sign of ASD³ that often leads to long-term challenges in reading comprehension. Although much of the research on reading has focused on comprehension alone, some studies suggest a relationship between pragmatics and reading skills^{4–6}. However, the neural mechanisms underlying pragmatic language in ASD remain underexplored. The main objective of this study is to assess the engagement of pragmatic network (PN), which involves brain regions like the Inferior Frontal Gyrus (IFG), dorsomedial prefrontal cortex (dmPFC), superior temporal gyrus (STG), temporal pole, Heschl's gyrus, among others^{7,8}, in reading comprehension in autistic children. This functional magnetic resonance imaging (fMRI) study examines the impact of an intensive reading intervention (Visualizing and Verbalizing, V/V) on pragmatic language processing in children with ASD. The V/V program is a 10-week, 200-hour intervention designed to enhance oral and written comprehension. Participants engage in one-on-one sessions with a trained learning process clinician^{9,10}. The sample included 21 children in the experimental group (ASD-EXP, 11.40 ± 1.84 years) and 17 children in the control group (ASD-WLC, 11.04 ± 1.40 years). Both groups completed assessments of reading comprehension (GORT11) and social communication, measure that encompasses pragmatic skills (SRS-SCI12) and underwent fMRI scans before and after the intervention. The ASD-EXP group received the intervention between pre-and-post-testing, while the ASD-WLC group received it afterward. Three analyses were conducted: (1) Paired sample t-test to evaluate changes in reading comprehension and social communication, (2) General Linear Model (GLM) analysis in FSLv6.0.313 to assess changes in brain activation, and (3) Spearman's correlation to examine the relationship between reading comprehension, social communication, and brain activation in the PN. Results showed that the ASD-EXP group exhibited significant improvements in reading comprehension ($t(18) = 4.17$, $p < 0.05$), and a slight, though not significant, improvement in social communication ($t(18) = -1.40$, $p = 0.19$). The ASD-EXP group showed post-intervention activation in the precuneus, extending to the fusiform gyrus (FFG), right LOC, and right cerebellum VI; and the left premotor (PMA) and supplementary motor (SMA) areas, extending to the IFG, dmPFC, and frontal eye fields (FEF). No significant activation changes were seen in the ASD-WLC group. Additionally, BOLD signal change in the left STG negatively correlated with changes in social communication ($\rho = -0.67$, $p = 0.02$). In conclusion, the V/V intervention improved reading comprehension in the ASD-EXP group, accompanied by increased activation in PN (precuneus, dmPFC, LOC, and IFG^{7,8}) and in reading comprehension areas (FFG and PMA)¹⁴. These findings suggest that intensive reading interventions can promote neuroplasticity, engaging PN and reading networks. Furthermore, the negative correlation between the STG with social communication, including pragmatic skills, indicated a positive impact of reading

intervention on these areas. The absence of significant changes in the ASD-WLC group highlights the intervention's specificity. These results suggest that targeted reading interventions may enhance reading comprehension and pragmatic skills and may improve social communication in autistic children.

C38 - Exploring neural correlates of discourse topic prediction via discourse markers

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Discourse markers (DMs, henceforth) are widely accepted across frameworks as serving key interactional functions, among them topicality management in interaction, aiding speakers in navigating the conversational flow and discourse progression. However, the body of evidence supporting the claim that these devices serve as cues to signal maintenance of discourse continuity or topic shift to the interlocutor is primarily theoretical and corpus-based, providing only limited insights into the cognitive mechanisms involved. This study provides neural evidence for the processing of three turn-initial Spanish DM configurations: “y” (“and”), perceived lengthened “y” (“and”), and “bueno y” (“well and”) and their alleged role as cues for continuity (the former) and discontinuity (the latter two). Participants ($n = 30$) of both Latin American and Peninsular varieties underwent EEG recording while passively listening to short three-turn dialogues (6 lists $\times$ 60 trials, Latin-square design), with critical utterances either continuing on the same topic or introducing a new topic, each preceded by one of three target DMs. Statistical analyses were conducted, focusing on the typical central-parietal topographical distribution of the N400 component in two time windows: 450–650 ms post-stimulus onset and 700–950 ms post-critical word onset. The first analysis, assessing core processing effects of DMs, revealed a significant main effect of DM ($p < 0.001$). Pairwise comparisons showed significant differences between “bueno y” and “y” ($p < 0.001$), and between “bueno y” and the perceived lengthened “y” ($p < 0.001$), but not between “y” and its perceived lengthened version ($p = 1.000$). The second analysis explored cognitive load in response to matching or mismatching expectations of discourse topicality set by the initial DM. No significant main effects of DM ($p = 0.594$), topic ($p = 0.576$) or DM $\times$ topic interaction ($p = 0.814$) were observed. Results from the first time window suggest that these devices encode specific pragmatic information and processing instructions, therefore generating distinct discourse expectations that translate into different processing efforts. Mean amplitudes of DMs revealed “y” and perceived lengthened “y” elicited similarly reduced N400s, aligned with continuity processing, whereas “bueno y” elicited larger negativity, suggesting greater processing demands, likely prompting the anticipation of topic shifts. Findings for the second time window suggest that topic shifts, while detected, may not consistently disrupt local semantic integration processes. One possible explanation is that the topic shifts presented were not disjunctive enough to elicit pronounced N400 responses when content contradicted expectations set by the markers. Overall, our results suggest that DM processing primarily modulates early predictive mechanisms, setting up initial expectations, while continuations are flexibly incorporated into the evolving discourse model without incurring costly processing efforts. This

dissociation between early DM effects and later integration challenges the theoretical assumption that the studied DMs directly signal topic (dis)continuity in upcoming discourse.

C39 - Understanding Sarcasm's Neural Correlates Through a Novel fMRI Spanish Paradigm

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Background: Sarcasm is a complex form of pragmatic language that involves recognizing a speaker's intention as incongruent with literal meaning. Understanding sarcasm engages both linguistic and social-cognitive (theory of mind, ToM) processes, but the neural underpinnings of sarcasm comprehension in ecologically valid, language-specific contexts remain underexplored. This study aimed to investigate the brain mechanisms supporting sarcasm processing in Spanish using a novel, validated event-related fMRI task. **Methods:** Eighteen healthy, right-handed Spanish speakers (mean age = 24.33 years) participated in the study. During fMRI scanning, participants viewed 60 cartoon-based vignettes across three conditions: sarcastic, literal, and baseline (image-only or text-only). All sarcastic and literal items shared identical utterances, with only the context varying, allowing isolation of pragmatic processing. Stimuli were presented for 4500 ms each, and participants classified the type of stimulus using a four-button response box. Accuracy and response times were recorded. Functional images were acquired using a 3T Philips Achieva scanner and analyzed using SPM12. First-level GLMs included four regressors corresponding to each condition, with second-level contrasts comparing sarcasm > literal and sarcasm > baseline. **Results:** Behaviorally, participants performed above chance across all conditions with no significant accuracy differences. Neuroimaging results for the sarcasm > literal contrast revealed left-lateralized activation in ToM-related areas: medial prefrontal cortex (mPFC), inferior frontal gyrus (IFG), superior temporal sulcus (STS), and temporo-parietal junction (TPJ), including the angular and supramarginal gyri. Additional activations were found in the amygdala, insula, temporal pole, and visual/motor regions, suggesting the involvement of broader contextual and emotional processing networks. The sarcasm > baseline contrast showed a similar pattern with additional engagement of the dorsolateral prefrontal cortex and primary sensorimotor cortices. **Discussion:** Findings support the hypothesis that sarcasm comprehension involves an interplay between ToM and linguistic systems. The mPFC and TPJ likely contribute to mentalizing and detecting context-meaning incongruence, while the left IFG and posterior middle temporal gyrus (pMTG) facilitate semantic integration and ambiguity resolution. Notably, sarcasm elicited broader activation beyond classic ToM areas, suggesting that pragmatic language comprehension requires integration of emotional, semantic, and contextual information. The pMTG may be

particularly crucial in resolving semantic narrowing during sarcasm, while the IFG may serve as a convergence site for evaluating speaker intent and meaning. **Conclusion:** This study provides novel insights into the neural architecture of sarcasm comprehension in Spanish, emphasizing the integrated function of language and ToM networks. Despite limitations due to sample size, results demonstrate that sarcasm engages an extensive fronto-temporo-parietal network, bridging linguistic processing and social cognition. These findings highlight the utility of ecologically valid paradigms in elucidating the neurocognitive mechanisms of pragmatic language.

C40 - The Neurodevelopment of Pragmatic Processing in Adolescence and Beyond

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In conversation, the literal form of an utterance often differs from the speaker's intended meaning. Nonetheless, we typically understand the meaning of such indirect speech acts (ISAs). This ability constitutes one of several pragmatic abilities. fMRI studies in adults show that processing ISAs (compared to direct speech acts) elicits greater activation in language and Theory of Mind (ToM) regions. In our previous investigation, we found that individual differences in pragmatic skill manifested in two clusters outside these networks during ISA processing. However, less is known about the neurodevelopmental trajectory of ISA processing in adolescence. Using an established fMRI paradigm, we investigated ISA processing (1) across adolescence and (2) into adulthood by comparing adolescents to adults with varying pragmatic skill levels. We collected new fMRI data from adolescent participants (n = 51), divided into younger (ages 13–15, n = 24) and older (ages 16–18, n = 27) age groups. Participants listened to short conversations ending with indirect or direct speech acts. We also included our previously collected adult data set (n = 57) in which participants completed the same paradigm. The adults were subdivided into two groups based on performance on two pragmatic behavioral tests: a low-scoring group (LS, n = 28) and a high-scoring group (HS, n = 29). We contrasted activity during ISAs and direct speech acts within each group and tested for differences between groups, using both whole-brain and ROI-based analyses. Our adolescent results replicated prior findings in adults. Activity increased between adolescence and adulthood in the posterior superior medial prefrontal cortex (mPFC). We also found age-related differences in activation in the left posterior intraparietal sulcus (IPS), overlapping with the canonical “frontoparietal network”. Younger adolescents showed greater activation in this cluster when listening to direct speech than ISA, whereas older adolescents showed little difference between conditions. We observed a similar pattern when comparing the adult groups, with the LS and HS groups mirroring the young and old adolescents, respectively. Activity in a cluster within the posterior cingulate cortex also differed between adolescents and adults, and between the LS and HS groups. The increasing activity in the mPFC suggests that this region may be a marker of pragmatic development, possibly reflecting a shift from general ToM to more conversation-specific pragmatic representations. Furthermore, we suggest that the increased activity in the IPS in the younger adolescents and the LS group during the processing of direct speech acts may reflect engagement of additional control functions. These groups may

be less certain about whether a direct interpretation is suitable, possibly over-interpreting direct trials. These control functions might involve (1) working memory to recall the previous conversational context and (2) structuring thoughts in an (erroneous) attempt to infer what a speaker may have implicitly meant. The similarity between young adolescents and the LS group indicates that pragmatics is still developing during adolescence, and that a delayed development may lead to persistent difficulties in adulthood. These findings suggest that aspects of pragmatic development depend on cognitive abilities other than language and ToM.

C41 - Discourse-level thematic context modulates lexical retrieval: Behavioral and neural evidence from younger and older adults

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Aging induces changes in language processing and production, including alterations in predictive processing and increased word retrieval failures (e.g., Barresi et al., 2000). Prior research has focused on retrieval failures arising from semantic interference induced by categorical word relations (e.g., dog and horse). However, retrieval in more ecologically valid settings, including discourse, may involve co-activation of thematic relations, which are context-dependent word associations (e.g., "butterfly" and "shovel" are exemplars of "garden"). Thematic context arguably requires both the formation of ad-hoc categories representing the theme and the maintenance of contextual information. These processes may be differentially affected by aging, as older adults show decrements in contextual processing and maintenance (e.g., Federmeier et al., 2010). The mechanisms underlying how thematic relations impact retrieval are poorly understood. Competing theories suggest that thematic context may either aid (e.g., Dark Side Model Revision, Oppenheim & Nozari, 2021) or interfere with (e.g., Swinging Lexical Network Hypothesis, Abdel Rahman & Melinger, 2009; 2019) retrieval. To determine how thematic context influences retrieval and whether the effect of context is age-invariant or not, we tested 24 younger ($M = 28.5$) and 23 older ($M = 70.35$) adults using a modified Blocked Cyclic Naming Paradigm (BCNP). Participants listened to a narrative establishing a thematic context (e.g., day at the beach) to simulate a discourse-like context. They then named thematically related or unrelated images in two block configurations: related items followed by unrelated items (related-first blocks), and vice-versa (unrelated-first blocks). After naming, participants recalled the narrative content to assess maintenance. We examined both behavioral responses during initial picture naming and across five repetitions, as well as neural responses using electroencephalography time-locked to image onset. We found that participants experienced behavioral facilitation from thematically related items in related-first blocks. However, when a delay was introduced and participants named unrelated items first (unrelated-first block), they instead experienced interference from thematic relations. Interestingly, younger adults experienced greater interference from related items than did older adults, but this effect diminished with repeated retrieval. Prior studies using the BCNP have identified an

enhanced anterior N2 response to unrelated images relative to categorically related items (e.g., Janssen et al., 2011; 2015). However, in our study, N2 amplitudes varied by block order. For both groups, N2 amplitudes were more negative for related items in related-first blocks and for unrelated items in unrelated-first blocks, suggesting that the mechanisms underlying retrieval are sensitive to thematic context. Moreover, the enhanced interference effect for younger adults may indicate that older adults did not maintain the narrative content to the same extent, which is further supported by our finding of poorer recall of narrative content by older adults. In sum, neither the Dark Side Model nor the Swinging Lexical Network Hypothesis were fully supported. Instead, we suggest that working memory modulates the relationship between thematic context and retrieval in discourse settings. We explore how this evidence of age-related decay of thematic context may have implications for prior findings of weakened predictive processing and poorer coherence in discourse for older adults.

C42 - Local Predictive Context Enhances and Speeds-Up Priming-Induced N400 Effect

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Imagine reading a shopping list: words such as apple, banana, and pear immediately create a strong sense of coherence, forming a predictive semantic context in which the next word orange fits naturally. In contrast, when the list begins with apple immediately followed by orange, the contextual support is weaker despite the identical semantic relatedness between the two words. This raises the question: How does local semantic context influence the processing of upcoming words, and how is it reflected in neural activity? Here, we conducted a priming experiment where participants ($n = 31$) performed a lexical decision task on targets that could be either real or pseudowords and were either related or unrelated to preceding primes. Each target was preceded by either one (short condition) or three primes of the same semantic category (long condition), while participants' brain activity was recorded using EEG. Our analysis focused on the N400 component elicited by the real word targets that were either semantically related or unrelated to the primes. Notably, while the priming-induced N400 effect is often associated with semantic integration, we hypothesized that our condition-based (long vs. short) N400 difference may additionally engage predictive mechanisms. Specifically, we propose that richer semantic context in the long condition may facilitate prediction of upcoming targets, influencing the N400 response. Given that cognitive abilities, such as working memory, processing speed or vocabulary size, may influence predictive processes, we also examined whether individual differences in these skills modulate the effect. Our results provided several insights. First, in the short condition, we surprisingly found no priming-induced N400 effect for unrelated vs. related targets, whereas the long condition showed a robust effect. Although increased priming could naturally boost activation levels through spreading activation, the sharp contrast between conditions is also consistent with the involvement of predictive mechanisms when a stronger context is available. Second, the N400 effect in the long condition had an earlier onset (approximately 200 ms), suggesting that richer semantic context may facilitate faster access to word meaning. This pattern aligns with findings by Nieuwland et al. (2020), who

reported that more predictable words elicited reduced N400 amplitudes starting as early as 200 ms after word onset. Finally, we observed a negative correlation between working memory tests scores and the N400 difference, with higher scores linked to a larger difference, suggesting that working memory capacity could benefit the employment of predictive mechanisms during semantic processing. Together, our findings provide supportive evidence that a coherent local context facilitates semantic processing. The enhanced target pre-activation can be explained by both spreading activation and predictive processing accounts. Moreover, the correlation between working memory and the N400 amplitude highlights how individual cognitive capacities can possibly hint at the nature of the mechanism behind semantic processing.

C43 - Emotional content and bilateral redundancy independently facilitate word processing

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Introduction Emotion-laden words usually elicit faster and more correct responses as well as stronger cortical activity than neutral words. Some studies also suggest more bilateral representation of emotion-laden than of neutral words. The bilateral redundancy paradigm allows for inferences about mechanisms of cross-hemispheric integration by comparing lexical decision performance after unilateral and bilateral presentation of visual stimuli. A bilateral advantage, the so-called bilateral redundancy gain, which is reflected in faster responses and higher accuracy, has been previously found for meaningful words, whereas it was absent for meaningless pseudowords. On the electrophysiological level, the word-specific bilateral gain has been reported to be reflected in a significantly stronger N1 after bilateral than unilateral presentation for words only. A possible explanation for the word-specific bilateral redundancy gain is that real words, but not pseudowords, are represented in bilaterally distributed memory circuits, which are activated more efficiently if both hemispheres receive the same input. If emotion-laden words draw even more on bilateral representations than neutral words do, coactivation of both hemispheres should lead to a stronger behavioural and neural bilateral redundancy gain for emotion-laden than for neutral words. **Methods** Performance, reaction times, and brain event-related potentials were measured from 27 student participants (10 male and 17 female, aged 20 to 35 years) while they performed a lexical decision task on 55 positive, 55 negative and 55 neutral German nouns and 165 pseudowords. Stimuli were presented for 200 ms each either to the left or right visual field or bilaterally in both visual fields with an innermost edge eccentricity of 1.56 degrees of visual angle. Words were matched across categories for arousal, imageability, concreteness, word frequency and word length. **Results** The results confirm previous behavioural findings regarding the word-specific redundancy gain, with faster responses and higher accuracy after bilateral presentation for words, but not for pseudowords. Emotional words showed a general processing advantage with faster reaction times and higher accuracy in all presentation modes. Both positive and negative words also elicited a stronger N1 ERP potential than neutral words. However, there was no evidence for a stronger bilateral gain, i.e. emotional content and presentation mode did not interact. In the

EEG, no specific N1 effect was observed for words following bilateral presentation. **Conclusion:** Data demonstrate that both bilateral presentation and emotional content facilitate word processing. Bilateral presentation specifically benefits real words but not pseudowords, supporting the view that real words are represented in bilateral neural networks. While emotion-laden words are accessed faster than neutral words and processed more efficiently on a neural level, this advantage occurs for all presentation conditions, arguing against a generally more bi-hemispheric representation of these words. The results constrain theories about the neural representation of emotion-laden words in the brain.

C44 Sandbox Series - Crossing conceptual terrain: ERP correlates of learning biology concepts through conversational tutoring dyads using metaphorical and literal explanations

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Metaphors are employed in science classrooms to help students understand abstract concepts by mapping them onto more concrete, familiar alternatives (e.g., describing enzymes and substrates as a “lock and key”). While educational research has shown that metaphors can support learning, prior studies have generally relied on small sample sizes, lacked control conditions, and mostly assessed metaphor use after learning without assessing baseline prior to learning. Only one EEG study investigating metaphor and learning, which taught participants metaphoric meaning of novel words and found that supportive metaphorical context facilitates such learning. This study will compare metaphoric learning against literal learning using behavioral measures (a science test) and electroencephalography (EEG). We hypothesized that metaphorically learned concepts, in comparison to literally learned, will become more familiar, more concrete, and better retained, as reflected by testing scores and EEG representations of those concepts. Specifically, we expected that metaphorically taught concepts will elicit a larger frontal N400 after learning, indexing greater concretization (Lai & Desai, 2019). On the basis of novel word learning literature, we also predicted that both literal and metaphoric conditions will show LN effects consistent with the incorporation of new meaning, or an episodic LP associated with having recently learned a novel word (Perfetti et al. 2005). Forty-six high school students (14-17 yo) learned 40 biological concepts (e.g. cilia), half metaphorically and half literally, during a one-on-one conversational tutoring session. In each trial, the concept was presented on the screen first. Then, the tutor used a script to introduce the concept, before elaborating it via 3 paragraphs either literally (The cilia move back and forth to clear mucus out of your sinuses and lungs) or metaphorically (The cilia form a broom that sweeps mucus out of your sinuses and lungs). Metaphoric and literal explanation scripts were matched for readability (Flesch, 2007). Immediately after the interactive tutoring, the concept was presented on the screen to end the trial. Before and after tutoring, participants gave concept familiarity and concreteness ratings and answered free-response and multiple-choice questions. EEG recordings were collected to analyze event-related potentials (ERPs) to the target concepts before and after student-tutor discussions. In a

preliminary analysis, concepts immediately after the tutoring showed an attenuated N400 in comparison to the very same concepts before learning, possibly suggesting a facilitation of semantic processing. Concepts after learning elicited a more positive late positivity (LP) than the very same concepts before learning, consistent with the episodic LP effect (Perfetti et al., 2005). These observations still need to be verified statistically. Oscillatory analyses are also being planned. Interpretations of EEG data will be supported by insights from the behavioral data and conversation data, which require annotation in the next few months. This study will provide novel insights into the neural correlates of real-time change in science concept representations during live learning.

C45 - Brains and language models converge on a shared conceptual space across different languages

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Human languages are vastly diverse, including different sounds, alphabets, syntax, and more. Despite these substantial differences in linguistic form, we can translate between languages and retain the intended meaning. While the forms of language are different, the meaning and function of these forms must be partly shared across speakers of different languages. How do different languages converge on a shared neural substrate for conceptual meaning? What is shared and what is language-specific? Honey and colleagues (2012) measured neural activity in anglophones and russophones when they listened to their respective languages, and found that neural activity was shared across languages in high-level language and default-mode areas. Recent work on interpreting multilingual large language models (LLMs) has found multilingual conceptual features at intermediate layers of the neural network (Lindsey et al., 2025). In the current study, we used LLMs to identify neural representations of the shared conceptual meaning of the same story as heard by speakers of three different languages. We used an open fMRI dataset where three groups of participants listened to an audiobook of *The Little Prince* in their respective native languages: English ($n = 49$), Mandarin Chinese ($n = 35$), and French ($n = 29$). The story was ~100 minutes long and was divided into 9 scanning sessions. We aligned the audio and text across the three languages for each sentence, resulting in a total of 1650 sentences. Using the transcripts, we extracted contextual word embeddings from three unilingual BERT models: one trained solely on English text, one trained solely on Chinese text, and one trained solely on French text. Despite the different models and languages, we found notable similarities between each pair of language embeddings after a simple rotation of the embedding features, especially in the middle layers. Next, we trained voxelwise encoding models to predict each subject's BOLD responses from the word embeddings for their own native language. First, we found that BERT embeddings predicted activity throughout the language network for each language. Critically, we then evaluated how well the encoding model predictions generalize across languages. For example, we evaluated predictions from the English model trained on the brain activity of an English subject against the brain activity of French and Chinese subjects. We found that models trained to predict neural activity for one language in speakers of that language generalize to different subjects listening to the same content in a different

language throughout high-level language and default-mode regions. Our results so far suggest that the neural representations of meaning behind different languages are shared across speakers of different languages and that language models trained on different languages converge on this shared meaning. These findings suggest that shared meaning arises from our shared environment and how we interact with it (and each other) in similar ways. 1. Honey et al. <https://doi.org/10.1523/JNEUROSCI.1800-12.2012> 2. Lindsey et al. <https://transformer-circuits.pub/2025/attribution-graphs/biology.html>

C46 - Context Affects Model-to-Brain Alignment in Language Comprehension

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Recent progress in artificial neural networks for natural language processing has raised the question of whether these models represent language in ways similar to the human brain. Previous studies have shown that contextual embeddings from transformer-based language models can predict brain responses with high accuracy (Schrimpf et al., 2021; Caucheteux & King, 2022) and outperform static lexical embeddings (Jain & Huth, 2018; Caucheteux & King, 2022). However, most of this work has focused on a single type of linguistic stimulus, typically narrative texts or isolated sentences. At the same time, it is known that the amount of context in a stimulus influences both semantic representations and the signal-to-noise ratio of the brain recordings (Deniz & Tseng et al., 2023). This raises an important question: How does the alignment between language model representations and brain activity change with the amount of context (in different conditions)? In this study, we compare how well transformer-based embeddings with different context lengths predict brain responses across different types of stimuli: isolated words, isolated sentences, and narratives. For each stimulus condition, participants read words presented one-by-one while brain data were recorded using functional magnetic resonance imaging (fMRI). The stimuli are based on 11 stories from *The Moth Radio Hour* (used in Huth et al., 2016). Using voxelwise encoding models and the fMRI data, we investigate how language model context length affects prediction performance and whether these effects localize to specific brain regions. We extracted contextual embeddings from each layer ($n=12$) of the BERT model with four different context lengths: 0, 5, 10, and 20 tokens. For comparison with a non-contextual model, static word embeddings (english1000) were also extracted. Motion energy features (Nunez-Elizalde et al., 2022) were calculated to account for sensory visual information. Banded ridge regression (Nunez-Elizalde et al., 2019) was used to fit joint encoding models for each voxel, layer, participant, and condition. Model performance was measured using Pearson correlation between predicted and recorded BOLD responses on held-out data. Our results reveal a clear effect of stimulus context on the context length selectivity of voxels. For isolated words, in all voxels, static word embedding outperforms all contextual embeddings

except for embeddings with 0 context length. For sentences and narratives, contextual embeddings for middle to late layers outperform static word embedding when context length is greater than 0. For voxels primarily in inferior frontal and prefrontal cortices, we observe a context length selectivity shift from shorter (5/10) to longer (20) from sentences to narratives condition. We did not find a simple match between model layers and brain regions (e.g., early layers to early brain areas and late layers to higher-order areas). Instead, the relationship depends on both the type of stimulus and how much context the model receives. This work highlights the importance of analyzing linguistic complexity explicitly when relating language models to brain data.

C47 - Resting-state functional connectivity between semantic and language networks in typical aging

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Deficits in specific aspects of language often impact communication among older adults. Typical declines in working memory do not explain impairments in language function, as some features, such as vocabulary and semantic knowledge, are not only preserved in old age, but improve throughout adulthood. While the semantic system remains well-preserved, the phonological and orthographic systems decline. Functional neuroimaging studies have identified a semantic network, specialized for the storage and retrieval of semantic knowledge, and a more recently recognized language network comprising brain areas activated for both language comprehension and production. However, how interactions between these two networks change with age remains unclear. As the older adult population continues to grow, identifying neural patterns linked to language ability can help clarify this gap in the literature. Forty cognitively unimpaired older adults (mean age = 69.8, SD = 6.0, range = 61-87; 33 women, 7 men) were drawn from an ongoing study at Rutgers University–Newark. Participants underwent structural and resting-state functional MRI and completed the Controlled Oral Word Association Test (COWAT) as a measure of semantic fluency. Neuroimaging data were preprocessed using fMRIprep 24.1.1 with its standard pipeline. Using AFNI (Analysis of Functional NeuroImages) software, afni_proc.py was applied to account for regressors of no interest. Binary masks for spatially defining the semantic and language networks were taken from previous studies, applied in MNI space, and used as seeds for calculating functional connectivity with regions outside the networks. Contrast maps were generated to compare areas of connectivity between the semantic and language networks. A 5 mm Gaussian smoothing kernel was applied before conducting group level analyses with 3dttest++ to examine how this contrast varied as a function of age, level of education, and semantic fluency. Results were corrected for multiple comparisons using cluster-based thresholding (voxel $p < 0.001$, mapwise corrected to $p < 0.05$). Areas were identified according to the Julich Brain atlas. Analyzing change in network connectivity with age, the language network showed stronger connectivity in the right angular gyrus (area PG); however, the semantic network only showed trending negative connectivity in the same region ($p = .07$). A significant difference in connectivity was observed at the interface between the semantic and language networks modulated by age and localized primarily to the right PG ($Z =$

4.21) adjacent to the supramarginal gyrus (area PF). Although connectivity between these networks was not significantly modulated by semantic fluency, this was not entirely unexpected as our sample was cognitively unimpaired (mean COWAT = 17.3, SD = 3.1). Our findings reveal that connectivity at the interface between the semantic and language networks is modulated by age. Though our sample consisted of solely older adults, the variability in age was sufficient to detect differences in connectivity patterns between semantic and language areas. Considered separately, the language network was significantly modulated by age, while the semantic network was not. This suggests that language functions are more vulnerable to age-related changes than semantic functions, and underscores the important role of age in the interactions between semantic and language networks.

C48 - Multilingualism WithOut Words: A non-lexicalist model of bilingualism

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Standard models of bilingualism are primarily concerned with how words/lexical representations in multiple languages are stored and associated in the mind (Multilink: Dijkstra et al., 2018; Revised Hierarchical Model: Kroll & Stewart, 1994; etc.). However, there is a growing consensus in linguistic theory that language cannot be organized around words, given that: a) structure above and below the word level must be part of the same system, and b) linguistic units (meaning, syntax, and form) do not necessarily align at the 'word' level (Krauska & Lau, 2023; Bruening, 2018; Haspelmath, 2017; etc.). We propose a non-lexicalist model of bilingualism, the Multilingualism WithOut Words (M-WOW) model, in order to realign theories of bilingualism with current morphosyntactic theory and psycholinguistic models, and account for a broader typology of languages. This is an extension of the WithOut Words (WOW) model of language production (Krauska, 2024), in which independent representations of meaning, syntax, and form are linked together by separate mapping mechanisms, one between meaning and syntax, and another between syntax and form. This model also integrates prosody and linearization in the process of language production. In contrast to other models of bilingualism, M-WOW allows a single term in the first language (L1) to correspond to a (phonological) word, morpheme, or complex phrase in the second language (L2), allowing much more flexibility in how different features are realized across languages and also expanding the possibilities for code-switching and code-mixing. M-WOW also allows for L2 acquisition to progress non-uniformly across language mechanisms; features of the L2 that the learner is able to identify at one level (e.g., form) can be incorporated into the language network even if they do not have sufficient evidence to develop corresponding representations at other levels (e.g., syntax and meaning). For example, at early stages of L2 acquisition, a learner can quickly gather evidence for the phonological forms of the language, and associate those forms with counterparts in their L1 (e.g., associating 'gato' (L2Spanish) with 'cat' (L1English)), but they may piggyback on the syntactic representations of their L1 without positing distinct representations for the L2 (e.g., L1English-L2Spanish learners may initially rely on the phonological cue to perform adjective or determiner agreement in noun phrases, rather than a feature of

grammatical gender; L2Spanish: 'o/ is masculine', not 'gato is masculine'). This enables the learner to maximize learning from directly observable input, while respecting cognitive economy. As the learner progresses, they can extract information about other types of representations from input based on the components of the L2 that they have already learned (e.g., a learner may use agreement patterns and distributional information to develop a syntactic representation for L2Spanish gato that does include a gender feature, in order facilitate more efficient processing in the language). Because the M-WOW model is non-lexicalist, it can accommodate a broader set of languages and linguistic phenomena, especially those that are not well-suited to lexicalist analyses, and provide new insights into the dynamic and variable process of second language acquisition.

C49 Sandbox Series - Longitudinal examination of white matter trajectories in typically developing bilingual and monolingual children

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Longitudinal neuroimaging studies have been instrumental in characterizing how the developmental trajectories of brain pathways underlie the development of complex cognitive functions like reading, which are key for academic and vocational advancement. However, the unique patterns of brain development in bilingual children have either not been taken into account or have been explicitly excluded from existing work. Different aspects of bilingual experience (e.g., language switching) necessitate functional adaptations, which further engage areas subserving cognitive control and short-term memory, as posited by the Adaptive Control Hypothesis (Abutalebi & Green, 2007). Moreover, as suggested by the Dynamic Restructuring Model (Pliatsikas, 2020), these adaptations result in sequential structural changes to gray and white matter regions responsible for language, cognitive control, and short-term memory. Yet, theories of bilingualism do not account for how bilingualism and reading development interact and shape these brain structures during typical and atypical development. The present study examined developmental trajectories of language, reading, and cognitive control related white matter pathways (as measured by fractional anisotropy, FA) in bilingual and monolingual typically developing children, leveraging the large-scale longitudinal data set from the Adolescent Brain Cognitive Development (ABCD) study. Three hundred and ninety-eight bilingual children (ages 9-12) and 398 monolingual peers matched on age, sex, parental education, household income, handedness, and nonverbal intelligence were selected for this analysis, revealing a complex association between white matter pathways' development over time and children's bilingual language exposure. Initial findings, using two timepoints of data for all children (at ages 9-10 and 11-12) and a third timepoint of data (at age 13-14) for approximately a third of the participants, indicate that across language, reading, and cognitive control pathways, bilingual children, as a group, show significantly lower FA values than monolingual peers at the baseline time point (i.e., 9-10 years old). This supports previous findings using this dataset (Ronderos et al., 2024), which is contrary to findings from bilingual adults who have significantly higher FA values than monolingual adults. Additionally, in line with the Dynamic Restructuring Model, the longitudinal data

indicate more rapid FA growth for bilinguals than their monolingual peers two years later, when these children are 12 years old. This would suggest a slower growth in early childhood but accelerated growth through late childhood and early adolescence (i.e., 9-12+ years old) for white matter development in bilingual children compared to monolingual children in pathways related to language and cognitive control. Furthermore, bilingual language exposure seemed to influence both initial FA values at baseline (intercept) and rate of growth (slope) for FA in language-related pathways. Overall, initial findings suggest that language exposure may uniquely impact the development of underlying brain structures associated with language, reading and cognitive control in children who use more than one language. Additional analyses will be conducted with data from release 6.0 of the ABCD study (expected in Spring 2025), which will include complete cohort data for timepoint 3 and partial cohort data from timepoint 4 to enable robust growth curve analyses of these effects.

C50 Sandbox Series - Investigating bilingual code-switching comprehension in natural conversation using EEG

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Bilinguals frequently engage in code-switching: Seamless alternation between languages in a given conversation without causing miscommunication (Poplack, 1980). Code-switching is governed by sociolinguistic factors such as proficiency, switching frequency, and attitudes towards switching (e.g., Salig et al., 2023). Crucially, these factors are not adequately captured by prior studies with controlled paradigms, such as lexical decision tasks and narrative-listening. Moreover, results thus far are mixed, with some studies showing a cost for processing code-switches (e.g., larger N400 effects; Yacovone et al., 2021), whereas others find no significant effect in more naturalistic contexts (Blanco-Elorrieta & Pykkänen, 2017). To address this gap, we conducted an electroencephalography (EEG) experiment where bilingual participants actively engaged in a natural, bilingual conversation. We evaluate the potential cost of intra-sentential Mandarin-to-English code-switches within a free-flowing conversational paradigm and examine how language proficiency may modulate this cost. 30 Mandarin-English bilingual participants (Mage = 21.6) were recorded with EEG during an hour-long conversation with a Mandarin-English bilingual research assistant (RA). Most participants were L1 Mandarin, L2 English speakers. Utterances of each interlocutor were recorded with headset microphones during EEG recording. Conversations were Mandarin dominant with spontaneous English code-switches. RA speech was annotated for Mandarin-to-English code-switches; the onset and duration of intra-sentential code-switches were used to identify EEG epochs of interest. On average, we find ~70 usable code-switches per conversation (range: 40-130) after applying exclusions (e.g., proper nouns and repetitions), providing adequate data for analyzing time-locked responses. We average waveforms time-locked to code-switch onset that are analyzed relative to responses to non-switch Mandarin-only sentences. Data analysis is currently ongoing. If there is a cost associated with comprehending code-switches in natural conversation, we predict a centro-parietal negative deflection 250-500 ms post-switch onset, reflecting increased processing difficulty or

prediction error derived from the matrix language (LAN/N400; Tanner & Van Hell, 2014). We also predict a late positive component (LPC) 600-1000 ms post-switch onset with a parietal scalp distribution, with a larger magnitude for participants with lower proficiency in English, suggesting reanalysis or increased integration effort (Yacovone et al., 2021). We expect an inverse correlation between the magnitude of each component and the duration of conversation as participants become more familiar with the RAs; they may begin to predict and anticipate code-switches more accurately alongside the matrix form (non-switched form; Moreno et al., 2002). We further explore multivariate decoding approaches as “cost” may not be monotonic as well as between-subject variation in terms of interlocutors’ respective linguistic backgrounds and code-switching practices. This study enhances the external validity of neurolinguistic code-switching research by utilizing a free-flowing, natural conversational paradigm. By embracing participant variability and naturalistic input, we aim to more accurately capture the neural dynamics underlying code-switching comprehension and the role that language proficiency plays in such processing. The findings of the current study may further support the development and critical analysis of naturalistic experimental paradigms that better reflect real-world bilingual language use.

C51 - Testing the role of heritage language (HL) experience on initial third language (L3) morphosyntactic processing using event-related potentials (ERPs)

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Introduction: The present study investigates the behavioral and neural signatures of initial third language (L3) processing among heritage bilingual language learners using event-related potentials (ERPs). The goals of the current study are twofold: to reveal if cross-linguistic influence affords neural sensitivity to morphosyntactic features after brief exposure to the L3, and to determine the role that heritage language (HL) experience plays in modulating this neural sensitivity. In recent years, researchers have turned towards studying the contributions of heritage bilingualism on third language acquisition. Heritage bilinguals are individuals raised in a multilingual environment in childhood. Like other bilinguals, heritage bilinguals have two potential transfer sources to choose from, namely the HL and the societal/dominant language. Yet recent research reveals heritage speakers to be particularly sensitive to overt morphophonological inflections (e.g., Di Pisa et al, 2022), a processing strategy that may arise due to their reduced input to the heritage language. As such, this study turns towards investigating if and how such processing strategies also manifest during L3 learning. **Methods:** To test this hypothesis, Spanish heritage speakers in the United States (US) (current $n = 23$) completed a mini-longitudinal language learning program aimed at teaching select (morpho-)syntactic properties of a mini-grammar based on Russian. Participants learned a total of 40 words and three (morpho-)syntactic properties via implicit instruction: grammatical gender, case morphology, and pronominal adjective placement. Following the learning phase, participants completed a grammatically judgement task (GJT) while their electroencephalogram (EEG) was recorded. The EEG GJT was presented at the end of the learning sessions, which occurred on average two days apart. During the GJT, participants read morphosyntactic violations for the first time

(i.e., a masculine noun with the feminine marker, the object noun with the nominative marker, etc.). **Results & Summary:** In comparison to the first session, an increased positivity around 200 milliseconds (ms) following the presentation of a gender agreement violation was observed during the second GJT. Additionally, an increased negativity at 400 ms post stimulus onset was also recorded at the second session. Similarly, case violations elicited a greater N400 response at the second session compared to the first session. Taken together, these preliminary findings suggest the deployment of attentional resources (as evinced by the P200 response) to be an important mechanism to engage when processing L3 features. The N400 response, typically present during semantic processing, is also noteworthy given the limited exposure participants had received to this language at test. Furthermore, the presence of a N400 in response to gender violations suggests attentional resources to be associated with downstream language-related processing. Critically, the N400 sensitivity was observed for novel features (i.e., case violations); neither Spanish nor English possess overt case morphology. If these trends continue, these results may provide support for the notion that heritage speakers rely on both prior linguistic knowledge as well as language experience (i.e., bias toward morphological fixation) to shape L3 outcomes.

C52 - Neural Evidence for Shared Conceptual Representations in Bilinguals

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The world is filled with a vast array of entities, from tangible objects like chairs and trees to intangible concepts like emotions and ideas. Humans use labels to classify these entities into categories based on shared features (Rosch & Mervis, 1975). Importantly, different languages emphasize distinct features when defining category boundaries (Malt, et al., 2003). As a result, concept boundaries can vary significantly across languages, such that even direct translations can map onto distinct underlying conceptual representations. This raises the question of how bilinguals’ conceptual system is structured such that it can accommodate cases where conceptual representations do not fully align across languages. Theoretically, bilinguals may either maintain separate, language-specific conceptual representations or integrate features from both languages to create conceptual blends (Blanco-Elorrieta & Caramazza, 2021; Taliaferro et al., 2025). Here, we addressed this question by recording MEG activity as 24 monolingual English, 24 monolingual Mandarin, and 25 bilingual Mandarin-English speakers performed a two alternative forced choice task (2AFC). Participants selected the best label for images of household objects that formed seven step continua between two unambiguous image/categories (e.g., a plate and a bowl). Bilingual participants completed the task in both English and Mandarin on separate days, with the order of languages counterbalanced across participants. This design enabled us to localize each language group’s conceptual boundary, defined as the point along the continuum where categorization shifted from one concept to the other. We found that bilinguals maintained a single conceptual boundary for both languages even when monolingual speakers of each language had a different one. This unified bilingual boundary shifted toward the language acquired earlier in life in unbalanced bilinguals and laid perfectly between the boundaries of each language when both languages were acquired simultaneously.

Additionally, we ran a spatio-temporal RSA analysis on MEG data where we tested whether neural activity in bilinguals aligned better with model matrices built based upon either i) conceptual representations defined by our monolingual English speakers ii) conceptual representations defined by our monolingual Mandarin speakers or iii) conceptual representations defined by our Mandarin-English bilingual speakers. Additionally, we tested for language-agnostic visual similarity-based representations in the visual cortex, with model matrices built from a visual neural net (ResNet) and human object similarity judgments. We found clusters of brain activity reflecting visual features and similarity ratings in the visual cortex across all groups starting approximately 180ms. In contrast, clusters aligning with conceptual representations localized to the left temporal lobe within approximately 250–400ms after stimulus onset. Crucially, bilinguals' neural patterns aligned more closely with the shared conceptual model than with either monolingual model. These results provide novel neural evidence that bilinguals do not maintain separate conceptual systems for each language but rather, rely on a shared conceptual system shaped by the age at which each language was acquired, and this conceptual representations are localized to the anterior temporal lobe.

C53 - Multimodal evidence for the integration of semantic and sensorimotor representations during the comprehension of naturalistic actions

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Our brain is remarkably adept at decoding the intentions underlying others' behaviors, allowing us to navigate complex social environments with precision. This ability is thought to rely on the dorsal Action Observation Network (AON), a core neural system that maps others' actions onto the observer's motor repertoire. Recent evidence, however, suggests that naturalistic action comprehension recruits a broader network extending beyond the AON. Specifically, regions along a ventral occipito-temporal gradient leverage object-based knowledge to generate an early "semantic prior" about the most plausible intention, which is then relayed to the AON for integration with sensorimotor representations. Yet, the neural mechanisms governing the temporal unfolding and interaction of semantic and motor processes remain partially understood. In this study, we combined functional MRI (fMRI) and magnetoencephalography (MEG) to examine the spatial and spectro-temporal dynamics of context-based action comprehension in 30 healthy participants. Participants viewed images of incomplete, everyday actions and were asked to infer the overarching intention. Crucially, actions were embedded in either congruent (e.g., reaching to grasp a full cup with a precision grip) or incongruent (e.g., reaching to grasp an empty cup with a precision grip) contexts. This manipulation—particularly the incongruent condition—enabled us to dissociate the contributions of sensorimotor and object-based semantic knowledge to action understanding. fMRI results revealed the engagement of canonical AON nodes, including dorsal fronto-parietal regions, and extended into ventral occipito-temporal

areas involved in semantic processing and object recognition. Context congruence effects emerged in a predominantly left-lateralized network encompassing parietal and temporal cortices. MEG data further elucidated the spectro-temporal unfolding of these effects. Action comprehension elicited left-lateralized desynchronization in the mu rhythm (8–14 Hz) across fronto-parietal and occipito-temporal regions, with stronger suppression for incongruent compared to congruent actions. Representational Similarity Analysis revealed that neural activity patterns were significantly explained by both an object-based semantic model and a grip-related sensorimotor model. Importantly, the semantic model showed an earlier peak in model fit (~150 ms), while the sensorimotor model peaked later (~220 ms), consistent with a temporal progression from semantic access to sensorimotor updating. Together, these findings provide converging spatial and temporal evidence for the integration of semantic and sensorimotor knowledge during naturalistic action comprehension, offering new insights into the neural dynamics supporting this key social ability.

C54 - Sensory-motor mechanisms for verbal working memory

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Conversational language relies on the transient maintenance of verbal working memory (vWM). Yet the precise neural mechanisms supporting vWM remain elusive. To address this gap, in this study, we recorded and analyzed neural signals from patients implanted with stereoelectroencephalography (sEEG) electrodes performing a lexical repetition task with a vWM delay. 37 patients (mean age = 31, 21 female) with electrodes implanted as part of their surgical epilepsy evaluation were recruited in this study. In each trial, patients heard one item from a corpus of 84 CVCVC-structured words or 84 matched nonwords (e.g., "bacon," "valuk"), and repeated the item aloud after a visual Go cue following a randomized 1.125±0.125s delay. As a control analysis, 18 of the recruited patients completed an additional lexical repeat task without a delay (immediate repetition). To characterize the spatiotemporal dynamics of vWM, we first preprocessed the intracranial recordings and identified clusters of local neural engagement as significant increases in high-gamma power (HG, 70–150 Hz) relative to a pre-trial baseline (cluster-based correction, $p < .05$). Electrodes with significant HG responses during vWM delay (Delay electrodes) were found ($N = 1009$) distributed in the dorsal and ventral speech processing streams (Hickok & Poeppel, 2007). Within these significant delay electrodes, 33.11% ($N = 402$) also had auditory responses (Auditory delay electrodes), 20.51% ($N = 249$) had motor responses (Motor delay electrodes), and 38.06% ($N = 462$) had both auditory and

motor responses (Sensory-motor delay electrodes), spatially adjacent to both Auditory and Motor electrodes, replicating previous results (Cogan et al., 2014, 2017). Together, this shows that vWM is supported largely by neural mechanisms for sensory-motor speech processing. Analyses on the subset of patients with the control task demonstrated that both Delay electrodes with auditory and motor responses functioned similarly even without delay (Auditory + Sensory-motor: 79.22% overlapped the corresponding category in control; Sensory-motor + Motor: 67.67% overlapped). This control analysis indicates that the vWM neural responses stem from sensory-motor mechanisms in general speech processing, even when no vWM component is explicitly required. To assess the representational content of vWM, we independently performed a general linear modeling (GLM) analysis of hierarchical linguistic features (acoustic, phonemic, and lexical status for word vs. nonword) on high-gamma neural responses in electrodes during the delay period (cluster-based correction, $p < .05$). We identified electrodes that were significantly predicted by higher-level phonemic ($N = 451$) and lexical-status ($N = 309$) features in delay, but the encoding of acoustic features was largely absent ($N = 44$), suggesting that vWM represents higher-level phonological and lexical features of verbal stimuli. Taken together, we found that vWM is supported by sensory-motor speech processing neural mechanisms that maintain higher-level linguistic representations.

C55 Sandbox Series - Functional MRI investigation of emotional prosody processing in older adults with and without stroke

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Prosody serves many communicative functions (e.g., linguistic, emotional) but is poorly represented in our neurobiological models of speech and language. Much of the literature argues that the different functional uses of prosody are associated with differences in lateralization (see Paulmann, 2016 for review) with greater emphasis on emotional prosody being processed predominantly in the right hemisphere (RH). However, studies with stroke survivors have revealed poorer emotional prosody processing abilities as a result of lesions in both the right (Ross & Monnot, 2008) and left hemisphere (LH; Leung et al., 2017). There is also evidence that cerebral lateralization is reduced in older adults (Cabeza, 2002), the RH can become dominant for language after perinatal stroke (Newport et al., 2022), and the RH can be recruited for language after LH stroke in adulthood (Wilson & Schneck, 2020). Given the high importance of intact emotion recognition for social functioning in general and after stroke in particular (O'Connell et al., 2021), these prior findings raise the following intriguing questions: 1) To what extent is emotional prosody lateralized to the right hemisphere (RH) in neurologically-intact adults? 2) How does lateralization of activation for emotional prosody compare to the lateralization of activation in a comparable language task (sentence comprehension)? 3) After stroke, does activation for tasks that the lesioned hemisphere would normally be dominant for increase in the non-lesioned hemisphere (i.e., in the LH for emotional prosody and the RH for sentence comprehension)? We are investigating these questions using fMRI in adult right-hemisphere stroke survivors (RHSS), left-hemisphere stroke survivors (LHSS), and demographically matched Controls. Our

three groups—RHSS, LHSS, and Controls—complete three tasks while undergoing fMRI scans: a sentence comprehension task, an emotion recognition task, and a beep detection task. The sentence comprehension task presents sentences (e.g., “dad always gives me books for my birthday”) with a relatively flat prosodic pattern, and then asks participants to indicate whether the sentence was about food, a gift, or a trip. The emotion recognition task presents similar sentences with prosodic patterns that differ from the sentence comprehension task and vary by emotion (happy, angry, sad), and then asks participants to indicate whether the speaker sounded happy, angry, or sad. The beep detection task presents the same sentences played in reverse and thus rendered incomprehensible, with a beep appended to some sentences, and then asks participants to indicate whether they heard a beep. Interim results from 10 RHSS and 17 Controls show right hemisphere dominance for emotional prosody and comparable task performance at the group level; however, lateralization indices are more variable among RHSS, with some participants showing increased LH activation that might be compensatory. We are currently collecting more data from RHSS and older Controls, as well as data from LHSS, in order to conduct statistical comparisons of strength and variability of activation and lateralization between groups, and analyses evaluating potential links between activation, lateralization, and task performance. We also intend to include data from younger adult controls to explore how lateralization may change over time in adulthood.

C56 - Lateralization over development: the neural basis of emotional prosody processing in children ages 4-12

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It has long been understood that core language functions are lateralized to the left hemisphere (LH) in most healthy adults. Other aspects of language, like emotional prosody (EP) - the vocal expression of emotion - are lateralized to the right hemisphere (RH). When adults have a stroke to one hemisphere, they show deficits in the corresponding cognitive function (in core language after LH stroke and in EP after RH stroke) with limited functional recovery. However, there is a growing body of evidence that in infants and young children, similar strokes do not have the same devastating effects on language. Individuals who had a perinatal stroke—a stroke around the time of birth—to the core language areas of the LH can successfully acquire their core language abilities in homotopic areas of the RH. The young brain's ability to support core language in the RH may be based on the fact that language functions are less lateralized early in life: a cross-sectional fMRI study of children between the ages of 4 and 12 showed considerable activation of the RH during language tasks in young children, and a gradual decline of that activation throughout childhood. This study focuses on the development of lateralization for EP processing. We hypothesized that, as shown previously for core language abilities, EP lateralization develops gradually over time with maturation and experience. Specifically, we expected that EP activation would begin somewhat bilaterally and shift increasingly towards the RH with age. To investigate this, fMRI data were collected from 41

neurologically healthy children ages 4-12. The fMRI task involved listening to English sentences that were spoken with a happy or sad emotion and judging the speaker's emotion (EP condition) or listening to the same sentences spoken neutrally and judging sentence content (neutral condition). Individual fMRI activation maps were generated by contrasting activation during emotional vs. neutral blocks to isolate activations specific to EP processing. Lateralization was measured using a lateralization index (LI), which compares activation in the LH vs. RH in frontal and temporal language regions. Group-level activation maps revealed fronto-temporal activation in both hemispheres, but stronger on the right, consistent with prior results in adults. Individual LIs in temporal cortex did not show an age effect, but in frontal cortex, lateralization increased significantly with age. Interestingly, language performance—a composite language score including oral syntax comprehension and two aspects of reading-related skills—was a significantly better predictor of degree of lateralization than was age, indicating the contribution of linguistic experience and maturity beyond chronological age. Overall, these findings lend support to the hypothesis that lateralization of EP develops over time with maturation and experience.

C57 - Cortical Tracking of Speech Meter during Natural Storytelling

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Syllabic stress provides critical acoustic and pragmatic cues during speech comprehension. Moreover, the alternation of stressed and unstressed syllables defines speech meter, which is known to facilitate speech recognition. Acoustically, in English, stress is defined by patterns of intensity, pitch, and duration. Although it has been hypothesized that stressed syllables may drive neural entrainment to the speech signal, empirical evidence for the effects of stress and meter on neural responses to speech is scarce. Recent work has revealed that the human speech cortex tracks syllables by responding to moments of rapid increase in speech intensity – peakRate events – which occur close to vowel onsets. Based on this acoustically defined marker of syllable processing, here we examine how stress and metric regularity influence 1) evoked neural responses to syllables and 2) oscillatory phase-locking to peakRate events. We recorded EEG while participants (n=26) listened to short children's stories. Participants heard one story that followed an irregular, speech-like meter typical of everyday speech, and another story that followed a regular meter with alternating stressed and unstressed syllables (x - -). Using temporal response function (TRF) modeling, we isolated the effects of syllabic stress and metric regularity on neural responses to peakRate events. Both stress and meter modulated early (within 50-150 ms) cortical responses to peakRate events. Specifically, stress enhanced neural responses to stressed syllables as compared to unstressed syllables, suggesting that stress is identified early during auditory processing. Moreover, while early responses to louder

syllables were enhanced overall, this effect was attenuated in the metrically regular condition, suggesting a reduced reliance on acoustic cues in favor of processing based on top-down metric expectations. Furthermore, we found that neural responses to unstressed syllables of larger intensity were temporally more extended (300-400ms) than for stressed syllables of similar intensity. In the time-frequency domain, neural phase-locking around 2 Hz (corresponding to stress rate in the stimuli) was stronger for stressed than for unstressed syllables. Such phase-locking patterns have been previously interpreted as endogenous oscillatory entrainment. However, an explicit model of evoked neural responses showed that this phase-locking pattern reflects the frequency and shape of evoked responses. This result directly shows that delta-phase locking to stressed syllables does not necessarily reflect oscillatory entrainment. It also provides a novel approach bridging between analyses of evoked responses and phase-locking to continuous speech. Overall, our findings reveal that neural responses to individual syllables integrate acoustic cues with perceived stress patterns and metric expectation. These neural dynamics may underlie the perceptual benefits of metrically regular speech, such as poetry.

C58 - Does the N400 Also Reflect Semantic Integration?

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The link between the N400 ERP component and semantic retrieval is well-established; however, recent challenges have been made to the claim that it is also sensitive to semantic integration. Delogu et al. (2019) performed an experiment that kept semantic priming constant, but presented a situation in which a target noun would be easier or harder to integrate; e.g., with a character either entering or exiting a restaurant, then opening a menu. They did not find an N400 effect—only a P600. From these null results and previous findings, they asserted that the N400 is only sensitive to retrieval effects, and the P600 is only sensitive to integration. Further work from the same lab (e.g., Delogu et al., 2021 and others) has continued to build on this claim. The present semi-replication builds on the work of Wang et al. (2025) to investigate whether the differences between Delogu et al.'s (2019) conditions may have too subtle to elicit an N400 effect. In contrast to Delogu et al.'s experiment, where the difference between conditions was a single word, our stimuli's between-condition differences were multiple words long (and thus harder to mentally correct/ignore); across conditions, sentence 2 contained the target word, sentence 1 contained a semantically related prime, and other words prior to the target were kept as neutral as possible to minimize lexical association effects. Participants read an equal mix of stories where the target was either consistent or inconsistent with the situation, answering comprehension questions about each story while EEG data was recorded. In contrast to Delogu et al.'s (2019) main finding, this study did find an N400 effect between conditions in addition to a P600 effect, indicating that the N400 can be sensitive to semantic integration effects. Taken in context with other studies that have found N400 effects when manipulating integration difficulty (e.g., Van Berkum et al.,

1999), the truth is unlikely to be as simple as Delogu et al. (2019) suggests, where the N400 indicates only semantic retrieval processes and the P600 indicates only semantic integration effects. Instead, it is likely that there is some overlap between the two processes, and that both ERP components are at some level sensitive to both processes. References: Delogu, F., Brouwer, H., & Crocker, M. W. (2019). Event-related potentials index lexical retrieval (N400) and integration (P600) during language comprehension. *Brain and Cognition*, 135, 103569. <https://doi.org/10.1016/j.bandc.2019.05.007> Delogu, F., Brouwer, H., & Crocker, M. W. (2021). When components collide: Spatiotemporal overlap of the N400 and P600 in language comprehension. *Brain Research*, 1766, 147514. <https://doi.org/10.1016/j.brainres.2021.147514> Van Berkum, J. J. A., Hagoort, P., & Brown C. M. (1999). Semantic Integration in Sentences and Discourse: Evidence from the N400. *Journal of Cognitive Neuroscience*, 11(6), 657–671. <https://doi.org/10.1162/089892999563724> Wang, W., Perfetti, C., & Helder, A. (2025). Getting to the situation: The N400 can indicate meaning integration beyond word priming. *Language, Cognition and Neuroscience*, 40(2), 177–194. <https://doi.org/10.1080/23273798.2024.2409905>

C59 - Neuroanatomical Differences in Children with Dyslexia

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Introduction: Developmental Dyslexia, or Reading Disability (RD), is a common learning disability marked by difficulties in word decoding that negatively affects academic and vocational outcomes. Neuroanatomical studies on RD have generally found reduced gray matter volume (GMV) in left occipitotemporal, orbitofrontal/inferior frontal, bilateral temporoparietal regions, and cerebellum (Eckert et al., 2016; Linkersdörfer et al., 2012; Richlan et al., 2013). However, findings have lacked consistency, likely due to small sample sizes, and variations in the studies' methodologies and statistics (Ramus et al., 2018). Surface-based measures offer advantages over GMV, including providing insights into the origins of the neuroanatomical aberrations. Differences in cortical thickness (CT), which likely reflects experience, have been reported in RD (Williams et al., 2018; Kujala et al., 2021), while sulcal depth (SD), which likely reflects prenatal developmental origins, has not been investigated. The present study used a large sample, representative of the United States, and tested for neuroanatomical aberrations using CT and SD measures. **Methods:** We selected from the Baseline data of the ABCD Study for monolinguals with Matrix Reasoning (MR, non-verbal reasoning) >85, NIH Toolbox Picture Vocabulary Test (verbal reasoning) >70, and excluded psychiatric and neurological disorders, visual or sensory impairment. Inclusion for the RD Group was based on <85 (16th percentile) on the Toolbox Oral Reading Recognition Test at both Baseline and 2-Year Follow-Up, while it was >90 for Controls. Propensity matching ensured groups were equated on socioeconomic status (SES), and MR, resulting in 293 Control and 285 RD participants (9.53 ± 0.5 years). MRI data were preprocessed using SPM12 (Ashburner & Friston, 2000) and CAT12. T-tests compared CT and SD between the two groups, controlling for age (months), sex, non-verbal reasoning, SES, ADHD,

pubertal status, and Study Site (voxel-wise height threshold $p < .005$ uncorrected, cluster-level extent threshold $p < .05$ FDR). **Results:** Compared to the Controls, the RD Group had less CT in two relatively small clusters around left and right insula. However, the RD group had less SD across all lobes and both hemispheres. The two largest clusters were in left and right insula cortex (the latter overlapping with the CT result) and there were eight other regions. Notably, the results overall included regions extending into brain areas associated with reading, such as left fusiform, superior temporal, inferior and middle frontal gyri; however, they also included their homotopic right-hemisphere counterparts. Of the overall volume of clusters 58% resided in the left and 43% in the right hemisphere. No regions with thinner cortex or lower sulcal depth were observed in the Control group. **Conclusions:** In the largest study of RD conducted under a unified protocol by relying on data from the ABCD Study, we found relatively thinner cortex in RD in left and right insula regions. However, shallower sulci were found across both hemispheres and all lobes, indicative of extensive aberrations not limited to left-hemisphere areas associated with language processing. These aberrations are likely antecedent to reading acquisition and specific in nature, given that less CT or GD was not observed in the controls.

C60 - Healthy cognitive aging of the language network: A task-based EEG study of interindividual differences

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Introduction In contrast to other cognitive domains, language remains largely preserved with age (Shafit & Tyler, 2014). Nonetheless, neurophysiological studies report age-related changes in the timing of neural processes during sentence processing (Barbieri et al., 2021; Pagán et al., 2025). Furthermore, aging is associated with higher interindividual variability, requiring an individual rather than a group-based approach. Notably, interindividual differences in neurophysiological responsivity during picture naming relate to individual-level cognitive performance (Bruffaerts et al., 2019). To study aging and language at the individual level, we tested the stability of individual neurophysiological responses to sentence processing within a cohort of young and older healthy adults using a functional identification approach, which has been extensively validated in young adults using fMRI (Fedorenko et al., 2010; 2024) and recently investigated using MEG (Huybrechts & Bruffaerts, preprint). Recent fMRI work using this approach has shown that the language network is preserved in aging (Billot et al., preprint). We expand these findings using EEG, as the high temporal resolution is well-suited to detect age-related neurophysiological changes. **Methods** We collected high-density-EEG in 21 native Dutch-speaking young controls (YHC; mean age: 23.4, education level: 16.5 years, 11 female) and 22 older controls (OHC; mean age: 67.4, education level: 15.1 years, 12 female). The functional identification task contained 80 sentences of 12 words, and 20 control sequences of 12 nonwords, matched for phonological properties and syllable length (adapted to Dutch from Fedorenko et al., 2010). Stimuli were presented sequentially for 500ms. Each sequence was followed by a probe judgement to assess attention and behavioural performance. To test whether EEG allows for a robust identification of subject-specific language-responsive sensors, we evaluated the stability of the language responses

within individuals across trials. Specifically, we examined the Spearman correlation in the size of the sentence effect (percent signal change for the sentence condition vs baseline) over all sensors within each participant across odd- and even-numbered trials and compared this to the correlations between different participants (Huybrechts & Bruffaerts, preprint). Results Behavioral data shows no significant differences in response accuracy between YHC and OHC ($p=0.27$), although response time was significantly higher in OHC (mean YHC: 1123ms, mean OHC: 1364ms, $p=0.01$). The mean correlation of the topographies of the neurophysiological responses was significantly higher within the same participant versus between pairs of participants in both YHC (mean within ρ : 0.68, mean between ρ : -0.01, $p<0.001$) and OHC (mean within ρ : 0.76, mean between ρ : 0.09, $p<0.001$). Conclusion The language network can be identified at the individual level in a robust and replicable way using EEG, using a similar approach as in fMRI and MEG. Although language performance remained stable with age, we observed significantly slower response times, perhaps reflecting underlying changes in neural processing efficiency. This individualized framework enables further research into age-related differences in the timing and strength of neurophysiological correlates of language. A potential application is the use of task-based EEG to discriminate between normal and abnormal cognitive aging (De Keulenaer et al., in press).

C61 - Hierarchical Predictive Processing during Naturalistic Reading

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Predictive processing has been a major framework for studying cognitive mechanisms. In the literature of language comprehension, studies have demonstrated that the brain elicits prediction error signals specific to various lexical and sub-lexical word properties. Recent evidence also showed that these predictions are likely organized hierarchically during naturalistic listening. Naturalistic reading, on the other hand, has received less attention in the field. We therefore tested the hierarchical predictive processing proposition in the domain of naturalistic reading comprehension. We expected to see three types of evidence as a result of a hierarchical predictive mechanism - 1) distinct prediction error signals at each level of the hierarchy, 2) a temporal order of prediction error signals from lower to higher levels of the hierarchy, and 3) higher-level predictions constraining lower-level predictions. To test our hypotheses, we asked participants to read fictitious story while their EEG and eyetracks were recorded. Using time-resolved regression, we modelled their regression fixation related potentials (rFRPs) with word surprisal, frequency, and orthographic prediction error (oPE) as regressors, each representing the prediction error signal on a specific level of the hierarchy. Cluster-based permutation showed that each of these regressors elicited a significant cluster in the rFRP. Word surprisal captured an N400 component; word frequency explained variance in the N1 and N250 components; and oPE explained variance in the narrow time range of N1 onset. This result suggested that each of these prediction error signals has a distinct topographic and temporal

pattern which constituted the first type of evidence we expected. Secondly, we sought to investigate the temporal order between these prediction error signals. For each effect, we identified peak effect latencies of each individual participants by finding the maximum correlation between the average peak effect topography and participant's topography at each time point of the rFRP. We found that the effect oPE was elicited significantly earlier than the effects of surprisal and frequency. No significant differences were found between surprisal and frequency effects. Hence, this provided evidence for a temporal order of prediction error signals where the sub-lexical signals (i.e., oPE) was elicited earlier than the lexical signals (i.e., surprisal and frequency). Lastly, we compared regression models differed on how oPE was calculated to test whether higher-level lexical predictions constrained lower-level orthographic predictions. We derived context-based and frequency-based oPE. The former weighted orthographic predictions with contextual word probability and the latter weighted them with word frequency. Both oPE represented hierarchical processes in the sense that orthographic predictions were dependent on higher-level word probabilities. Cross-validated R² showed that the model with context-based oPE performed significantly better than the one with frequency-based oPE and the non-hierarchical model. This suggested that the brain uses prior context to formulate orthographic predictions. All in all, our study demonstrated that naturalistic reading engages a hierarchical predictive process as proposed by the predictive processing framework.

C62 Sandbox Series - Right hemisphere sensitivity to speed, structure and emotion during narrative processing

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Introduction: The role of the right hemisphere in language remains controversial. Current models suggest different degrees of right hemisphere involvement from simple homologous activity to specialization: the right hemisphere integrates information on a slower timescale than the left (Oderbolz, Poeppel, & Meyer, 2025), right hemisphere lesions lead to social, emotional and pragmatic impairments (Younes et al., 2022), and discourse level processing preferentially engages the right hemisphere (Thye, Hoffman, & Mirman, 2024) suggesting its importance in the creation and updating of a situation model (Kurby and Zacks, 2015). These findings lead us to three distinct and mutually compatible hypotheses of the right hemisphere's contribution to narrative processing: (i) if the right hemisphere integrates slower temporal windows, then the speed at which a stimulus is presented should modulate right hemisphere activity; (ii) if it is sensitive only to discourse-level information then contrasting complete stories with lists of words or phrases should modulate right hemisphere activity and (iii) if it is sensitive to emotional content, then the right hemisphere should more accurately track the emotional evolution of a narrative. Methods: Data collection for this project is ongoing. MEG responses to two personal essays are being collected. We manipulated both the structure and speed at which the stories are being presented in a blocked design. Stories were chunked into small phrases and then flashed for 300ms per chunk in rapid parallel visual presentation (RPVP) either as Intact stories, as SentenceLists (order of the sentences was shuffled), or as

WordLists (with all the words shuffled and then organized into chunks suitable for RPVP). The three levels of structure were then crossed with a speed manipulation with a 150ms gap between chunk offset and onset in the fast speed and a 500ms gap in the slow speed. Comprehension was assessed through self-reports at the end of each block as well as a chunk recognition task. In a separate behavioral experiment, 80 participants were asked to rate the emotional valence, intensity and their overall engagement for both stories at the two presentation speeds. We will fit a regression model that predicts the ratings using MEG source time courses to identify the network that is tracking the emotional engagement of the essays. Preliminary Results: Results from the Ratings study showed that self-reported comprehension was lower for the faster than the slower speed. However, there was no effect of Speed on emotional valence, intensity or overall engagement suggesting that regardless of perceived comprehension, the emotional processing of the essays remained the same. Pilot MEG data shows that responses to the stimuli overall dampen when the stories are presented at a faster speed. This effect does not seem to be more prominent in the right hemisphere over the left. BA22 and 44 show a higher amplitude for trials in the Intact condition in the right hemisphere while there is no such distinction in the left.

C63 - Assessing syntactic processing during natural reading in hearing and deaf adults: An EEG/eye-tracking co-registration study

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Most EEG studies examining neural processes involved in reading utilize unnatural paradigms where readers are not allowed to move their eyes. Both Rapid Serial Visual Presentation (RSVP) and "RSVP with flankers" (three words presented simultaneously) paradigms require participants to fixate on a centrally presented word. We used an EEG/eye-tracking co-registration design, which allowed participants to read naturally. Fixation-related potentials (FRPs) were analyzed, time-locked to eye fixations on a target word. We examined the sensitivity of deaf and hearing readers to English verb agreement violations (e.g., The small sailboat leisurely drift into the calm ocean) and word order violations (e.g., Hot tea can warm your hands a on chilly day). Our previous ERP studies revealed that deaf and hearing readers were equally sensitive to word order violations, exhibiting a P600 at the violation (RSVP paradigm; Emmorey et al., 2025), and both foveally and parafoveally using the RSVP with flankers paradigm (Akers et al., 2024). In contrast, both studies revealed that deaf readers lacked a P600 to agreement violations (either foveally or parafoveally) compared to reading-matched hearing readers. However, deaf readers showed a word final N400 "wrap-up" effect, indicating neural sensitivity to the error during sentence final integration processes (Emmorey et al., 2025). To date, we have tested 23 deaf signers and 15 hearing English speakers matched on age and reading abilities. In contrast to previous studies, neither group exhibited a P600 when fixating on the first word in word order violations, but the deaf readers showed a P600 when fixating on the second word in the violation (e.g., "on" in "a on chilly day"). Neither group showed evidence of wrap-up effects on the final word for sentences containing a

word order violation. Consistent with previous work, only hearing readers were sensitive to agreement violations, exhibiting a P600 when fixating on the verb violation. Hearing readers also exhibited late negativity when the violation was in the parafovea. In contrast to the word order violations, both deaf and hearing readers showed sentence final N400 wrap-up effects in sentences that contained an agreement violation. For agreement violations, our results parallel previous EEG studies: deaf readers are not immediately sensitive to agreement violations at the site of the violation, but they do show sensitivity to these violations when re-evaluating the sentence after reading. For word order violations, surprisingly, neither group exhibited a P600 at the violation, whereas previous studies revealed robust P600 effects for both groups. We attribute this difference to the ability of readers to "autocorrect" the order of the short function words during natural reading, parallel to transposed word effects. In sum, the results indicate that deaf and hearing readers have different sensitivities to English grammar during natural reading, which has not previously been investigated. Emmorey et al. (2025). Assessing sensitivity to semantic and syntactic information in deaf readers: An ERP study. *Neuropsychologia*. Under review. Akers et al. (2024). An "RSVP with flankers" ERP study of foveal and parafoveal processing deaf and hearing readers: Effects of semantic and syntactic violations. Psychonomic Society Meeting.

C64 - Real-time word anticipation across the lifespan: age-related differences

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Prediction, supported by integration, plays a key role in comprehension (Ferreira & Chantavarin, 2018). This study explores (1) how aging affects lexical cloze-probability during reading, and (2) how language experience (LE), working memory capacity (WMC) and executive control (EC) modulate age-related differences. Predictive processing allows young adults (YAs) to speed up and reduce fixations on high-cloze vs. low-cloze words (Luke & Christianson, 2016). We ask whether this ability declines with age. Existing evidence is mixed: some studies based on the resource-based hypothesis (H1) report that older adults (OAs) predict less efficiently across conditions, showing more fixations and regressions than YAs overall (Schotter, 2012). Others, based on the experience-based hypothesis (H2) argue that although word prediction capacity declines with age, context and individual differences, like LE, result in larger cloze-probability effects for OAs only in low-cloze words, but not in high-cloze ones (Payne et al., 2021). We conducted an eye-tracking study with 45 YAs (18-34 years; 22.97(3.4)) and 49 OAs (60-80 years; 69.46(3.7)) healthy native Spanish speakers. Participants read the same Spanish sentences from Foucart et al. (2014) containing target nouns with high- vs. low-cloze probability. WMC was measured via the automated reading span task, EC via the Stroop and Keep Track tasks, and LE with the BEST test and a reading habits questionnaire (RH). Based on prior work (Payne et al., 2021) we expected that (1) YAs would show faster early integration of high-cloze words (shorter first fixation), while OAs would exhibit

larger late-stage cloze-probability effects (more regressions and longer total reading times for low-cloze nouns); and (2) if LE mitigates age-related declines it would be expected to reduce the magnitude of cloze-probability effect mainly for OAs. LMER analyses revealed main cloze-probability effects (larger fixations and more regressions to low-cloze words), WMC (larger fixations with lower WMC) and group (larger fixations and more regressions for OAs than YAs) in the pre-, post- and critical regions. At the critical region, YAs showed a trend for larger cloze-probability effects in early reading measures, whereas OAs exhibited larger effects in later, integrative measures. Cognitive abilities modulated these effects differently across groups: higher WMC enhanced cloze-probability effects in YAs but was associated with reduced effects in OAs. Monitoring & updating capacity influenced reading effort mainly in OAs, with lower rates linked to increased processing difficulty; inhibitory control (stroop) measures did not clearly modulate the cloze-probability effects of the participants. However, LE modulated cloze-probability effects in both groups, with larger modulation in OAs: lower vocabulary and RH were associated with larger cloze-probability effects. The findings support H2 suggesting that (1) cloze-probability is maintained differently across the lifespan and is context-sensitive: YAs predict more efficiently at early stages, while OAs struggle more in integrating low-cloze words later; and (2) cloze-probability effects are modulated by cognitive resources and LE, with WMC and LE playing key roles: lower WMC exacerbate cloze-probability difficulties, while greater LE mitigates those age-related declines.

C65 - Neurophysiological Effects of a Visual-Auditory Language Intervention in Children with Autism Spectrum Disorder (ASD): Evidence from Event-Related Potentials (ERPs)

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Communication difficulties are commonly observed in individuals with autism spectrum disorder (ASD) (Soong, 2000). Among various language intervention strategies, picture books are frequently utilized as effective tools in speech-language therapy, while music-based activities have also been shown to enhance language development in children with ASD (Geretsegger, Elefant, Mössler, & Gold, 2014; Simpson & Keen, 2011). Importantly, previous research has identified atypical auditory and visual processing in individuals with ASD, including delayed or diminished event-related potential (ERP) responses (Bonnell et al., 2010). ERPs thus provide a powerful method to evaluate neurophysiological changes following targeted interventions. This study aimed to examine changes in vocabulary comprehension and ERP responses before and after a 6-week hybrid intervention program incorporating both picture books and music activities. Ten children with ASD (aged 4–9 years) participated in two sessions per week, totaling 12 sessions. Standardized language comprehension was assessed using the Peabody Picture Vocabulary Test (PPVT), and both visual and auditory ERP recordings were obtained one week before and after the intervention. Our findings revealed the following: (a) although no statistically significant improvement was observed in group-level PPVT scores, 7 of the 10 participants demonstrated individual gains; (b) in the visual

modality, P300 latency was significantly reduced following the intervention, suggesting enhanced visual cognitive processing; (c) in contrast, no significant changes were observed in the latency of the auditory P200 and N200 components. These preliminary results provide insight into the neural basis of intervention effects in ASD and suggest potential avenues for refining language therapies. Future studies should further explore how combining visual and auditory modalities through picture books and music may differentially support language development in children with ASD.

C66 Sandbox Series - Mapping the Role of Right Pars Triangularis in Post-Stroke Aphasia: A Planned GIMME Analysis of TMS-Induced Connectivity Changes

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Introduction: Noninvasive brain stimulation to the right pars triangularis (rPTr) has been explored as a treatment for post-stroke aphasia, with mixed outcomes across individuals. While inhibitory rPTr stimulation has sometimes improved naming, the underlying neural mechanisms remain unclear. Traditional interhemispheric inhibition (IHI) models suggest a maladaptive role for the rPTr. Still, recent evidence points to a more nuanced, potentially compensatory function in the context of perisylvian language regions and their right hemisphere homotopes. This project aims to clarify the functional role of the rPTr by examining its directed connectivity with bilateral language-related regions before and after TMS using Group Iterative Multiple Model Estimation (GIMME). Critically, an advantage of GIMME is that it allows us to uncover valid group and individual connections that relate to TMS efficacy. Thus, we can identify individual differences in the rPTr connectivity to the language network, which should improve our ability to determine what connections are necessary for effective TMS stimulation to the rPTr. Study Design and Planned Analysis: We recruited 21 individuals with chronic aphasia due to left hemisphere stroke and administered inhibitory TMS to the rPTr. Resting-state fMRI data were collected pre- and post-TMS. GIMME will be used to model individual-level directed connectivity between key language nodes (bilateral IFG pars triangularis, MTG, SMG, and precentral sulcus). Behavioral responses to TMS will be indexed by changes in naming accuracy, focusing on phonological errors. We are particularly interested in whether individual differences in connectivity profiles (e.g., inhibitory rPTr → IPTr vs. excitatory rPTr → rMTG connections) relate to TMS outcomes. Preliminary Direction and Interpretation: Data collection is in progress, and analytic strategies are being finalized. Our pilot analyses and prior work suggest that specific rPTr connectivity patterns may explain TMS-induced naming changes. We hypothesize that inhibitory connections from rPTr to left hemisphere language areas may reflect maladaptive interference, while excitatory connections to the right hemisphere language nodes could indicate compensatory recruitment. We anticipate identifying multiple connectivity “phenotypes” across individuals, reflecting divergent neural strategies for supporting naming after stroke. Value of Sandbox Participation: This work is in the planning and early analysis phase. Sandbox feedback will be instrumental in refining our model space, selecting optimal ROIs, and interpreting observed connectivity patterns. We hope to discuss the use of GIMME for

modeling individual variability in network dynamics, the challenges of targeting multifaceted regions like rPTR, and the broader implications for tailoring TMS protocols in aphasia rehabilitation.

C67 - Repetitive Transcranial Magnetic Stimulation Targeting the Right Anterior Temporal Lobe to Improve Lexicosemantic Impairments in People with Post-stroke Aphasia

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Repetitive Transcranial Magnetic Stimulation (rTMS) is a non-invasive brain stimulation that can enhance aphasia recovery. Most rTMS studies in post-stroke aphasia target the right Inferior Frontal Gyrus using inhibitory stimulation. However, this approach does not account for the variability in clinical profiles, lesion sizes and sites among individuals with post-stroke aphasia. Some authors have highlighted the limitations of this approach, given the complexity of language processes and paths for aphasia recovery. Persons with post-stroke aphasia (PWA) may experience difficulties such as anomia or produce semantic errors due to lexicosemantic impairments. Lexicosemantic processes involve a large brain network that includes the Anterior Temporal Lobe. Although the exact role of the ATL in lexicosemantic processes is still debated, we propose that it is a promising target for rTMS in PWA. Our aim is to target the ATL in PWA suffering from lexicosemantic impairments to improve language processes. We hypothesize that stimulating the ATL with rTMS will engage the connected network through intra- and inter-hemispheric connectivity, including the ventral semantic stream. In a multiple baseline Single-Case Experimental Design (SCED), we aim to include three PWA with lexicosemantic impairments. Each participant will perform five linguistic tasks (a Picture Naming task, an Auditory Naming task, a Word-Picture Matching task, a Lexical Decision task and a Semantic Decision task) five times a week for one or two weeks, to establish baseline scores for each participant. The baseline length will be pseudorandomized across participants following SCED guidelines. Then, each participant will receive continuous inhibitory Theta Burst Stimulation targeting the right ATL, five times a week for two weeks. After each rTMS session, participants will perform all linguistic tasks. A follow-up measurement will be taken one month after the end of the study. The study is still ongoing, with P1 having completed all sessions, P2 having received all rTMS sessions, and P3 currently being recruited. After stimulation, P1 showed significant improvement in the Picture Naming task with an increase in accuracy (Tau=0.674, p=0.001, SETau=0.240), in the Auditory Naming task with an increase in accuracy (Tau=0.466, p=0.025, SETau=0.287) and a decrease in reaction time (Tau=-0.480, p=0.031, SETau=0.310). We also observed a decrease in reaction time for the Semantic Decision task (Tau=-0.494, p=0.014, SETau=0.282). For P2, initial results showed an improvement in Semantic Decision in terms of accuracy (Tau=0.535, p=0.023, SETau=0.309) and reaction time (Tau=-0.690, p=0.003, SETau=0.264), as well as a decrease in Picture Word Matching reaction time (Tau=-0.662, p=0.004 (SETau=0.274). This study aligns with previous findings about the role of ATL in lexicosemantic processes. By stimulating the

ATL, we suggest that rTMS impacts ventral pathways by affecting areas linked to the ATL, inducing a specific improvement in lexical retrieval processes. This study also highlights the possibility of choosing the cortical target for rTMS based on the clinical profile of the participant, making it more accessible to clinicians. Incorporating rTMS into clinical practice could be based on a combination of literature data (selection of the cortical target and stimulation parameters) and practitioner expertise (contraindications and side effects management).

C68 Sandbox Series - Using fNIRS to characterize resting state functional connectivity in people with aphasia and analyze their response to therapy

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Prior studies have highlighted the importance of the right hemisphere homologous language network in aphasia recovery, particularly in the subacute-to-chronic phase. We developed a telemedicine-delivered therapy engaging diverse right hemisphere-dominant skills to target nouns and verbs within utterances in people with aphasia (PWA), called "PICTURE-IT." Our team has utilized telemedicine-based therapy previously through an anomia treatment targeting lexical skills called "CoDeLT." Given recent support for the use of network-level analysis to investigate post-stroke language impairment and limitations of fMRI, we conducted a preliminary examination of the utility of functional Near-Infrared Spectroscopy (fNIRS) for measuring PICTURE-IT's impact. First, we compared pre-treatment fNIRS-derived resting state functional connectivity (rs-FC) in PWA to age-matched controls. Subsequently, we explored how pre-treatment rs-FC related to therapy outcomes. Fifteen neurologically healthy older adults (11 men, 4 women; mean age: 58.9 +/- 17.4 years) were compared with two PWA who had received fNIRS in the randomized cross-over trial of PICTURE-IT versus an established naming treatment, CoDeLT. Inclusion in the trial required deficits on either a noun or verb naming test, and the primary outcome was pre- to post-therapy change in noun naming. PWA1 was a 55-year-old right-handed man with a subacute bilateral (left>right) thalamic stroke who received PICTURE-IT then CoDeLT. PWA2 was a 49-year-old right-handed man with a chronic right temporal ischemic stroke who received CoDeLT then PICTURE-IT. fNIRS optodes were positioned over bilateral perisylvian regions resulting in 46 long and 8 short channels. Channels over ventral and dorsal regions within each hemisphere were averaged pairwise across two sequential runs. Data were preprocessed in NIRS Toolbox (Santosa et al., 2018), and channel-wise rs-FC was computed using a prewhitening, robust-fit Pearson correlation routine. Bayesian Tests of Deficit (Crawford & Garthwaite, 2007) were used to evaluate group differences in rs-FC. PWA1 exhibited significantly higher right intra-hemispheric dorsal FC (Z=2.66, [CI: 1.57, 3.77], p=0.022) and lower ventral inter-hemispheric FC (Z=-2.28, [CI: -3.27, -1.32], p=0.044) than controls. He demonstrated a 27% improvement on the BNT following PICTURE-IT (near ceiling), and only a 3% increase following CoDeLT. PWA2 also exhibited higher right intra-hemispheric dorsal FC (Z=2.30, [CI: 1.32, 3.30], p=0.042) and lower ventral inter-hemispheric FC (Z=-3.58, [CI: -4.99, -2.14, p=0.004) than controls. PWA2 exhibited a numerical trend toward lower intra-hemispheric left ventral FC (Z=-1.98, [CI: -2.84, -1.10, p=0.075).

He demonstrated a modest but better response to CoDeLT (17%) than the right-hemisphere engaging PICTURE-IT (3%). Despite both PWA demonstrating similar fNIRS rs-FC patterns compared to controls at pre-treatment, they exhibited opposite trends of therapeutic benefit. These findings align with the notion that therapies engaging RH regions may be most beneficial in earlier stroke recovery phases. Future directions include expanding the number of participants and evaluating pre- to post-treatment changes in rs-FC. Crawford, J. R., & Garthwaite, P. H. (2007). Comparison of a single case to a control or normative sample in neuropsychology: Development of a Bayesian approach. *Cognitive Neuropsychology*, 24(4), 343–372. <https://doi.org/10.1080/02643290701290146> Santosa, H., Zhai, X., Fishburn, F., & Huppert, T. (2018). The NIRS Brain AnalyzIR Toolbox. *Algorithms*, 11(5), 73. <https://doi.org/10.3390/a11050073>

C69 - Preliminary evidence for tuning of the auditory system during speech planning

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The central nervous system (CNS) closely monitors auditory feedback during speech production—a process critical for both speech acquisition and maintenance (Perkell, 2012; Guenther & Vladusich, 2012). Impairments in auditory monitoring are linked to various speech disorders, including stuttering (Terband et al., 2009; Daliri et al., 2017). While current models of speech production emphasize monitoring after speech initiation (Houde & Nagarajan, 2011; Hickok, 2012; Guenther, 2016), they do not account for whether or how the CNS optimizes the auditory system in advance of speech onset. Understanding such sensory preparatory mechanisms has theoretical and clinical implications but remains largely unexplored. This study aims to elucidate the predictive modulation of the auditory system during speech planning and to develop a theoretical framework for how the CNS prepares for effective auditory monitoring before speech onset. Prior work from our lab has shown that motor predictions can modulate auditory processing even before speech initiation—referred to as pre-speech auditory modulation (Daliri & Max, 2015a, 2015b, 2018). We hypothesize that the CNS employs an active mechanism whereby motor predictions fine-tune the auditory system in a speech-specific manner to enhance monitoring efficiency. We conducted a pilot study ($n = 7$) using electroencephalography (EEG) and speech acoustics in a novel experimental paradigm to test this. Participants sat in a sound-attenuated room and completed five blocks of speech production and silent reading conditions. Each trial began with a fixation cross presented for 500 ms, followed by the display of a word in white text. In 75% of the trials, a brief auditory stimulus (subject-specific /ɛ/ or /æ/, 40 ms duration, 75 dB SPL) was presented 400 ms after word onset. Then, 200 ms later, the word changed from white to green, serving as the “go” cue for participants to produce the word. In the silent reading condition, participants viewed and read the word silently without vocalizing. No auditory stimulus was delivered in the remaining 25% of trials (no-audio trials). We recorded event-related potentials (ERPs) in response to the auditory stimuli presented during speech planning or silent reading. The stimuli were either congruent with the planned word (e.g., /ɛ/ before producing /ɛd/) or incongruent (e.g., /æ/ before producing /ɛd/). After removing

baseline responses using no-audio trials, we measured the N1-P2 peak-to-peak amplitude (70–250 ms) as an index of auditory responsiveness. We then calculated pre-speech auditory modulation by subtracting ERP amplitudes in the speech condition from those in the reading condition. Results revealed significantly greater pre-speech modulation in congruent trials than incongruent trials, suggesting that the auditory system is fine-tuned speech-specific during planning. These findings suggest that the CNS engages in predictive, speech-specific auditory modulation before speech initiation. This work challenges current models of speech production and lays the groundwork for understanding how preparatory neural mechanisms support fluent speech. This work was supported by a New Investigator Grant from the Arizona Biomedical Research Centre (RFGA2024-022-018) and an ISSR Seed Grant from Arizona State University, both awarded to Yaser Merrikhi.

C70 - Subprocesses in speech planning: a voxel-based lesion-symptom mapping study of Apraxia of Speech

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Speech planning is typically characterized as an intermediate phase in the speech control network (Van Der Merwe, 2021). It involves the ventral premotor cortex (vPMC), with input from subcortical, frontal, and parietal regions. Computational models differ in how they depict the architecture of this network (Hickok et al., 2023; Miller & Guenther, 2021). Apraxia of Speech (AOS), a disorder affecting speech planning, provides a disease model for understanding system breakdown. Prior voxel-based lesion-symptom mapping (VLSM) work supports vPMC's role in speech planning (Basilakos et al., 2015; Conterno et al., 2021). However, a key prediction of computational models and clinical observations remains untested: that AOS can be behaviorally and neurally disambiguated into phonetic and prosodic subtypes. This study investigates AOS subtypes by examining prevalence of speech error features (prosodic, phonetic) and associated neural correlates using VLSM. Participants included 87 left-hemisphere chronic stroke survivors (39 female/48 male; mean age 60.83; mean lesion volume 97.17cm³; mean chronicity 43.87mos). Participants underwent neuroimaging with high-resolution MPRAGE/FLAIR scans; lesions were manually traced. Behavioral testing included the ASRS-3 and WAB-R. Participants with AOS were subtyped as phonetic/prosodic/mixed based on a phonetic-to-prosodic feature ratio ((phonetic-prosodic)/(phonetic+prosodic)) derived from the ASRS-3. We interpreted ratios ≤ 0.3 as prosodic; > 0.3 and ≤ 0.3 as mixed; and > 0.3 as phonetic. VLSM (DeMarco & Turkeltaub, 2018) outcome variables included WAB-AQ; ASRS-3 Apraxia Severity, Aphasia Severity, Phonetic Features, and Prosodic Features; as well as the subtype ratio. Significance was set at $p < 0.005$ and cluster-corrected at $p < 0.05$, 10,000 permutations. 43.68% of our sample received an AOS diagnosis as indicated by ASRS-3. Of these participants, 47.37% showed Prosodic subtype; 28.95% showed Mixed subtype; and 18.42% showed Phonetic subtype. VLSM examining ASRS-3 Apraxia Severity revealed a significant cluster in ventral pre- and postcentral gyrus, also overlapping with white matter. VLSM examining ASRS-3 Aphasia Severity revealed a significant cluster encompassing superior temporal gyrus (STG) and

posterior parietal cortex (PPC), while VLSM examining WAB-AQ revealed a significant, overlapping cluster in STG. VLSM examining ASRS-3 Phonetic Features with ASRS-3 Prosodic Features as covariates (and vice versa) revealed no significant clusters. VLSM examining subtype ratio with ASRS-3 Apraxia Severity as a covariate revealed only a subthreshold cluster in subcortical white matter, potentially implicating SLF III in phonetic AOS. The overall prevalence rate indicates that almost half of our sample has AOS, replicating prior work (Ziegler et al., 2022). We found strong behavioral support for distinct AOS subtypes, with rates of prosodic subtype double that of phonetic subtype. Our lesion results replicate prior VLSM work, showing that AOS is related to lesions in vPMC and the surrounding white matter, and aphasia to lesions in STG and PPC (Basilakos et al., 2015). We did not find lesion evidence supporting the neural disambiguation of phonetic and prosodic subtypes, i.e. that speech planning can be split into phonetic and prosodic subprocesses. However, the subthreshold cluster in subcortical white matter relating to subtype ratio points to future work using connectome-based lesion-symptom mapping.

C71 Sandbox Series - Consolidation of a “new” Speech-motor pattern : Preliminary Evidence

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Sleep plays a critical role in memory consolidation, particularly in learning complex motor sequences and integrating new linguistic information. The role of sleep in establishing a new speech-motor pattern is underexplored. This study investigates the effect of sleep on perception and production accuracy following training on non-native contrast (Danish vowels /y/-/ø/). The data collection for the fMRI study is completed but the analysis is still ongoing. The data collection for the perceptual identification task is ongoing. Forty native English speakers (18-24y, M = 19.7, SD = 3.5) were randomly assigned to train in the evening (SLEEP group, n = 19) or in the morning (REST group, n = 21). Participants were trained in the perception of the vowel contrast through a two-alternative forced-choice task (200 trials), followed by a production training phase where participants imitated the target vowels (200 trials). After a 12-hour delay, participants completed an a T1 structural scan and fMRI scan while producing the learned speech sounds (32 trials for each vowel) prompted by a visual category label. Neuroimaging data were acquired using a 3-Tesla Siemens Prisma scanner. Perception accuracy was assessed both during training and at the end of the fMRI session, while production accuracy was assessed both during training and in the scanner. The outcome measures of perception is the percentage of correct responses in a perceptual identification task after the training and another one after the fMRI task. The primary measure of production accuracy will be a perceptual identification score from native Danish speakers who completed an online task to identify the training productions and in-scanner productions of our participants. Danish speakers are presented with the recordings of the learners' productions and asked to identify if it was either /y/ or /ø/. We aim to recruit a total of 40 Danish participants. To date, 3 Danish participants have completed the rating task for productions during training, and 14 participants for the sounds produced in-scanner. A secondary production measure was the Euclidean distance calculated between participants' formant values (of F1, F2, F3) and our target token's values, where a smaller distance indicated greater

production accuracy. Preliminary findings suggest that the SLEEP group exhibited greater retention of learned vowel contrasts in perception compared to the REST group. We did not observe a significant group-level difference in the secondary production measure. The fMRI analyses have indicated potential differences in hippocampal (REST>SLEEP), and cortical (REST<SLEEP) activations. Results from these ongoing analyses may contribute to our understanding of sleep's role in second-language acquisition by demonstrating its benefits for both perceptual and motor aspects of speech learning. More broadly, the findings may provide insight into how memory consolidation mechanisms support linguistic learning and retention.

C72 - A narrative review of neural oscillations linked to auditory (phoneme) perception

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Time-frequency analysis (TFA) is a valuable method in electrophysiological research, as it captures the dynamic patterns of neural oscillations over time and across frequency bands. Unlike traditional ERP analyses, TFA reveals both evoked and induced brain activity, offering deeper insight into the temporal and spectral processes that underlie speech and language comprehension. Event-related spectral perturbations (ERSPs) derived from TFA hold potential as biomarkers for identifying and understanding auditory and speech-language deficits. This narrative review explores which ERSPs are associated with auditory input processing in neurotypical adults and individuals with speech-language pathologies. The review focuses specifically on event-related spectral power within distinct frequency bands, distinguishing between two key auditory functions: auditory discrimination, the ability to detect differences between sounds, and auditory categorization, the grouping of similar sounds into meaningful speech categories. Additionally, the review examined the literature on how reliable the event-related spectral perturbations are within these frequency bands for the MMN and P300 effects elicited by tonal and linguistic stimuli, as analyzed through time-frequency methods in neurotypical adults. The electronic databases PubMed, Web of Science, and Embase were searched for relevant studies from 18 until 25 November 2024. The main reasons for exclusion were populations or analyzing techniques beyond the scope of this review (e.g. no TFA, non-neurotypical population). In total, 17 studies were included in this narrative review. Most included studies examined oddball paradigms using tonal stimuli, as the relationship between the MMN component and specific frequency bands has not yet been studied in paradigms with phonemes. The review revealed that auditory discrimination is primarily associated with event-related spectral perturbations in the gamma and theta frequency bands. In contrast, attentive auditory categorization involves a broader range of frequency bands, with gamma, theta, alpha, beta and delta oscillations all contributing. Regarding reliability, the findings indicate that P300 amplitude showed moderate to excellent reliability, particularly for standard tones, with continuous EEG proving more reliable than evoked power. Longitudinal studies further suggest that these time-frequency dynamics remain stable. In conclusion, these findings enhance our understanding of the neural dynamics involved in auditory input processing. However, the field remains in its early stages,

with limited research on the test-retest reliability of ERSPs, particularly in relation to the MMN and P300 components elicited by tonal and linguistic stimuli. Current evidence is largely restricted to neurotypical adults, leaving important gaps regarding clinical populations with speech-language pathologies. Future research should investigate phoneme-based paradigms and examine neural oscillations in individuals with speech-language disorders. Such work is essential for advancing theoretical models of auditory processing, refining diagnostic tools, and improving the evaluation of intervention outcomes in both research and clinical settings.

C73 - Mapping Audiovisual Speech Comprehension in Naturalistic Contexts

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Traditional paradigms in cognitive neuroscience, while valuable, often fail to capture the richness of real-world experiences. In many experimental designs, auditory, visual, and language components of stimuli are deliberately isolated, introducing what has been termed a “laboratory-style” bias (Zhang et al., 2021). While such controlled settings are effective for identifying consistent neural responses, they fail to reflect the complexity of everyday perception. To address this gap, researchers have increasingly adopted naturalistic paradigms such as movie watching, which offer rich, cross-sensory stimulation and engage a broader range of neural processes. This approach has been used to evaluate responses across a wide number of cognitive domains (Saarimäki, 2021; Maguire, 2012). Speech perception, for instance, is inherently multisensory—requiring the integration of auditory cues, lip movements, and facial expressions. Prior neuroimaging studies have suggested that the left posterior superior temporal sulcus (pSTS) plays a key role in this integration, particularly when auditory and visual inputs are congruent (Beauchamp et al., 2005). A patchy organization exists within this region: some areas respond selectively to sound, others to visual input, and some to both. This structure shows heightened activation when audiovisual cues align, suggesting a specialized role in binding multisensory information. However, many prior studies have made use of McGurk stimuli, which involve incompatible auditory and visual speech information. The degree to which the pSTS is involved in multisensory speech processing under naturalistic conditions is unclear. The current study aims to assess multisensory speech perception using the full-length film *Back to the Future* (1 hour and 47 minutes duration), leveraging fMRI data from the Naturalistic Neuroimaging Database (NNDb) (Ali et al., 2020). We manually annotated 8,634 speech events by onset time, which were then convolved with a hemodynamic response function to create regressors for a general linear model (GLM) analysis. Based on prior literature, we hypothesized increased activation in the superior temporal gyrus (STG) for audio-only words, visual cortex responses for audiovisual speech, and robust pSTS activation during naturalistic viewing. Using a whole-brain corrected threshold, we consistently identified speech-related activation in bilateral STG across all six participants for both audio-only and audiovisual speech. Contrary to expectations, we did not observe visual cortex activation. However, we found enhanced activation in the left pSTS in all participants, supporting its role in integrating speech information in dynamic, naturalistic contexts. These findings

underscore the value of movie-watching paradigms in capturing ecologically valid speech processing. By extending traditional experimental approaches, this method offers promising new insights into how the brain supports real-world communication.

C74 - The Relationship Between Speech in Noise Comprehension and Moderate-to-Vigorous Physical Activity in UK Biobank

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INTRODUCTION: Many listeners report difficulty following conversations in noisy environments regardless of hearing ability. Despite decades of interest in understanding why some listeners struggle to understand speech in noise more than others, answers remain elusive. Prior work suggests that communicating in noisy environments requires the upregulation of executive functions supported by activity in dorsolateral prefrontal cortex. Given the rich literature supporting the benefits of physical activity for executive functions, we hypothesized that spending time in moderate-to-vigorous physical activity would be beneficial for speech in noise comprehension. **METHODS:** Participants (N=95,259; 55.9% female) in the UK Biobank dataset wore an accelerometer for 7 days and completed questionnaires. Derived accelerometer data came from a machine-learning model classifying movement behaviors as time spent in sleep, sedentary behavior, light physical activity, and moderate-to-vigorous physical activity. Participants also answered two questions about their hearing status: “Do you have any difficulty with your hearing?” and “Do you find it difficult to follow a conversation if there is background noise (such as TV, radio, children playing)?” By breaking participants into two groups based on their “yes” and “no” answers to those questions, we ran a logistic regression to see if time spent in moderate-to-vigorous physical activity decreases the likelihood of reporting a hearing problem or a problem with speech in noise. Additionally, we ran another analysis grouping participants into whether they spent at least 150 minutes (>1.49% of their week) in moderate-to-vigorous physical activity or not (i.e., < 1.49% of their week). We then ran logistic regressions to determine if spending at least 150 minutes in moderate-to-vigorous physical activity decreases the likelihood of reporting a hearing problem or a problem with speech in noise. **RESULTS:** We found that spending more time in moderate-to-vigorous physical activity significantly decreases the odds of reporting a hearing problem or problem with speech in noise. Specifically, for every 1% increase in time spent in moderate-to-vigorous physical activity, the odds of reporting a hearing problem decrease by 2.04% and the odds of reporting a hearing problem decrease by .96%. Spending at least 150 minutes in moderate-to-vigorous physical activity was a significant predictor of hearing outcomes for both questions. Meeting this criterion was associated with a 7.6% reduction in the odds of reporting a hearing problem and a 5.3% reduction in the odds of reporting difficulty with speech in noise. **DISCUSSION:** These findings show that more time spent in moderate-to-vigorous physical activity and spending at least 150 minutes of moderate-to-vigorous physical activity per week is associated with a significantly reduced likelihood of reporting a hearing or speech in noise problem. These findings suggest that physical activity may be a protective factor in age-related speech in noise comprehension decline. The answer to

improving adversity with degraded speech may not lie in another product or advancement in technology but rather in the simplicity of a lifestyle change. Targeting physical activity as a non-invasive and low-cost intervention may make the common decline in speech in noise comprehension that comes with age less imminent.

C75 - How Minds Connect: Semantic Dimensions Drive Differential Patterns of Neural Synchronization

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Communication underpins human social interactions, allowing thoughts to flow between minds. Each utterance carries rich contextual semantic information across sensorimotor, emotional, intentional, and attitudinal dimensions. Sharing these representations is believed to be supported by inter-brain neural synchronization (NS), which measures neural alignment between speakers and listeners. We propose that effective communication relies on the exchange of various semantic dimensions, each influencing NS differently over space and time. Grounded in embodied-cognition theory and the social-brain hypothesis, we predict that perceptual, emotional, and socially relevant semantics significantly impact NS due to their evolutionary importance. We conducted a pseudo-hyperscanning MEG experiment using a storytelling-listening paradigm involving a native Mandarin speaker and 22 listeners. Ten semantic dimensions (perception, motor, socialness, emotion, time, space, animacy, causality, drive, and attention) were evaluated for content words (406 nouns and 360 verbs) by independent raters. We employed a novel speaker-listener predictive encoding modeling approach to estimate each dimension's contribution to NS while controlling for acoustic and phonetic features. Of the ten dimensions tested, four emerged as strong NS drivers: Perception, Emotion, Causality, and Attention. Their effects spanned language and association networks, including the auditory cortex, mid-temporal areas, inferior parietal lobule, inferior frontal gyrus, and pre-/post-central gyri. Two main patterns emerged: a rapid speaker-leading window (~260 ms) across all region pairs, and a bidirectional pattern with speaker leads (-1000 ms, -250 ms) and listener leads (+200 ms) connecting frontocentral and tempoparietal networks. Dimension-specific profiles were evident, with Emotion showing speaker leads limited to bilateral frontal region pairs, while Causality and Attention exhibited unique speaker-listener bidirectional patterns. Classification analyses confirmed that these speaker-listener shared semantic features were represented through partly segregated neural "communication channels". These findings support theories positioning human communication within embodied and socially adaptive representations that leverage distinct pathways and timing to transfer information between minds.

C76 - Patterns of structural variation in human auditory cortex revealed by data-driven curvature-based clustering

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The human auditory cortex is distinguished by enormous variation in the patterns of cortical folding seen across individuals. An objective characterization of structural variation

in human auditory cortex is important because variation in auditory cortical morphology has been associated with phonological processing (Eckert, 2024), auditory expertise (Golestani et al., 2011), language disorders (Leonard et al., 2001), and language lateralization (Tzourio-Mazoyer et al., 2014). Primary auditory cortex is situated on Heschl's gyrus (HG), which traditionally has been described as having three distinct gyrification patterns: a single gyrus, a common stem duplication, or a complete posterior duplication (Marie et al., 2015). Situated posterior to HG, gyrification of planum temporale (PT) is also highly variable but less well characterized (Tzourio-Mazoyer and Mazoyer, 2017). Characterization of folding patterns on the superior temporal plane is typically based on manual inspection of brain volumes or surfaces (Morosan et al., 2001; Rademacher et al., 2001), but many patterns of individual morphology are not well described by these three categories. Moreover, prior work has not considered variation in HG and PT folding simultaneously. In this study, we used an unsupervised data-driven clustering approach to characterize folding patterns of the superior temporal plane (including HG and PT) based on a large sample (n=1065) of brain scans from the Human Connectome Project. Using local measures of cortical curvature obtained from FreeSurfer reconstructions, we calculated the Gaussian similarity between all pairs of subjects for gyrification within the superior temporal plane. The resulting similarity matrix was submitted to elbow-optimized k-means clustering to identify common patterns of gyrification across individuals. In contrast to the three classic categories, this data-driven clustering suggested that superior temporal morphology was best characterized by five distinct gyrification patterns. We found two distinct variations of the single HG morphotype: (i) a single HG with evident gyrification of PT (32% of hemispheres) and (ii) a single HG with minimal gyrification of PT (26%). We also found curvature patterns consistent with (iii) classic common stem duplication of HG (16%) and (iv) classic complete posterior duplication of HG (9%). Finally, we observed a previously undescribed curvature pattern intermediate between the classic single HG and common stem duplication, consisting of (v) a wider HG with a notch at the anterolateral end (18%). We also illustrate how these morphological variations are paralleled in variation in the cortical microstructure (intracortical myelination). Overall, these results expand our understanding of the range of individual variation in the morphology of auditory cortex. Future applications of these data-driven techniques may offer new routes to understanding structure-function correspondence in human auditory cortex, including how atypical patterns of gyrification characterize neurodevelopmental or neuropsychiatric variation in language and audition.

C77 - Direct Brain Recordings Showing Neural Prioritization of Speech Over Music in Children

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Our brains are constantly filtering sounds. How does the brain solve the 'cocktail party problem' seamlessly, sometimes even without conscious effort? While extensively studied in adults, understanding how these auditory processing mechanisms develop and mature throughout childhood remains a critical gap in our knowledge. Using intracranial stereo-electroencephalography (sEEG), we investigated this implicit auditory attention question by presenting 52 pediatric participants (ages 4-22, 29M/23F, over 8000 electrodes total, with over 800 temporal lobe electrodes total) with audiovisual movie trailers that contained both speech and music. Our naturalistic approach provides critical insights into real-world auditory processing beyond traditional laboratory paradigms. We extracted and analyzed high gamma band activity (70-150 Hz) to index local neural firing. Data were analyzed using a computational source-separated encoding analysis. We used deep neural networks to decompose the mixed speech-music stimuli into isolated speech and music components, then built separate encoding models for each condition (speech only, music only, and original speech-music mixture). Although the participants heard only the original speech-music mixture, we found that brain activity in the superior temporal gyrus (STG), Heschl's gyrus (HG), and superior temporal sulcus (STS) was significantly better predicted using speech-only models ($p < 0.001$) suggesting preferential and early encoding of speech even with competing music. Analysis of age-related effects revealed a significant relationship between age and speech correlations in STG ($p < 0.001$), indicating that the pediatric brain demonstrates an intrinsic neural bias toward socially relevant auditory information that emerges early and strengthens throughout development. Our findings demonstrate how different brain regions implicitly attend to specific components of mixed auditory streams, with specialized temporal lobe networks enabling the separation and processing of speech and music simultaneously, even in the absence of explicit attentional directives. This suggests that selective attention processing in implicit attentional scenarios may emerge as an inherent neural capability, rather than a purely conscious, top-down mechanism. These results have significant implications for understanding developmental communication disorders and may inform targeted therapeutic interventions for children with auditory processing deficits.

C78 - A drift-diffusion decomposition of conditions that underlie shallow "good enough" processing of spoken sentences

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Although listeners may have the competence to engage in a word-by-word analysis to build a syntactic representation of a heard sentence, in everyday conversation, listeners may, almost by necessity, process the sentence only to a shallow or "good enough" level to derive its meaning. The possibility has been raised that processing schemata may be flexible, such that under some circumstances, comprehension decisions are more likely to be based on an incomplete analysis where heuristic-based sampling and plausibility are used rather than a full syntactic analysis. We report two experiments in which adult participants were tested on their ability to determine the meaning of auditorily presented sentences. In some cases, the

thematic roles had been reversed to produce an implausible version of the sentence using the same set of words as the original sentence. After a sentence had been heard, participants were presented with a visually displayed question that probed their understanding of the meaning of the sentence. A participant providing a plausible, yet syntactically incorrect judgment about the meaning of an implausible sentence was taken as an index of shallow processing. In Experiment 1, 32 participants were given two different orienting instructions while completing the listening task (instructions that emphasized either the speed or accuracy of the comprehension decision). To vary perceptual challenge, spectral clarity was also manipulated such that speech was either heard clearly or degraded in spectral richness. Hierarchical Bayesian drift-diffusion modeling was used to probe latent decision-making processes that influenced the participants' comprehension decision. Results indicate that orienting instructions that emphasize speed and perceptual challenge both increase the likelihood that the assumed meaning of implausible sentences will be based on plausibility. Of special interest, drift-diffusion modeling revealed a dissociation where orienting instructions selectively influenced the amount of evidence required for the participant to make a comprehension decision (a parameter often associated with frontal regions), while sentence plausibility selectively influenced the rate of evidence accumulation (a parameter often associated with parietal and temporal areas). In Experiment 2, 64 participants were tested on the same materials without the use of vocoding to replicate the main drift-diffusion model results. The comprehension, reaction time, and drift-diffusion results of Experiment 2 replicated the results of Experiment 1. The findings from these experiments suggest that comprehension processes are highly flexible and are modulated by both the demands of a task as well as the clarity of the speech signal. These results are interpreted in terms of an underlying neural decision-making mechanism in which the listeners' development of the meaning of an utterance is due to the accumulation of evidence from the syntactic and semantic content.

C79 Sandbox Series - BrainAGE as a predictor of phonetic perception

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Behaviorally, individuals differ in the extent to which they learn, encode, and represent speech sounds. In recent evidence, differences in fine-grained phonetic perception predict individual differences in other language outcomes. Several studies report no effect of age on tasks that assess sensitivity to phonetic category structure suggesting that aspects of phonetic perception are resilient to the effects of aging (Myers et al., 2024). However, a number of biological and environmental factors also shape the development and trajectory of changes in brain structure in adulthood, and these changes do not track smoothly with chronological age. Considering that differences in brain structure and measures associated with brain aging predict phonetic expertise, we asked whether age-related changes in brain structure reflect differences in phonetic perception. We collected a structural MRI from 60 adults ages 18-78, along with phonetic decision data, and a battery of

cognitive and linguistic assessments. Participants in this sample were recruited in five equal age-bands. This sample allows us to analyze differences in the behavior of adults across the lifespan as opposed to a dichotomous view of younger and older adults. The Visual Analog Scale (VAS) phonetic decision task provides insight into individual differences in phonetic skill. Listeners rated tokens on vowel and VOT continua spanning canonical endpoints and ambiguous tokens. Several measures of phonetic perception were derived from this task using a four-parameter logistic regression to extract slope and consistency estimates for each participant. These measures reflect the extent to which individuals retain within-category representations, and how consistent their representations are of specific tokens. We quantified individual differences in brain structure using the BrainAGE algorithm. BrainAGE is a supervised learning algorithm that uses T1 images to calculate an estimate of “global” brain health by comparing grey and white matter volume, and cortical thickness to T1 images of other individuals across the lifespan. A positive “BrainAGE gap”, or the difference between an individual’s estimated BrainAGE and chronological age, suggests that the brain is aging faster than anticipated and has been associated with both subtle and clinical levels of cognitive decline and exposure to environmental stressors (Kalc et al., 2024, Nemati et al., 2024, Gotlib et al., 2023). In this project we discuss a) how VAS outcomes relate to other measures of cognitive-linguistic fitness across the lifespan, and b) if participants’ overall brain “health” predicts individual differences in phonetic perception. We hypothesize that there will be few differences between the behavior of younger and older adults, but that BrainAGE may relate to other aspects of an individual’s development that predict subtle differences in their phonetic acuity. Preliminary evidence shows a weak negative relationship between overall VAS consistency and BrainAGE gap suggesting that individuals that show evidence of decelerated aging have more consistent phonetic representations. These results, together with further analyses quantifying regional differences in BrainAGE, contribute to a better understanding of the ways that differences in signatures of neural aging impact phonetic perception.

C80 Sandbox Series - Tuning in to clarity: How the brain tracks and remembers clear speech

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Consistent with the effortfulness hypothesis (Pichora-Fuller et al., 2016; Rabbitt, 1968) clear speech is often easier for listeners to process than conversational speech, leading to improved recall and recognition memory. However, the underlying mechanisms responsible for this facilitative effect remain unclear. One possibility is that clear speech enhances encoding of deeper lexical and semantic information, while another suggests that acoustic features are primarily responsible. To investigate this, we are conducting a study using continuous electroencephalography (EEG) in 80 older adults as they listen to both clear and conversational sentences embedded in background noise. All sentences are highly constraining and mixed with +3 dB speech-shaped noise created from averaged clear and conversational speech samples, ensuring consistent acoustic masking across conditions. Importantly, our participants represent a range of hearing acuities, which allows us to examine how individual differences in peripheral hearing

may interact with the neural encoding of speech. Preliminary behavioral results indicate better recognition memory, more accurate cued recall of sentence-final words, and improved performance on grammaticality judgments for clear speech. To further explore the neural basis of these effects, we plan to conduct neural speech tracking analyses on the EEG data. Neural speech tracking provides a window into how well the brain encodes the speech signal and has been linked to both intelligibility and attentional engagement. Given the variety of existing speech tracking techniques and the variability in reported outcomes, this project will compare multiple approaches — including encoding, decoding, and cross-correlation methods, to assess the robustness and reliability of neural encoding metrics. By doing so, we aim to identify which aspects of neural speech tracking are most sensitive to the processing benefits of clear speech, and how these may differ as a function of hearing acuity. These analyses will be conducted following recent best-practice recommendations for frequency and time-frequency domain studies of neural time series (Keil et al., 2022). We predict that neural speech tracking will be stronger for clear than for conversational speech, and that individuals with poorer hearing will show reduced tracking fidelity. Furthermore, we expect the degree of neural tracking enhancement for clear speech to predict the behavioral memory benefit, linking perceptual encoding with downstream cognitive performance.

C81 Sandbox Series - Rethinking the classic sentence-picture matching task as a measure of complex syntax comprehension in aphasia

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Investigating the specific effects of syntactic complexity in sentence processing research remains challenging due to confounds in various linguistic and cognitive factors, such as working memory and semantic surprisal. Traditional methods for assessing complex sentence comprehension, especially in clinical populations, often employ syntactically complex sentences with contrived structures that are rarely used in natural language, making it difficult to isolate syntactic processing from other cognitive demands brought on by these stimuli. To address this issue, we have developed a novel experimental approach aimed at more accurately isolating syntactic processing by minimizing extraneous cognitive demands during sentence comprehension. Our study utilizes a sentence-picture matching task, employing the same sentence stimuli as Wilson et al. (2010). The key innovation in our design is the introduction of various prime conditions that precede the target sentences, intended to facilitate the processing of syntactically complex structures like object-extracted relative clauses as in (1). (1) The boy who the girl is hugging is green. In our experimental paradigm, participants are presented with one of five conditions before encountering the target sentence: (i) the main verb of the sentence, (ii) the subject of the relative clause, (iii) a semantically related but non-licensing context sentence, (iv) a semantically-related licensing sentence as context, or (v) no prime. For example, for the target sentence in (1), the primes would be: (i) hug, (ii) girl, (iii) hugging can bring comfort, (iv) two boys and a girl are crying. Following the prime (or lack thereof), participants are tasked with matching the target sentence to one of two pictures displayed on the screen.

Distractor pictures have either role foils (agent and patient roles reversed), or color foils (agent and patient roles retained, different colors in image). We hypothesize that all prime conditions will facilitate processing of syntactically complex sentences, as measured by higher accuracy and faster response times (RTs), relative to the sentence presented in isolation. Furthermore, we predict that the licensing sentence condition will yield the most significant improvements in both accuracy and RT due to its provision of semantically and pragmatically relevant information. The potential implications of this research are far-reaching. By more effectively isolating syntactic processing, our findings may challenge existing theories of sentence processing, particularly for syntactically complex sentences. This is especially relevant for clinical populations with reduced working memory or cognitive resources, where the ability to differentiate between syntactic complexity effects and other cognitive demands is crucial for accurate assessment and intervention. Our innovative approach not only contributes to a more nuanced understanding of language processing but also offers a methodological advancement in psycholinguistic research. By minimizing confounding factors and providing a more ecologically valid context for syntactic processing, this study paves the way for more precise investigations of language comprehension across various populations and linguistic structures. Data collection is underway and we expect to be able to present pilot data from both healthy young adults and stroke survivors at SNL.

C82 - Hey ChatGPT, what are the neural bases for integrating the meaning of single words into sentences?

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Introduction - Neural representations of single concepts have been extensively studied for years, identifying a left-lateralised network encompassing ATL, AG, medial PFC, precuneus, IFG, VTC, pMTG: the semantic system. However, less is known about the neural basis for combining single concepts into increasingly complex representations, like sentences. To investigate this combinatorial process, we leveraged sentence embeddings derived from large language models (LLMs), which capture the overall meaning of sentences, to examine how this process is distributed across the semantic system. **Methods and Results** - We reanalysed an fMRI study (N=24) where participants read 240 Italian sentences formed by a subject, a verb, and a complement (e.g. "The cops arrest the thieves"). To isolate sentence-level meaning from that of the individual words, sentence embeddings (SONAR by Meta) were used to build (a) a model of sentences presented in their original order and (b) a model derived from sentences with scrambled word order. Through representational similarity analysis (RSA), we contrasted the ordered and scrambled (a > b) models, revealing that sentence-level meaning is represented uniformly across the whole semantic system. While this manipulation produced robust regional differences in the magnitude of representational strength, no specific regions showed a greater relevance to combinatorial meaning when the proportional change in captured information was assessed. To further investigate whether different regions within the semantic system support distinct aspects of the combinatorial process, we focused on the roles played by nouns. Specifically, we constructed two "impoverished" models where sentence meaning is impacted by removing one sentence component: (c) the subject ("The arrest

the thieves"), or (d) the final noun ("The cops arrest the"). We found that the removal of the subject (c > d) more strongly affected sentence-level meaning in core areas of the semantic system: the precuneus, left ATL, and vmPFC. In contrast, final noun removal (d > c) more strongly impacted sentence meaning in regions processing contextual associations: right PPA and RSC. **Conclusion** - The comparison between original and scrambled sentences suggests that the semantic system is uniformly engaged in the integration of single words into sentence meaning. However, while focusing on different sentence components, differences were observed in dissociable brain regions. Core regions of the semantic system provide the foundation of the meaning for the sentence, while regions known for processing contextual associations are integrating the new piece of information with the rest of the sentence. This study shows an innovative way to use LLMs, specifically sentence embeddings, by altering aspects of the original sentences (like word order or specific components) to investigate different linguistic and semantic processes.

C83 - Jungle tiger, tiger jungle: Tracking the feature constellation of phrases and their constituent parts using MEG during serial and parallel presentation

Simone Krogh¹, Liina Pykkänen¹; ¹New York University

A hallmark of human language is the ability to construct complex meanings from simpler pieces using hierarchical structures. Noun-noun compounds exemplify this at a basic level: Different pairings of the same lexical material yield distinct concepts like VALLEY TIGER (animate) and TIGER VALLEY (inanimate) based on the head noun (Kamp & Partee, 1995). Unlike prior research focusing on the combinatorial operations themselves (e.g., Maran et al., 2022; Pykkänen, 2019), we ask how composition affects the neural representations of individual lexical items. Specifically, we use animacy decodability as a proxy for how neural representations evolve depending on functional roles (TIGER as head noun: CHINESE VALLEY TIGER; TIGER as nominal modifier: CHINESE TIGER VALLEY) and the type of initial modifier (MARBLE VALLEY TIGER; a representation of an animal). The test data for our logistic regression classifier are brain responses to our all-caps, low-probability three-word phrases and corresponding controls with ungrammatical modifier ordering (e.g., VALLEY CHINESE TIGER) during magnetoencephalography (MEG) recordings. All stimuli are shown word-by-word in Rapid Serial Visual Presentation (RSVP) as well as flashed all-at-once in Rapid Parallel Visual Presentation (RPVP; Snell & Grainger, 2017). RPVP has been widely used in recent years to study Sentence Superiority Effects, i.e., facilitated processing for structured vis-à-vis unstructured representations. Regardless of presentation mode, each trial stimulus is followed by a briefly flashed target stimulus that either matches or differs from the target stimulus by one word. The training data for our classifier are brain responses to individual animal and location exemplars (e.g., TIGER and VALLEY) recorded in a separate block. Once trained, classifier accuracy on RSVP trials over time is assessed word-by-word to determine if the animacy of individual lexical items and/or the entire phrase is represented neurally. The relative decodability of nominal modifier vs. head noun animacy allows us to assess if hierarchical structure impacts the processing depth of lexical items. MARBLE VALLEY TIGER-trials, with their animate-to-inanimate conceptual shift, further

allows us to test animacy decodability when animacy differs between the head noun and full constituent. Exploratorily, we examine temporal decodability of animacy in RPVP trials and spatial decodability of animacy in both presentation modes. As expected, our online behavioral pilot ($n = 25$) reveals clear instances of a structural superiority effect across presentation modes, a sanity check that supports the validity of our experimental design. MEG data collection and analysis are underway (projected $n = 35$), with expected completion by September. If the parser is sensitive to hierarchical structure, we expect successful classification only for head nouns, not nominal modifiers. This would indicate that neural representations of lexical items are not accessed in their entirety unless necessary. As for MARBLE VALLEY TIGER-trials, we expect the neural data to first reflect the animacy feature of the head noun and then of the full constituent if processing proceeds in an incremental fashion (Schumacher, 2013). Should the temporal decoding accuracies pattern differently across RSVP and RPVP, this would suggest that input seriality constrains the feature constellation of phrases and their constituent parts.

C84 - A Merge-Based Approach to Early Syntactic Negativities

Kevin Guzzo¹, William Haddican¹, Yasuaki Shinohara², Valerie Shafer¹; ¹City University of New York, ²Waseda University

This research presents interdisciplinary experimental work at the intersection of neuroscience and syntax, aiming to illuminate language processing mechanisms through the integration of theoretical linguistics, behavioral data, and electrophysiological evidence. To achieve this, we focus on Early Syntactic Negativities (ESNs), which are rapid negative electrophysiological responses known to be elicited by phrase structure violations at the onset of unexpected lexical categories. Accounting for the unique properties of ESNs has inspired two distinct approaches. First, Friederici's (1995) "Syntax First" model explains the early latency as a reflection of the automatic processing of lexical information in the first stage of its three-stage model. In contrast, Dikker's (2010) Sensory Hypothesis attributes ESNs to 'form-based' prediction errors in the sensory cortex, rather than to syntactic violations. In this work, we develop a novel approach to ESNs. Our hypothesis posits a direct link between ESNs and violations of the operation Merge the sole structure-building operation in the minimalist program (Chomsky 1995). The approach thereby posits a direct electrophysiological correlate of a class of formal representational violations. A key component of our approach is the unification of two previously disparate experimental paradigms used to elicit ESNs in the literature, which we demonstrate are subsumed under a single syntactic distribution predicted by the Merge hypothesis. Furthermore, our hypothesis generates an additional behavioral prediction: a sentence with a Merge violation will be significantly less acceptable than a sentence containing other types of violations. In two experiments, we examine ESNs elicited from previously undocumented elliptical constructions, specifically sluicing and swiping, using event-related potentials (ERPs) and behavioral acceptability judgments. We recruited eighteen native speakers of North American English as participants, all of whom had no speech or language deficits and normal or corrected-to-normal vision. Each experimental sentence was visually presented in two parts. The first part consisted of the complete presentation

of the initial conjunct containing the antecedent for ellipsis. Participants pressed the spacebar to proceed to the second part, containing one of three ellipsis conditions. Following a 300ms fixation cross, the second conjunct appeared word-by-word, each for 300ms. Upon completing the sentence, participants rated its acceptability on a seven-point Likert scale. Our experimental design contrasted violations of ellipsis constraints with Merge violations, systematically manipulating grammaticality within sluicing and swiping constructions. For example, the sentence "The receptionist received something from some organization," was completed with one of the following: (a) "but I don't know from what organization, honestly" (Grammatical Baseline); (b) "but I don't know what organization from, honestly" (Ellipsis Violation); or (c). "but I don't know what from organization, honestly" (Merge Violation). Our results revealed significant differences in the ESN effect for sentences containing a Merge violation compared to both grammatical and ellipsis violation conditions ($p < .05$). Additionally, we observed significantly lower acceptability ratings for sentences with Merge violations in comparison to those with ellipsis violations. Our findings suggest compatibility between the Merge Hypothesis and Dikker's Sensory Hypothesis, as Merge violations were indexed by an ESN recorded at both inferior anterior and inferior posterior sites.

Poster Session D

Saturday, September 13, 5:00 - 6:30 pm, Field House

D1 Sandbox Series - Simulated Attack: A Network Neuroscience Approach to Understanding Stroke and Language Recovery

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Introduction: Stroke is the leading cause of aphasia affecting around 2 million people in the United States. A key challenge in stroke research is the lack of pre-stroke data. This limits our ability to understand the changes resulting from the stroke. Stroke patients often have a different community organization (i.e., modularity) relative to healthy controls. Critically, modularity is related to stroke outcomes, including language deficits. However, the nature of these modularity changes and their relationship to clinical outcomes is confounded by the lack of premorbid data and difficulty in isolating the contribution of individual regions in natural lesions. To fully comprehend how a stroke changes modularity, we must address two questions: 1) how does damage to specific brain regions relate to global shifts in modularity? 2) Do these shifts relate to behavioral deficits? This will allow us to identify what brain regions are responsible for the larger global shifts we see in stroke patients and determine if behavioral deficits are related to focal damage or a by-product of the stroke in its totality. To address these questions, we will simulate focal lesions in a healthy brain and examine how the removal of each brain region relates to modularity changes. We will then use an existing stroke data set to predict behavioral deficit based on our simulated models.

Study Design, Planned Analyses, and Preliminary Results: We independently simulated the removal of all regions of the brain from the structural brain networks in 41 healthy controls (mean age: 58.57 ± 10.8 years). Specifically, we represented each subject's brain as a graph, where brain regions are nodes and the pathways connecting them are edges. We performed this procedure in structural networks with nodes defined by a multiscale anatomical atlas (Lausanne) and a multiscale functional atlas (Schaefer). This allowed us to examine if parcellation choice impacts modularity shifts, and if a novel atlas consensus procedure was a better fit than a single atlas. To date, we have removed each node in a given parcellation to address our first question and calculate the modularity difference between the healthy and lesioned brain in each atlas. Preliminary results suggest that modularity increases in frontal, parietal and temporal lobes and decreases in occipital lobe. In planned Aim 2 we will employ a simulated attack applying naturalistic lesions from real anterior and posterior strokes, commonly associated with aphasia, to healthy controls to estimate modularity shifts and compare the resulting shifts to the simulated results in Aim 1. Planned Aim 3 is to use the simulated modularity change scores from Aim 1 and Aim 2 to predict WAB-AQ sub-tests and naming (via Philadelphia Naming Test) in both anterior and posterior strokes depending on the sub-test, and conceptual semantic knowledge (via Pyramids and Palm Trees) in posterior strokes using support vector regression. **Sandbox Participation Benefit:** This analysis is in the pilot stages. Sandbox feedback will be instrumental in evaluating our methods for the simulated attack approach and refining our network methods to articulate important questions in clinical aphasiology.

D2 Sandbox Series - Phase-amplitude coupling analysis to identify receptive language cortex in epilepsy patients

Srijita Das¹, Haley Mendez², Stephen Gliske³; ¹Graduate Student, University of Nebraska Medical Center, ²Research Intern, University of Nebraska Medical Center, ³Associate Professor, University of Nebraska Medical Center

Patient-specific mappings of the eloquent cortex are crucial for minimizing deficits following resective surgery, particularly in epilepsy patients, among whom one-third are resistant to anti-epileptic drugs. For these individuals, surgery offers the next best option, but successful outcomes depend on accurately localizing eloquent cortical regions, such as language, to minimize post-surgical deficits. Language is innately complex and critical to localize due to the atypical cortical language representation in epilepsy patients. Electrocortical stimulation mapping (ESM), the current gold standard for language localization, is invasive and depends on accurate pre-implantation mapping. Magnetoencephalography (MEG) offers a non-invasive alternative by enabling clinicians to identify surgical candidates and guide electrode implantation for ESM. Its utility for language mapping using simple dipole method remains limited to single point in space for a given point in time. In this work-in-progress study, we evaluate our previously validated localization method based on phase-amplitude coupling (PAC) for receptive language cortex localization in epilepsy patients undergoing MEG. Our approach employs a passive auditory language (PAL) task, which consists of audio clips from natural speech played either forward or backward, each lasting 500-800 ms, presented every 2.5 seconds. From a

retrospective database of 178 epilepsy patients who completed MEG language tasks, 25 patients underwent the PAL paradigm. Preprocessing was conducted in MNE-Python, including notch filtering at 60 Hz and independent component analysis for rejection of cardiac and ocular artifacts. We will proceed with further processing like our published method. Specifically, in Brainstorm we will create epochs of 1000 ms with 100 ms as pre-stimulus baseline. We will average the epochs across trials to generate evoked files and perform source-reconstruction using LCMV beamforming. PAC will be quantified using a time-resolved sliding window approach (500 ms) with 1-12 Hz as the low-frequency (LF) band and 30-300 Hz as the high-frequency (HF) range. PAC will be calculated on the time-courses of neural activity for 148 brain regions defined by the Destrieux atlas. Next, we will apply tensor decomposition to reduce the dimensionality of our six-dimensional data (brain scouts, LF bin, HF bin, patient, time window, speech or non-speech event). Density-based spatial clustering (DBSCAN) clustering with silhouette evaluation will be employed to identify task-activated brain regions as outliers, most of the brain is not involved in the language task. A linear mixed-effects (LME) model will be constructed with PAC as a response variable, expected regions as fixed effects and patients as a random variable. A binary support-vector machine (SVM) classifier will be developed for the language task to predict brain regions depending on PAC values. We will validate PAC-derived maps against ESM results to assess their clinical accuracy. We expect to observe elevated phase-amplitude coupling in the posterior superior temporal gyrus of the dominant hemisphere, consistent with known receptive language function. This abstract presents our analytic framework and early observations, with particular emphasis on developing individual-level PAC profiles to assess functional language lateralization and localization. This study advances the application of PAC as a biomarker for functional language mapping, with implications for broader neuroimaging research.

D3 - Neuronal encoding of social constructs during natural human dialogue

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Social interaction is central to the human experience, allowing for humans to navigate dynamic, and often unpredictable interactions and make meaningful connections with one another. However, due to the stochasticity of these natural interactions, understanding the neural components that constitute social communication remains a major challenge. In this study, we leveraged a unique opportunity to perform semi-chronic recordings from frontotemporal neurons ($n = 251$) in participants ($n = 5$) engaged in natural dialogue to reveal intricate cellular representations of social interactions. To address the inherent variability in this dataset, we mapped single neuronal recordings to relevant social metrics using natural language processing (NLP) techniques such as topic modeling and sentiment analysis, using these metrics to uncover trends and patterns within subsequent neuronal recordings. We then identified neurons with selective responses

to these constructs and modeled their ensemble activities. By mapping neuronal activities across hundreds of interaction events, we identified neurons that reflect various aspects of conversations, including clout, authenticity, conversational dynamics, analytical content, and social dimensions. Our findings reveal how distinct neurons represent the agency of interaction and transition across agents. Collectively, these findings begin to shed light on some of the basic cellular building blocks that underlie natural social communication in humans and provide a framework for understanding social behavioral and communication disorders from a neuronal standpoint.

D4 - Distinct mechanisms of inhibition in language production

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Introduction. It is widely assumed that behavioral interference signals representational conflict, tapping inhibitory control. Some assume this inhibitory control to be a unitary function, regardless of task. In contrast, theoretical models distinguish between tasks in which stimulus-driven information is sufficient to arrive at the correct response vs. those in which such information leads to the incorrect response. An example of the former is contextual similarity. A picture of a “cat” is harder to name in the context of semantically/phonologically (“dog”/“mat”) similar pictures, but the target picture ultimately drives processing more strongly towards the correct answer. In contrast, tasks like picture-word-interference contain stimuli that naturally elicit a prepotent incorrect response unless overridden by task goals. The current project uses robust machine-learning (ML) techniques for analyzing EEG data to examine the generalizability of the neural states representing conflict across these two task types. **Methods.** Twenty-eight native speakers of English completed a picture-naming paradigm. In each block, two pictures were introduced and then appeared randomly for 8 trials each. Two manipulations were embedded: (a) A contextual-similarity manipulation: 5 blocks containing semantically-similar pairs, 5 phonologically-similar pairs, and 5 unrelated pairs. (b) A name-reversal manipulation: in the first half of each block, participants called pictures by their canonical names. In the second half, they called each picture by the name of the other picture in that block, creating a Stroop-like effect. Behavioral data were collected along with EEG data using a 128-channel system. We conducted behavioral analyses, traditional stimulus- and response-locked EEG analyses, a representational similarity analysis (RSA), and a set of ML-based analyses. The ML techniques have the advantage of using the entire data structure and timeline, without cherry-picking electrodes and temporal windows. Three classifiers (linear ridge, support vector machine, and decision tree) were trained to decode neural signatures of conflict within tasks. The best-performing classifier, evaluated using nested k-fold cross-validation, was selected for subsequent analyses. Additionally, we performed temporal generalization analyses to map the stability and generalization of neural patterns over time, as well as a leave-one-out cross-validation analysis to investigate across-participant generalizability. **Results.** Behaviorally, both manipulations created interference. Traditional EEG analyses and RSA showed stark differences between the neural states induced by contextual-similarity and name-reversal. Five sets of

analyses were conducted using the ML technique. The first two showed robust classification abilities within each task. The third set showed successful cross-classification of semantic and phonological similarity within the contextual-similarity manipulation. The fourth set showed successful classification of new participants’ data within each task. Finally, the fifth set showed no evidence of successful classification across the two manipulations. **Conclusions.** We found that conflict states are generalizable within tasks, and even to new participants in those tasks, showing the ML method’s power in detecting generalization when present in the neural data. However, the neural states induced by conflict in the two tasks were shown to be unequivocally distinct. This finding is compatible with theoretical models of inhibitory control that distinguish between conflict that can or cannot be resolved solely by stimulus-driven processing.

D5 - Involvement of the left angular gyrus and posterior superior temporal sulcus in semantic control

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Semantic control refers to the goal-oriented control of semantic representations. As such, it is both a subset of general cognitive control and a crucial component of the controlled semantic cognition (CSC) framework. Previous fMRI meta-analyses suggest the left inferior frontal gyrus (IFG), the left angular gyrus (AG), and left posterior lateral temporal cortex are crucial to semantic control. However, it is unclear whether activity in these regions reflects processes that rely on semantic representations or domain-general control rather than semantic control. Here, we investigated whether activation during semantic judgement correlated with semantic and non-semantic control performance measured in a semantic control task outside the scanner. Participants included 61 neurotypical adults (Age=61.5y (11.1); Gender=32F/29M; Education=17.4y (2.5)). All participants performed a semantic control task requiring rapid selection of targets from foils, where the target and foil objects were semantically related (S) or unrelated (U). In the no-switch conditions (S1, U1), the target remained same throughout the block. In the switch conditions, the target was switched in a repeated sequence of two (S2, U2) or three (S3, U3) stimuli. In this way, we expect the S3 condition to represent high semantic control demand, and U3 to represent high non-semantic control demand. Participants also completed an adaptive semantic decision fMRI task to measure activation during semantic judgement. Mean activation on this task was calculated for each participant in ROIs defined based on group-level activation and Spearman’s correlations related ROI activation with performance on the semantic control task. Linear regressions analyzing S1, S3, U1, and U3 conditions were conducted to assess all ROIs simultaneously as predictors, including age, education, and fMRI task performance as covariates of no interest. Spearman’s correlations showed significant relationships between activations and performance on the

semantic control task at the highest switching-demand level (S3) in the left IFG ($r(59)=0.35$, $p=0.026$), left pSTS ($r(59)=0.38$, $p=0.026$), left medial orbitofrontal region ($r(59)=0.32$, $p=0.033$), and left AG ($r(59)=0.32$, $p=0.033$). No correlations were significant for the S1, U3, or U1 conditions. Linear regressions showed activity in the AG significantly predicted both S1 ($\beta=0.038$, $p=0.035$) and S3 ($\beta=0.039$, $p=0.048$) performance. Furthermore, activity in the pSTS was a significant predictor of S3 performance ($\beta=0.073$, $p=0.0045$), while anterior temporal activation predicted S1 performance ($\beta=-0.080$, $p=0.035$) and medial orbitofrontal activation significantly predicted both U3 ($\beta=0.065$, $p=0.0092$) and S1 ($\beta=0.040$, $p=0.023$) performance. Our findings suggest the AG may be involved in semantic processing regardless of switching-demand, implying the AG's role in the CSC framework may be in semantic representation rather than in semantic control. Contrastingly, activity in the pSTS was not a significant predictor of performance on the S1 condition, suggesting this activity may be modulated by need for greater semantic control. Critically, activation in these ROIs did not predict U3 performance, suggesting their role is specific to semantic demands. Interestingly, we did not replicate previous evidence for the IFG's role in semantic control. Further work is necessary to analyze the subdivisions of the IFG and investigate whether they may differentially impact semantic control ability.

D6 - Producing code-switches: Adaptation of cognitive control in code-switching

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Background: The role of language context in modulating executive control during production remains underexplored. Prior work often used constrained tasks, e.g., picture naming [2], which lack sentence-level activation. To bridge this gap, our study employs a reading-aloud paradigm—a balance between naturalistic production and control—given evidence of shared phonological [3] and planning processes between reading and speech [4]. We investigate how dense code-switching during production influences executive control by using a conflict adaptation paradigm in which reading dense code-switching or unilingual Spanish sentences is mixed with a flanker task [5,6]. We specifically test two competing hypotheses. Hypothesis A predicts that dense code-switching allows for a free gateway between languages and requires less inhibition, leading to increased flanker interference relative to unilingual sentences [7]. Hypothesis B predicts that dense code-switching recruits inhibitory control, thereby reducing subsequent flanker conflict due to cross-task adaptation. **Method:** Early Spanish-English bilinguals ($n = 31$ after 2 were excluded because of proficiency) read aloud experimental sentences in two language contexts: unilingual Spanish and dense code-switching (Table 1). Each experimental sentence was followed immediately by a flanker task with congruent (<<<<<, >>>>>) or incongruent (<<<<<, >><>>) arrow arrays. Reading responses were recorded and annotated by trained bilingual coders. Trials were excluded if the audio was unclear, the participant made self-corrections, or the sentence did not contain the intended code-switching pattern. Trials with flanker response times <100 ms or >2000 ms and incorrect flanker responses were also excluded. Flanker RTs from remaining trials were analyzed using a linear mixed-effects model. The final model included flanker congruency, language

context, and their interaction as fixed effects, and a by-participant random intercept. **Results:** Of the 1488 recorded experimental trials, 1163 trials (78.1%) from 31 Spanish-English bilingual participants were retained after applying pre-registered exclusion criteria. A significant main effect of flanker congruency was observed: participants responded more slowly to incongruent ($M = 728$ ms) than congruent ($M = 602$ ms) trials, indicating successful replication of the standard flanker interference effect ($b = 0.310$, $SE = 0.018$, $t = 16.80$, $p < .001$). There was no main effect of language context ($b = -0.015$, $SE = 0.018$, $t = 0.83$, $p = .406$), nor a significant interaction between flanker condition and context ($b = -0.038$, $SE = 0.037$, $t = -1.02$, $p = .307$). Reading aloud sentences with dense code-switches did not significantly influence subsequent performance on the flanker task compared to reading unilingual Spanish sentences. **Discussion:** Although bilingual language production is theorized to recruit domain-general control [1], the current findings suggest that merely reading code-switched sentences aloud does not exert a measurable influence on flanker task performance over reading unilingual sentences, thus neither Hypothesis A nor Hypothesis B was born out. This null effect may reflect the controlled nature of the reading-aloud task, which lacks the planning demands of spontaneous speech. Alternatively, code-switching may have involved cognitive control, but this may not have carried over to the subsequent flanker trial due to the reading and Flanker tasks being very different in nature.

D7 - The Spoken Word: An adaptable model for science communication and lab outreach in the language sciences

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INTRODUCTION. As language scientists, how does our work percolate out to non-academic audiences? Here, we introduce The Spoken Word—a research magazine designed to make language research more accessible to non-scientists—and provide an adaptable model to improve our field's connection with a curious public. This publication began as a short newsletter in 2018 and has since grown into a full-fledged magazine published yearly in print and online. The articles transform language research—including basic research into the neurobiology of speech, language, and aphasia—into vibrant stories of hope, wonder, resilience, curiosity, and discovery intended for non-expert audiences. The motivations for this publication are two-fold. While we aim to create content that is broadly accessible, our primary audience are people with aphasia and their caregivers. Each issue has several foci: highlighting cutting-edge research on aphasia and 'how language works' to help our readers advocate for themselves in clinical settings and beyond and to show that engaging in language research leads to tangible and interesting discoveries that improve lives. Just as importantly, every article in The Spoken Word is written by undergraduate students invested in language science. Complex communication is a skill, and one that is essential for future academics, clinicians, and thinkers. Purposeful training in communication better prepares our students to engage their audiences with nuance and

compassion. The Spoken Word continues to grow as it finds new ways to serve our readers, giving the neurobiology of language the spotlight it deserves. **METHODS.** As part of our goals with our research digest, we have developed a science outreach model that makes our materials publicly available for other labs to create their own magazine, which is currently hosted on OSF. These materials include previous issues, a two-semester curriculum that provides week-by-week instruction and assignments that leads novice science communicators from start to a polished public-facing article, and example assignments. We recognize that labs, and individual scientists, often want to engage with public audiences about their work but often don't know where to start. This open-source model provides a beginner-friendly framework that labs can use to kick-start their own outreach efforts—one which we hope to share with SNL attendees. We have also solicited feedback from readers, via survey and interview, to better understand if our research magazine covers language science topics that our readers are interested in. From that feedback we have made several changes, including making audio recordings of each article available on Spotify and our lab website. **SIGNIFICANCE.** From basic science exploring the neurobiology of speech perception to evaluating clinical treatments for aphasia, communicating what we discover and how we discover it is an essential component to science. Amidst a growing anti-science culture, especially in the United States, scientists will need to invite the public to engage with science and be sure to listen to their questions and concerns. By increasing the ease of outreach, we can all work towards a society that values scientific insights writ large; including those made in the language sciences.

D8 - PyCREA: A Python Package for Neurobiologically Grounded Semantic Representations

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Semantic embedding spaces have been used to represent and quantify the meanings of words since the introduction of distributional linguistic models in the 1950s (Harris, 1954; Firth, 1962). Historically, these models have been based upon word co-occurrences and context to define the semantic content of a word. Modern NLP semantic embedding spaces (GloVe, Pennington et al., 2014; Word2Vec, Mikolov et al., 2013) have introduced more complicated analysis methods, but their creation of vectors is fundamentally limited to latent semantic analysis. These embedding spaces have been successful at representing the semantic content of words, but they have drawbacks in terms of explicit feature selection and linkage to neurobiological mechanisms. Finally, they efficiently represent linguistic semantics, but they don't necessarily represent the same semantic space as the brain (Tong et al., 2022). Due to these limitations, our group previously developed the CREA (Concept Representation as Experiential Attributes) framework (Binder et al., 2016). CREA is derived from human judgements of words based on 65 neurobiological ratings from 0-6 including sensory, motor, spatial, temporal, affective, social, and cognitive experiences. This framework addresses potential limitations of LSA-based embeddings, particularly their lack of interpretability and weak alignment with large-scale brain networks. In this work, we present a new tool for efficiently accessing and using these ratings: PyCREA, a Python package. This package currently contains a database of 960 word embeddings, and the

experimental scripts to acquire new embedding ratings. The library also contains functions to retrieve and compare vectors for selected words across all 65 dimensions or chose specific ratings for comparison. The package is currently available via Github (<https://github.com/WiredBrains-Lab/CREA-Vectors>) and installable via pip (<https://pypi.org/project/PyCREA/>). With the release of the PyCREA package, we hope to provide researchers with an additional resource to efficiently conduct studies using this neurobiologically grounded semantic model.

D9 Sandbox Series - Syntactic Network Analysis in Aphasia: Preliminary Findings from Narrative Discourse

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Persons with aphasia (PWA) typically produce speech that is less syntactically complex than neurotypical speakers. Although traditional discourse metrics (e.g., mean length of utterance, clausal density, verb-to-noun ratio) capture some aspects of syntactic ability, they often overlook higher-order structural properties of language. Emerging work has highlighted the utility of network science approaches in quantifying lexical-semantic organization in aphasia, but its application to syntax remains largely unexplored. This project models syntactic organization in aphasia using tools from network science. We explore the extent to which network metrics capture syntactic differences between aphasia subgroups (fluent vs nonfluent PWA). We also examine how method of network construction (dependency versus co-occurrence) impacts the sensitivity of these metrics in capturing syntactic deficits. 104 PWA described the picnic image from the Western Aphasia Battery-Revised (WAB-R). All PWA were adult monolingual English speakers with no reported history of acquired neurological conditions, other than left hemisphere stroke, and were at least 3 months post onset of stroke at time of testing. PWA were categorized as fluent (N = 55) or nonfluent (N = 49) based on WAB-R fluency subscores (nonfluent PWA ≤ 5 and fluent PWA > 5). Speech samples were transcribed and cleaned to exclude disfluencies (e.g., filled pauses, repetitions, self-corrections). For each group (fluent versus nonfluent PWA), we constructed two types of syntactic networks: dependency networks, where nodes represent lexical items and edges reflect syntactic dependency relations between items, and co-occurrence networks, where edges reflect linear adjacency between items. All networks were constructed using lemmatized forms to reduce redundancy. Preliminary results revealed that both co-occurrence and dependency network analyses captured hallmark reductions in lexical diversity (nodes) and syntactic connectivity (edges) in nonfluent PWA. Across network types, nonfluent PWA consistently exhibited higher modularity (co-occurrence: $M_{\text{nonfluent}} = 0.151$, $M_{\text{fluent}} = 0.142$; dependency: $M_{\text{nonfluent}} = 0.209$, $M_{\text{fluent}} = 0.201$) and average shortest path length (co-occurrence: $M_{\text{nonfluent}} = 2.62$, $M_{\text{fluent}} = 2.58$; dependency: $M_{\text{nonfluent}} = 2.73$, $M_{\text{fluent}} = 2.71$), indicating more segregated and less efficient syntactic structures. Fluent PWA demonstrated greater small-worldness (co-occurrence: $M_{\text{fluent}} = 29.07$, $M_{\text{nonfluent}} = 21.60$; dependency: $M_{\text{fluent}} = 10.79$, $M_{\text{nonfluent}} = 10.46$), reflecting better integration of local and global syntactic connections. Network type influenced

sensitivity to group differences. Co-occurrence networks revealed distinctions in clustering ($M_{\text{fluent}} = 0.46$, $M_{\text{nonfluent}} = 0.42$) and small-worldness ($M_{\text{fluent}} = 29.07$, $M_{\text{nonfluent}} = 21.60$), suggesting greater sensitivity to discourse-level disruptions. Dependency networks also captured similar group differences, though with smaller effects, except for an increase in clustering among nonfluent PWA ($M_{\text{nonfluent}} = 0.26$, $M_{\text{fluent}} = 0.24$), potentially reflecting reliance on repetitive, formulaic structures. These findings suggest that co-occurrence networks are more sensitive to discourse-level disruptions, while dependency networks may highlight core syntactic simplifications common in nonfluent aphasia. Ongoing work is expanding these analyses to include a larger sample of PWA as well as incorporating disfluencies into the networks to explore how disruptions in fluency impact network structure. Additionally, future analyses plan to examine individual-level syntactic networks to probe the relationship between network metrics, traditional measures of discourse, and standardized aphasia language assessments.

D10 Sandbox Series - Detecting Narrative Language Deficits in Aphasia Using Continuous EEG During Speech Production

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Background: Assessing narrative deficits in stroke-induced aphasia is a laborious and time-consuming process. Developing objective, efficient assessments for narrative speech in aphasia therefore remains a highly relevant objective. Recent studies have leveraged continuous electroencephalography (EEG) recordings during speech comprehension to assess the presence and severity of narrative deficits, but this has not been applied to speech production. Given that some persons with aphasia (PWA) may demonstrate impaired production, but preserved comprehension, or vice versa, determining the neurophysiological correlates of speech production in PWA is highly warranted. This study aims to (1) determine whether continuous EEG recordings during spontaneous speech production can detect the presence of aphasia, and (2) to evaluate whether behavioral narrative speech metrics correlate with neuroelectrical activity patterns in PWA. Specifically, we hypothesize that theta and delta band activity may be less powerful in PWA compared to controls, and may be related to narrative speech characteristics. **Methods:** Data collection is ongoing. Final samples will comprise a group of PWA exhibiting varying narrative speech deficits, and a group of age-matched neurotypical controls. Participants are first asked to sit with eyes closed, then with eyes open, for five minutes each, to establish resting-state EEG activity. They then take part in an expressive language task, including open questions (e.g., "Tell me about your stroke"), and a variety of widely used picture prompts (including pictures from the Western Aphasia Battery, Boston Diagnostic Aphasia Examination, and a Cinderella story). Participants must produce at least 10 minutes of speech to ensure sufficient data generation. During speech production, EEG signals are recorded using 64 scalp electrodes, and these continuous signals are assessed for oscillatory power in each of six activity bands identified in previous research (alpha, beta, low gamma, high gamma, delta, theta; ~1-100 Hz). Narrative quality metrics (mean length of utterances [MLU], words per minute [WPM] and correct information units [CIU]) are extracted from participants' language samples to compare complexity of

narratives to the strength of oscillations in each band. **Results:** Preliminary findings from two neurotypical controls highlight the roles of the Delta (1-4Hz) band: power in this band was significantly higher during speech production than during resting-state EEG ($F(5) = 3.273$, $p < .01$; Tukey's adjusted post-hoc, speech v. resting, $p < .001$). In addition, visual indications for differences in the theta (4-8Hz) and low gamma (30-70Hz) bands were present, though these were not statistically reliable with the current dataset. Given that both participants were neurotypical controls, no correlational analyses between measures of narrative ability and EEG power have been made thus far. **Preliminary Conclusions:** Continuous EEG detected differences between narrative and resting-state activity in neurotypical pilots, suggesting this method is sensitive to language production. While the delta band has been comparatively under-highlighted in behavioral and cognitive research, some previous literature has emphasized the role of this band in semantic tasks and inhibitory control. This paradigm is therefore highly promising for application to the assessment of speech and narrative deficits. Ongoing data collection including PWA and age-matched controls will elucidate this further.

D11 - Decreased functional connectivity to the pre-supplementary motor area underlying serial order memory impairment in a case of transcortical motor aphasia

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【Background and Objective】 The left pre-supplementary motor area (pre-SMA) contributes to the processing of sequential linguistic information (Cona, 2017) together with the regions involved in verbal working memory - the left opercular part of the inferior frontal gyrus (Broca's area) and the left supramarginal gyrus (the phonological loop), and the left middle frontal gyrus (the central executive). Disconnection between these regions may contribute to deficits in order memory, but the neural basis of such impairment remains unclear. In this study, we investigated functional connectivity in a patient with transcortical motor aphasia (TCMA) who exhibited order memory impairment following a lesion near the left pre-SMA. **【Participant】** The participant (female, 79, right-handed) developed aphasia following subarachnoid hemorrhage and subsequent cerebral infarction. On day 104 post-onset, T2-weighted MRI revealed a hyperintense lesion in the subcortical region of the left superior frontal gyrus. She was diagnosed with mild TCMA. Apraxia of speech was not present, but spontaneous speech was non-fluent, characterized by a reduced speech rate and shortened phrase length. Auditory comprehension and repetition abilities were largely preserved. In verbal working memory assessment, a selective impairment in order memory was observed: performance on an item recognition task was comparable to that of healthy controls, whereas performance on an order recognition task was significantly reduced. **【Functional connectivity analysis】** MRI data were acquired on 104th day post-onset using a 3-T MRI scanner (Galan; Toshiba). The fMRI data for resting state functional connectivity analysis were obtained with a GE-EPI

sequence (TR, 2500 ms; voxel size, 3.75 × 3.75 × 4 mm³; 20 slices covering the whole brain). A total of 120 scans were carried out. MRI images were preprocessed using CONN software as follows: 1) motion corrected, 2) spatially normalized into the MNI space, 3) spatially smoothed with 9-mm FWHM Gaussian kernel, and 4) temporally band-pass filtered (0.008 - 0.09 Hz). Regions of interest (ROIs) were set on the left pre-SMA (MNI coordinates: MNI-5 6 53), pars opercularis part of Broca's area (-54 6 18), left supramarginal gyrus (54, -39, 24), and the left middle frontal gyrus (-38, 44, 26). The correlation coefficients between ROIs were calculated and compared with data derived from healthy subjects database (NeuroSynth) (threshold < .20). **【Results】** The patient showed reduced functional connectivity between the left pre-SMA and any of the other ROIs. However, functional connectivity between the left IFG and the left supramarginal and middle frontal gyri was preserved. **【Discussion】** In contrast to the healthy cohort, where the left pre-SMA exhibits functional connectivity with the left IFG, supramarginal gyrus, and middle frontal gyrus, the patient displayed decreased connectivity between these areas. However, the functional connectivity normally observed between the left IFG and both the supramarginal and middle frontal gyri was preserved. The decrease of functional connectivity between the left pre-SMA and both the left IFG and the middle frontal gyrus suggests a potential neural basis for the patient's impaired order memory.

D12 - Shifting Activation in Subacute to Chronic Stroke Recovery: A Functional Near Infrared Spectroscopy Study.

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Introduction: Discourse comprehension deficits following left hemisphere (LH) or right hemisphere (RH) stroke can severely affect participation in everyday conversations. The right prefrontal cortex (PFC) and left superior temporal gyrus (STG) are critical structures employed in a non-lesioned brain during discourse comprehension (Morales et al., 2022), but how discourse comprehension recovery unfolds over time following LH versus RH stroke remains incompletely understood (Barbey et al., 2014). Evidence suggests that recovery of auditory comprehension in LH stroke is marked by an average shift in peak activation from contralesional to ipsilesional structures including the STG (Saur et al, 2010). This study used functional near infrared spectroscopy (fNIRS) to examine how lesion lateralization influences longitudinal changes in bilateral PFC and STG activation during discourse comprehension from subacute to chronic stroke stages. **Methods:** Individuals with LH and RH ischemic stroke completed discourse comprehension tasks that included three alternating blocks of ~1min stories from the Discourse Comprehension Test (Brookshire & Nicholas, 1993) at 3 months (subacute; LH N=19; RH N=5), 6 months (LH N=22, RH N=5) and 12 months (LH N= 19, RH N= 9). fNIRS data were acquired using a NIRSx NIRSport2 device with 16 sources and 16 detectors positioned over bilateral perisylvian regions, resulting in 46 long- and 8 short-distance channels. Raw fNIRS data were processed using standard processing

steps before using a general linear model to estimate oxygenated hemoglobin (HbO) using Homer3 software. Averaged changes in HbO in bilateral ROIs (PFC, STG) were analyzed for each stroke group (LH/RH) at subacute (3m) and chronic (6m,12m) time points. **Results:** A priori analysis consisted of one-sample t-tests and Wilcoxon signed-rank tests, based on Shapiro-Wilk normality assessments, to test whether mean HbO changes differed from zero across ROIs at each timepoint. RH participants showed significant activation in the right lateral PFC at 3 months, $t(4) = 2.44$, $p = .036$, $d = 1.09$. LH participants showed modest activation in the left STG at 6 months, $t(21) = 1.83$, $p = .041$, $d = 0.39$. All other comparisons were non-significant ($p > .05$). Due to low group-level power and stroke heterogeneity, Fisher-Freeman-Halton exact tests with Monte Carlo sampling (10,000 samples, 99% CI) were used for participant-level analysis. All tests were non-significant (Monte Carlo $p = 1.000$), including for LH strokes (left/right STG, left/right PFC) and RH strokes (left/right STG, left/right PFC) at all timepoints. Pearson chi-square and likelihood ratio tests also yielded non-significant results ($p > .14$), showing no consistent activation patterns over time within individuals. **Conclusions:** Contrary to the literature-based hypothesis, no consistent shift from contralesional to ipsilesional activation was observed across regions or timepoints. A key limitation of this preliminary study is that lesion size and location were not accounted for—an ongoing challenge in fNIRS research. These findings suggest that compensatory mechanisms may be highly individualized and depend on individual characteristics, such as lesion location and health of the contralesional hemisphere. Future studies will evaluate the distinct patterns of change in activation across individuals, and how these changes relate to accuracy of comprehension.

D13 - Language Network Brain Connectivity and Social Communication in Autism Spectrum Disorder

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Introduction: Autism spectrum disorder (ASD) is characterized by core challenges in social interaction and communication, often assessed using instruments such as the Social Responsiveness Scale (SRS)1. While language ability is an integral part of social communication, studies have not often addressed the relationship between the brain's language network functioning and social communication. Several previous studies have reported uncorrected or non-replicable correlations highlighting the need for stratified, network-specific approaches2. In this study, we leveraged data from the Autism Brain Imaging Data Exchange (ABIDE-I) repository to examine how the brain's functional connectivity within three core networks, Reading Network (RN), Language Network (LN), and Pragmatic Network (PN), affected either elevated (indicative of pronounced social-communication challenges) or diminished (indicative of fewer such challenges) SRS scores3. **Methods:** ABIDE I resting-state fMRI data from 704 participants were preprocessed using CPAC (Configurable Pipeline for the Analysis of Connectomes)4. Participants were grouped into two distinct subgroups: Cluster 1 (Low-SRS; $n = 180$ (23.68 ± 16.16) 147 M) and Cluster 2 (High-SRS; $n = 126$ (99.80 ± 23.87), 112 M)—via k-means clustering ($k = 2$). K-means clustering

algorithmically determined the cut-off between low and high SRS groups (approximately mid-way between clusters at an SRS score around 60–65), rather than relying on a predefined threshold, allowing an empirically-driven distinction between participants with mild versus pronounced social-communication challenges. For the ROI-ROI, functional connectivity (ROIs selected from the Harvard-Oxford Atlas) was computed using the CONN toolbox⁵ and results were thresholded at a connection-level significance of $p < 0.01$, with a cluster-level correction of $p < 0.05$. Results: Group-level comparisons revealed differences in functional connectivity across all three networks. In the RN, the High-SRS group [$F(4,696) = 5.95$, $p < .01$] exhibited stronger connectivity between the bilateral precentral gyrus and Supplementary Motor Area (SMA) in addition to bilateral occipitotemporal cortices (iLOC, to ITG). In both the LN [$F(4,696) = 8.13$, $p < .001$] and PN [$F(4,696) = 8.15$, $p < .001$], the High-SRS group showed stronger connectivity between frontal (IFGop, OFC, SFG, FP) and temporoparietal (pMTG, aMTG, TP, aSTG) areas. Furthermore, increased connectivity was also found in the LN for the IFGtri, AG, and pSTG regions. By contrast, the Low-SRS group showed no statistically significant connectivity within each network. Conclusion: This study provides novel evidence that differences in functional connectivity across core reading, language, and pragmatic networks may underlie the extent of social-communication difficulties in autism. Participants with higher (worse) SRS scores exhibited increased connectivity across a broader set of brain regions within these networks, potentially suggesting increased effort in processing pragmatic and socially nuanced information⁶ and compensatory recruitment during reading tasks with social demands⁷. In contrast, better SRS profiles aligned with more efficient, specialized network organization- possibly reflecting reduced social-cognitive load. These findings reveal how heterogeneity in sociability in ASD may be mirrored in the organization of social-linguistic brain systems. This also underscores the value of stratifying individuals by symptom severity. By linking specific social profiles to distinct neural patterns, the current findings underscore the need for subgroup-level inferences in neuroimaging research in autism.

D14 - Emotional regulation in individuals with developmental dyslexia.

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The ability to regulate emotion develops through the gradual growth of self-regulatory capacities during childhood. However, emotional regulation is refined through situational demands, interpersonal influences, and individuals' goals within a given context. For most children, improvements in emotional regulation contribute to greater well-being. In contrast, for children with developmental disorders, regulating emotion often involves challenging environments and competing goals (e.g., Do I make trouble and go to the principal's office or read in front of my classmates?). Further, as children mature into emerging adulthood, expectations for socially appropriate emotion management increase. Developmental dyslexia, a specific difficulty in reading despite adequate intelligence, motivation, and instruction, is characterized by impairments in phonological awareness, reading fluency, and spelling. Although much research has focused on the academic challenges associated

with dyslexia, its broader emotional consequences remain underexplored. Adolescents and emerging adults with dyslexia often experience not only academic difficulties but also heightened rates of depression, anxiety, low self-esteem, externalizing behaviors, and poor stress management. These findings highlight the need to understand emotional regulation in individuals with developmental dyslexia. Methods We examined executive functioning in 129 participants, 22 of whom (17.05%) self-reported a prior diagnosis of developmental dyslexia. Standardized reading measures from the TOWRE-II (Torgesen, 2012) and WRMT-IV (Woodcock, 2011) confirmed self-report. Executive functioning, including emotional regulation, was assessed using the Behavior Rating Inventory of Executive Functioning – Adult Version (BRIEF-A; Roth, 2005). The BRIEF-A consists of 75 behavior statements, with participants indicating whether each behavior had been never, sometimes, or often a problem over the past month. The measure yields nine composite scales of executive functioning: Inhibition, Shift, Emotional Control, Self-Monitoring, Initiate, Working Memory, Plan/Organize, Task Monitor, and Organization of Materials. Analyses were conducted in R version 4.4.2. Assumptions of normality and equality of variance were assessed via the Shapiro-Wilk and Levene's test, respectively. Independent samples t-tests were used to compare mean scores between individuals with and without developmental dyslexia. Results A comparison between individuals with and without developmental dyslexia across the nine BRIEF-A standardized scales revealed a significant difference only on the Emotional Regulation scale ($t_{126} = 2.18$, $p = .032$), with a medium effect size (Cohen's $d = 0.51$, 95% CI [0.05, 0.97]). Conclusion Our findings suggest that adolescents and emerging adults with developmental dyslexia experience challenges in emotional regulation, even when other aspects of executive function are comparable to their peers. While historically developmental dyslexia was studied primarily through the lens of academic performance and neurobiological dysfunction in brain regions associated with reading and language, it is increasingly evident that its impact extends beyond these domains. Despite its importance, emotional regulation remains an underexplored area in dyslexia research. A more comprehensive understanding of dyslexia that integrates cognitive and emotional challenges may guide the development of effective educational practices and interventions. Recognizing and supporting emotional regulation in those with dyslexia may promote not only academic achievement but also social and emotional well-being. By addressing emotional regulation alongside reading skills, educators may foster greater resilience and long-term success in those with developmental dyslexia.

D15 - The relation of the home literacy environment to white matter pathways associated with language in children 5-8 years old

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Phonological and semantic processing are two critical components of language comprehension. Behavioral studies indicate the home literacy environment (HLE) is associated with phonological awareness and vocabulary skills (Niklas & Schneider, 2013; Sénéchal & LeFevre, 2014). Studies have also found relations between the HLE and white matter pathways in

the brain for children in infancy, preschool, and kindergarten (Davison et al., 2023; Hutton et al., 2020; Turesky et al., 2022). Although prior work suggests relations between the HLE and white matter in younger children, studies have not yet examined the relation of the HLE to white matter pathways in older children. Additionally, the specific relations of the HLE to tracts associated with phonology (arcuate fasciculus [AF] and superior longitudinal fasciculus [SLF]) and semantics (inferior fronto-occipital fasciculus [IFOF] and inferior longitudinal fasciculus [ILF]) across development have not been investigated (Vanderauwera et al., 2018; Vandermosten et al., 2012; Yeatman et al., 2011). The present study examined the relation of shared reading to these white matter pathways in a group of children 5-6 years old ($N=79$, $\text{Mage}=5.9$, 48 females, 85% White) and a group of children 7-8 years old ($N=107$, $\text{Mage}=7.6$, 68 females, 82% White). Participants completed standardized assessments and diffusion-weighted imaging scans. A series of pre-registered node-wise regression analyses tested relations with parent-to-child reading. The tracts were divided into 100 nodes. For each age group, a mask of the top 30 nodes (with a cluster-wise threshold of 3 nodes) most associated with standardized scores of phonological awareness (in the AF and SLF) or semantic knowledge (in the IFOF and ILF) was made. Relations with shared reading were examined in the nodes defined by these masks, as well as across all 100 nodes of each tract. All analyses were controlled for age and socioeconomic status. Results suggest weak evidence ($p<0.05$ and a cluster-wise threshold of 3 nodes) for the relation of shared reading and fractional anisotropy in some of the 30 nodes most associated with semantics in the IFOF for the group of children 5-6 years old. These nodes were in one cluster toward the anterior portion of the tract (4 nodes, average $r=0.29$). These results build on the prior work in this age group which did not examine this tract. This work provides insight on the relation of environmental factors to white matter pathways associated with language at a key time in which children are learning to read. Books geared towards younger children may have more pictures than those geared towards older children and a portion of the IFOF is thought to be involved in picture-naming (Giampiccolo et al., 2025). Additionally, in a behavioral study on this age group, a randomized control trial found that following an intervention focused on teaching parents how to engage in dialogic reading and print referencing practices, children in the intervention group had significantly more of an increase in picture naming compared to children in the control group (Sim et al., 2014). Future research with more precise HLE measurements is needed to verify weak evidence.

D16 - How learning to read a second language reshapes children's visual and language cortices

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Learning to read, a cultural invention, has been shown to profoundly modify the brain (Dehaene et al., 2015). While previous studies have predominantly focused on first language (L1) literacy acquisition, it remains unclear how learning to read a second language (L2), typically acquired after mastering reading in the native language, reorganizes children's brain. To investigate how reading network for L2 emerge and interact with the existing L1 network at the earliest stage of L2 acquisition,

we measured children's neural responses to Chinese and English words (their native and second languages), as well as faces and houses, in three groups of children ($N = 58$) with varying levels of English learning experience: L2 pre-readers, L2 beginning readers, and L2 advanced readers. We first found that with increasing L2 experience, English-word-specific activation emerged in the left ventral visual area, and extended to the left inferior parietal lobule (IPL), precentral gyrus (PreCG), and supplementary motor area (SMA). This activation may be associated with the effortful demand in phonological processing in L2. The top 10% most-responsive voxels in the classic visual word form area also exhibited significantly stronger responses to English words in both beginning and advanced readers compared to pre-readers. Furthermore, we observed that the number of English-word-specific voxels in the left ventral visual area initially increased and then decreased with accumulating L2 experience. These voxels also gradually shifted away from the peak activation site for Chinese words. In the left IPL, the number of English-word-specific voxels gradually increased with accumulating L2 experience, and their average distance from the peak of the Chinese-word-specific cluster became farther. At the individual level, both the left ventral visual area and IPL showed upward trends in the number of English-word-specific voxels from pre-readers to beginning readers. However, from beginning to advanced readers, voxel count showed a downward trend in the left ventral visual area but continued an increase tendency in the left IPL, suggesting a trend of functional shift in L2 processing with growing experience. Representational similarity analysis indicated that only advanced readers had formed a stable neural representation for English words in the left ventral visual area, whereas such stable neural representation was absent in pre- and beginning readers. The left IPL showed a gradual stabilization of English word representations with increasing L2 exposure, despite the absence of significant group-level differences. Together, these findings provide a picture of how the visual and language-related cortical networks in children dynamically reorganize in response to L2 learning, demonstrating how neural plasticity supports bilingual literacy development.

D17 Sandbox Series - Tracking Brain Activity in Language Cortical Regions During Naturalistic Social Interaction in Early Childhood

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Background: In adults, language processing is typically left-lateralized, engaging three canonical regions of the cortex: the inferior frontal gyrus, middle temporal gyrus, and superior temporal gyrus. These regions appear to be established during childhood, though they continue to specialize throughout development into early adolescence. Children under the age of nine tend to exhibit reduced lateralization, with relatively greater right-hemisphere activation in temporal regions compared to adults. Most neuroimaging studies of language processing have focused on isolated components of phonology, semantics, or syntax. Yet, language is inherently social and typically unfolds in dynamic, interactive contexts. In real-life settings, individuals rarely process language in isolation or in response to brief artificial auditory stimuli. Instead, language comprehension

often occurs in rich, multimodal environments that demand the integration of linguistic and social information, and is typically followed by language production. Studies using more naturalistic stimuli, such as short stories or lullabies presented with visual supports, have reported more diffuse activation patterns across both hemispheres, including regions associated with language and social cognition. Our understanding of how the brains of children younger than seven process language remains limited, in part because this age group is significantly underrepresented in fMRI research. Functional near-infrared spectroscopy (fNIRS), a wearable, silent, and relatively movement-tolerant imaging method, has recently shown promise in addressing this gap by enabling the study of brain activity in more naturalistic, socially interactive contexts. **Aim:** The objective of the current study is to investigate how young typically developing children's brains process language during both comprehension and production in everyday situations. **Methods:** Brain responses to language will be examined across three increasingly naturalistic contexts: a movie-viewing task, a sentence repetition task, and dyadic conversations embedded within an experimenter-child play-based interaction. In the movie-viewing task, children are presented with a short story visually supported by a movie. In the sentence repetition task, the experimenter produces a short sentence and instructs the child to repeat it. During the play-based interaction, the experimenter and child engage in three different play activities (pretend play with figurines, Pop the Pig, and construction with magnetic tiles) while having a natural conversation. Within this interaction, we will identify and extract sequences of dyadic back-and-forth exchange (e.g., child-experimenter-child-experimenter or experimenter-child-experimenter-child turn-taking patterns) and analyze brain activity specifically during those conversational moments. Brain activity across all three contexts will be recorded using a portable, fibreless NIRx NIRSport2 system, equipped with 16 sources, 15 long-separation detectors, and 8 short-separation detectors. The optode layout is designed to bilaterally cover anterior and posterior cortical regions, specifically targeting the middle and inferior frontal gyri, the temporo-parietal junction, and parts of the superior temporal lobe. The source-detector distance is approximately 30mm. **Possible outcomes:** We expect to observe diffuse patterns of activation across both hemispheres, consistent with prior work using naturalistic stimuli. As task demands become more socially embedded and ecologically valid, we anticipate increased functional connectivity between anterior and posterior regions across the left and right hemispheres.

D18 - "Et tu, Whatsyourname?" Evidence that hippocampal atrophy underlies age-related difficulties at recalling people's names

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We have increasing difficulty recalling people's names as we get older. However, both the pattern of the declines and the reasons why they occur have remained unclear. Given the striking hippocampal atrophy in aging, and evidence implicating the hippocampus in recalling as well as learning associations, we hypothesized that hippocampal atrophy may contribute to age-

related declines at recalling proper names. Names learned later in life should be particularly susceptible to the hippocampal declines, given that knowledge learned in the hippocampus gradually undergoes 'systems consolidation' (the formation of direct connections between neocortical representations that were initially indirectly linked via the hippocampus), leading to a decreasing reliance on this structure with time. Specifically, names learned later in life — that is, with later ages-of-acquisition — should thus show particular recall declines because less time has passed since they were learned as compared to earlier-learned names, so they should depend more on the hippocampus. In a cross-sectional continuous-age design, we asked 126 native U.S. English speakers (ages 18-85) to name pictures of 90 famous people — specifically, 10 people who were especially famous in each of the nine decades from the 1930s to the 2010s (e.g., Amelia Earhart in the 1930s, Malcom X in the 1960s, Mike Pence in the 2010s). We predicted particular age-related declines in retrieving the names of people who were famous more recently (e.g., from the 2010s), since those names should generally have been acquired more recently, and thus should have later ages-of-acquisition. Age-of-acquisition estimates given by each subject for each name confirmed that names from later decades indeed had later ages-of-acquisition. We also segmented hippocampal and other gray matter volumes from whole brain and high-resolution hippocampal MRI scans. Unlike in previous studies, overall proper name recall did not decline with age. Instead, there was actually a positive effect of age on naming performance (accuracy increases, reaction-time decreases) for names from early decades (e.g., 1930s-1950s). However, this age effect became increasingly negative (accuracy decreases, reaction-time increases) for names from later decades (1990s-2010s). The results were robust, also holding when controlling for name frequency and for which names were known to individual participants. Preliminary mediation analyses suggest that the age-related performance declines found for later decades were mediated by atrophy of the hippocampus, but not by any of several control structures (entorhinal cortex, inferior frontal gyrus, middle temporal gyrus). In sum, the evidence suggests that as we get older, we do not seem to have more difficulty retrieving people's names that were learned earlier in life. Rather, age-related naming difficulties may be limited to names learned during (later) adulthood. Further, these naming declines appear to be driven by atrophy of the hippocampus. We discuss basic research and translational implications, including the possibility that therapeutic approaches that improve hippocampal function may alleviate naming difficulties in aging — and perhaps also in Alzheimer's disease, in which such difficulties are even more pronounced, and in which the hippocampus declines to an even greater extent.

D19 - Cerebellar Contribution in Learning-Related and Error-Related Activity during Artificial Grammar Learning

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During rule acquisition automation, the posterior cerebellum shows reduced learning-related activity, reflecting its plasticity (Balsters & Ramnani, 2011, J. Neurosci.). However, changes in

error-related cognitive activity remain less understood. In the cerebrum, the activation was suppressed by the automation of familiar syntactic knowledge but enhanced by repetition of unfamiliar knowledge (Weber et al., 2016, *J. Neurosci.*). As Crus I/II of the posterior lobe is associated with advanced cognitive processing, we examined if these regions support the learning- and error-related activities differently. In this study, we used longitudinal fMRI to investigate the cerebellum's role in artificial grammar learning. In accordance with Balsters and Ramnani (2011), we distinguished learning-related (i.e., correct processing) and error-related (i.e., incorrect processing) activities based on whether participants successfully applied an internal model of grammar knowledge. This study has two objectives: (1) To determine if Crus I/II were engaged in correct and incorrect processing differently, we compared these activities in the early and late stages and correlated activation differences with participants' reaction times (RT) to account for the individual differences. (2) To assess whether Crus I/II exhibit different plasticity in correct and incorrect processing, we compared changes in the two activities between stages and examined the interaction between activity type and stage. Seventeen Cantonese-speaking participants (mean age = 20.9, SD = 2.51) completed one fMRI session before (pre-fMRI) and one after training (post-fMRI), following the first behavioral learning session. Inside the scanner, participants judged the grammaticality of the sentence within 3.2 s. The pre- and post-fMRI sessions shared the same paradigms but used different stimuli. Behaviourally, participants demonstrated an overall improvement in grammar processing following training, with significantly higher d-prime scores in the post-fMRI than pre-fMRI, $t(16) = 4.69$, $p < .001$. However, there was no significant difference in RT, $t(16) = 0.89$, $p = .384$. Regarding the difference between correct vs. incorrect judgment, the bilateral Crus I/II activities were higher for correct than incorrect grammar judgment in both sessions (pre and post). However, while this contrast was not associated with RT in the pre-fMRI session, a significantly negative correlation was revealed in the left Crus I in the post-fMRI session. These findings suggested that while the bilateral Crus I/II were relatively disengaged in incorrect grammar judgment, the contrast between correct vs. incorrect judgment was especially prominent in the left Crus I for participants with rapid grammaticality judgment. Regarding plasticity (pre-post differences), the activity in bilateral Crus I/II decreased from early to late stage for correct judgment, which is consistent with Balsters and Ramnani (2011); however, no significant change was observed in incorrect judgment activity. There was no interaction effect between activity type and stage. Overall, these findings suggest that the Crus I/II play a greater role in learning-related activities during grammar processing, with potential hemispheric differences that link to individual differences. This research was supported by Faculty Reserve awarded to M.C.-M.F. by the Faculty of Humanities, HKPolyU, and a postgraduate studentship awarded to Z. L.

D20 - The 'what', 'how', and 'where' of statistical learning: A comprehensive synthesis and new neurocognitive theoretical framework

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During recent decades it has become clear that the ability to learn environmental regularities—known as statistical learning—is crucial for human language learning, as well as cognition more generally. Considerable advances have been made in this area of research, which is growing at a near-exponential rate. However, as pointed out in recent influential critiques, the field appears to be at a crossroads. In particular, there remain fundamental questions about just 'what' statistical learning is, 'how' it occurs, and 'where' in the brain it is implemented. Here we address these questions by adopting a framework inspired by Marr's (1982) classic levels of analysis, which broadly correspond to the questions of 'what' (the computational level), 'how' (the algorithmic level), and 'where' (the implementational—i.e., neurobiological—level). At the 'what' level, we suggest that statistical learning may be most usefully defined prototypically, as an umbrella term that encompasses a cluster of learning situations that tend to have certain characteristics, namely the learning of structured patterns, encountered over multiple exposures, under incidental conditions. We focus on three tasks that often meet these criteria: embedded pattern (e.g., word segmentation), artificial grammar, and serial reaction time tasks. At the 'how' level, we focus on two widely-studied learning algorithms: prediction-based learning and chunking. At the 'where' level, we focus on two well-studied learning and memory structures—the basal ganglia and medial temporal lobe—as well as neocortex. We comprehensively review and synthesize the cognitive and neural literature on statistical learning and then map the different levels to each other. We propose and show that statistical learning is supported by "many-to-many" mappings. Specifically, we suggest statistical learning can be carried out by different cognitive algorithms (both prediction-based learning and chunking) and different neural structures (in particular the basal ganglia and medial temporal lobe, but also certain neocortical regions), and moreover each structure can subserve more than one algorithm and task. Importantly, the relative reliance of statistical learning on particular algorithms and structures may be a function of a wide range of task, item, context, subject, and other factors. We suggest that this "many-to-many" viewpoint is a more advantageous way to think about statistical learning compared to perspectives that emphasize one algorithm or neural substrate over another. Finally, we discuss future directions. We emphasize that the cognitive algorithms and neural structures implicated in statistical learning are quite well-understood based on independent research from the broader study of the neurocognition of learning and memory. This independent knowledge generates a wide range of specific and often novel predictions that might not be made in the more circumscribed study of statistical learning alone. In sum, our framework has the potential to substantially advance the field of statistical learning by offering a clear account of the conditions under which statistical learning occurs and the cognitive and neural substrates that support it.

D21 - LEFT POSTERIOR CINGULATE CORTEX VOLUME REFLECTS INTERPERSONAL SCHIZOTYPY IN ATYPICALLY LATERALIZED INDIVIDUALS

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Atypical language lateralization, characterized by right-hemisphere dominance instead of the typical left-hemisphere specialization, has been associated with increased risk for neurodevelopmental and psychiatric disorders, such as autism and schizophrenia (Ocklenburg & Güntürkün 2024). However, it remains unclear whether this brain organization serves as a marker of vulnerability in clinically healthy individuals. In this study, we examined the relationship between atypical language lateralization and the presence of autistic and schizotypal traits in a non-clinical population, while also exploring grey matter volume differences in the brain associated with these traits. Structural MRI data were analyzed using SPM12 and the CAT12 toolbox (Gaser et al., 2024), based on harmonized datasets from 120 individuals with typical ($n = 60$; 34 women; Mean age = 23.75, SD = 4.49;) and atypical ($n = 60$; 30 women; Mean age = 25, SD = 6.36) language lateralization. Language lateralization was assessed through specific functional MRI tasks (verb generation), and autistic and schizotypal traits were measured using the Autism Spectrum Quotient (AQ) and the Schizotypal Personality Questionnaire (SPQ), respectively. The whole-brain voxel-based morphometry (VBM) was conducted to study brain regions showing differential associations between brain volume and questionnaire scores across groups. Multiple linear regression models revealed a statistically significant difference ($k = 1291$; $p = 0.036$, cluster-level corrected) in the association between volume in the left posterior cingulate cortex (LPCC) and scores on the SPQ_AAP subscale, which assesses items related to interpersonal emotional distancing. Post-hoc analyses revealed that individuals with atypical lateralization showed a positive relationship between volume in this region and SPQ_AAP scores ($r = 0.271$, $p = 0.036$). No significant relationships were observed in typical individuals and no significant group differences were found in the relationship between AQ scores and grey matter volume. These findings suggest that atypical language lateralization may be associated with structural alterations in brain regions involved in self-referential processing, emotional regulation, and social cognition. The results are consistent with previous research linking schizotypy—particularly its interpersonal dimension—to non-canonical patterns of lateralization (Villar-Rodríguez et al., 2024). In conclusion, this study provides evidence that differences in brain volume and language lateralization may be associated with specific subclinical traits of schizotypy, potentially serving as indicators of vulnerability in the general population. References: -Ocklenburg, S., & Güntürkün, O. (2024). *The lateralized brain: The neuroscience and evolution of hemispheric asymmetries* (2nd ed.). Elsevier. -Villar-Rodríguez, E., Cano-Melle, C., Marin-Marin, L., Parcet, M. A., & Avila, C. (2024). What happens to the inhibitory control functions of the right inferior frontal cortex when this area is dominant for language?. *Elife*, 12, RP86797. -Gaser, C., Dahnke, R., Thompson, P. M., Kurth, F., Luders, E., & Alzheimer's Disease Neuroimaging Initiative. (2024). CAT: a computational anatomy toolbox for the analysis of structural MRI data. *Gigascience*, 13, giae049.

D22 - Bilateral ventral pathways support phonological awareness at reading onset in Spanish-speaking children

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Learning to read is one of the most significant milestones in cognitive development. While the neural architecture of reading is well-documented in adults, the developmental pathways supporting reading acquisition remain poorly understood—especially in languages other than English. This study addresses this gap by investigating the cognitive and neuroanatomical foundations of early reading in monolingual Spanish-speaking children from Mexico. We assessed 61 children (ages 6 to 8 years; 41 early readers and 20 non-readers) using selected tasks from the Evaluación Neuropsicológica Infantil, a cognitive battery tailored for Latin American populations. Seven oral language tasks were administered: word repetition, non-word repetition, sentence repetition, picture naming, phonemic blending, and phoneme and word segmentation. Principal Component Analysis (PCA) revealed two components explaining 58% of the variability: a Phonological Awareness Component, with high loadings on phonemic blending, phoneme segmentation, and non-word repetition; and a General Verbal Skills Component, dominated by repetition and naming tasks. Early readers scored significantly higher than non-readers on both components (Phonological: $p < 0.001$; Verbal: $p = 0.02$), with a stronger effect in the Phonological Component (Phonological: $r = 0.72$; Verbal: $r = 0.27$). Diffusion-weighted MRI data were acquired from all participants, and probabilistic tractography was performed to reconstruct five bilateral white matter tracts associated with reading: the arcuate and superior longitudinal fasciculi (dorsal pathway) and the inferior longitudinal, fronto-occipital, and uncinate fasciculi (ventral pathway). PCA on tract-based dkiFA values revealed two components explaining 65.2% of the variability: a Bilateral Ventral Component with high loadings on bilateral inferior longitudinal, fronto-occipital, and uncinate fasciculi and a Bilateral Dorsal Component with predominant contributions from bilateral arcuate and superior longitudinal fasciculi. Cognitive-neuroanatomical associations revealed that the Phonological Cognitive Component positively correlated with the Ventral Anatomical Component ($r = 0.41$, FDR-corrected $p = 0.003$) and the Verbal Cognitive Component correlated with the Dorsal Anatomical Component ($r = 0.33$, FDR-corrected $p = 0.019$). Additionally, early readers exhibited significantly higher dkiFA values only in the Ventral Component (Ventral: $p = 0.003$, Dorsal Component: $p = 0.45$). To further explore this relationship, we conducted a mediation analysis including the Bilateral Ventral Component dkiFA as the independent variable, reading status (i.e., early reader or non-reader) as the dependent variable, and the Phonological Awareness Component score as the mediator. The direct effect (ADE) did not reach significance (ADE = 0.15, $p = 0.34$) suggesting that the relationship between reading status and white matter structure is completely mediated by phonological awareness. These results highlight a critical role of bilateral ventral white matter pathways in supporting early literacy development through phonological skills in Spanish-speaking children. This pattern may reflect the reduced reliance on lexical decoding in transparent orthographies. Furthermore, our findings challenge the prevailing assumption that phonological skills are exclusively supported by the left dorsal pathway.

Together, these findings underscore the developmental flexibility of the brain's reading network and provide compelling evidence that the neural mechanisms underlying reading acquisition are shaped by linguistic and educational context, rather than being universally fixed.

D23 Sandbox Series - Developing a Tactile Habituation Task for DeafBlind Children Using Wearable Haptics

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Congenitally DeafBlind children face profound barriers in early access to language and social interaction, often resulting in cascading negative effects on cognitive development (McInnes & Treffry, 2018). Because traditional methods for assessing perception and cognition typically rely on visual or auditory input, both for stimulus delivery and behavioral response (Noles, Danovitch, & Cashon, 2024), they remain largely inaccessible to this population during sensitive developmental windows. This project explores a fully tactile approach to investigating early perceptual and cognitive processes by pairing controlled haptic input with physiological measures. Our long-term goal is to develop a nonlinguistic habituation paradigm, delivered entirely through touch, that uses heart rate (HR) as the dependent measure to assess quantity perception and discrimination in DeafBlind children. Because gaze and reaching behaviors are not reliably accessible in this population, we instead rely on continuous HR data to track responses to tactile stimuli. As an initial step, we designed a wearable haptic device that delivers temporally structured vibration sequences and records HR through an integrated optical sensor. Critical to our process was the feedback from multiple DeafBlind protactile-using team members. We collaboratively worked to ensure the device's interface and functions could be fully operated by touch, incorporating their feedback to maximize usability and accessibility. To evaluate the feasibility of our paradigm, we conducted internal validity testing with eight hearing, sighted adults (5 male; 19-31y, M=25.3y) from our local network. We aimed to elicit periods of measurable focused attention in participants, indexed by changes in their HR. Participants received a pattern of vibrations through a wrist-based haptic wearable and were asked to identify the pattern. In total, five haptic profiles were presented to each individual in random order. In one version, participants (n=5) chose the pattern from a set of six tiles with patterns of dots and dashes (representing short/long vibrations, respectively). The three remaining participants reported the pattern using written dots and dashes. Accuracy was 100 percent; participants were attending to the task. HR data was continuously collected. Results show HR modulation at the onset of haptic sequences, indicating the paradigm elicits measurable autonomic responses. However, the direction (increasing vs. decreasing), magnitude (absolute values ranging from 2 to 20 bpm from baseline), and latency of HR response varied across individuals. This raises important questions about how to characterize responses for a task that depends on stimulus-specific processing and habituation as a trigger for subsequent trials. Our testing results support the potential of combining wearable haptics with physiological measures to investigate early cognitive processing through touch alone. By eliminating auditory, visual, and linguistic demands, this paradigm may enable the investigation of

cognitive capacities, such as quantity perception in DeafBlind children, that are typically inaccessible through conventional methods. This abstract is submitted to the Sandbox series to gather feedback on stimulus design, interpretation of HR as a dependent measure in habituation paradigms, and strategies for adapting this method for use with young DeafBlind children, including baseline-setting and trial triggering in a habituation framework.

D24 Sandbox Series - Measuring language anxiety in d/Deaf, DeafBlind, and hard of hearing communities

Christina Kim¹, Rachel Sortino¹, Taylor Delorme¹, Thalia Guettler¹, Katie McClyman¹, Rachel Baroway¹, Kaityln Marnien¹, Courtney Roberts¹, Laurel Aichler¹, Tiffany Bridgett¹, Onudeah Nicolarakis¹, Shilpa Hanumantha Lacy¹, Poorna Kushalnagar¹, Rachel Pizzie¹; ¹Gallaudet University

Language Anxiety is a negative emotional response related to using, expressing, or understanding language. It is a unique challenge to developing language skills and some people in linguistic minorities are at greater risk of developing it. For example, some members of American d/Deaf, DeafBlind, and Hard of Hearing (DDBHH) communities have adverse childhood communication experiences from decreased language access. Over time, chronic communication breakdowns with caregivers or other close social relationships can lead to learned negative associations with language. Many DDBHH Americans develop bilingual American Sign Language (ASL) and English language skills to navigate signing communities and the predominant hearing population. The goal of our research was to create a culturally sensitive measure of bilingual language anxiety across ASL and English for DDBHH people. Measuring bilingual language anxiety among DDBHH individuals is vital to understanding how negative emotions associated with both languages are related to challenges in developing bilingual language skills. Our team has developed a new ASL-English measure, the Language Anxiety Inventory (LAI), with extensive collaboration and feedback from DDBHH teammates and community members. DDBHH people shared their experiences with emotion and language through semi-structured interviews (N = 11). Items were developed from common patterns across interviews and refined from iterative feedback through cognitive interviews (N = 12) and focus groups (N = 22). The LAI questionnaire has 60 parallel items with ASL and English subscales in which participants rate their varying levels of anxiety. The LAI includes sections on early childhood experiences, current language experiences, and receptive and expressive language skills across both ASL and English. To explore the reliability and validity of the LAI as a measure of anxiety and negative experiences associated with ASL and English, we are conducting an online study with a final goal of N = 220 DDBHH participants. In addition to the LAI, participants answered a self-reported assessment on bilingual language background, assessing factors such as age of language acquisition for ASL and English. Participants also completed the Academic Anxiety Inventory and the PROMIS-Deaf to assess additional negative emotional experiences associated with academic environments and adverse childhood communication experiences. We will evaluate the psychometric properties of our newly developed LAI questionnaire. Using factor analysis, we will explore whether our questionnaire items represent two subscales for English and ASL. We will use an item-wise

principal components analysis to confirm how each questionnaire item is represented across components of variance within our DDBHH sample. We expect that each language subscale will have high internal consistency, which will be evaluated by calculating Cronbach's alpha within each subscale and the questionnaire overall. We also predict that the ASL and English subscales will represent relatively independent domains of anxiety and will have low intercorrelation. By establishing the LAI as a measure of bilingual language anxiety, future research directions will explore if language anxiety detracts from bilingual language proficiency in ASL and English. Our work characterizing language anxiety across bilingual languages will provide new insight into the relationship between emotion, language development, and communication in the DDBHH community.

D25 - Investigating sensitivity to binding constraints in L1 and L2 English using event-related potentials

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We investigate Mandarin Chinese-speaking learners of English's sensitivity to binding theory constraints (Chomsky, 1981) to address an ongoing debate over whether second language (L2) processing is guided by grammatical constraints similar to native speakers. Some studies have shown that target-like interpretation of L2 reflexives is possible for some learners despite L1/L2 differences (e.g., Jiang, 2009), but other studies have argued that L2 learners do not follow binding constraints initially during processing, but rather consider a discourse-prominent antecedent (Shallow Structure Hypothesis, Clahsen & Felser 2006; 2018; Felser et al., 2009; Felser & Cummings, 2012). This study used ERPs to address this debate by comparing the processing of reflexives and pronouns to examine if L2 learners adhere to binding constraints online. Twenty-five L1-Chinese L2-English learners and 26 L1-English speakers were asked to read 160 English sentences word by word in four conditions during an EEG experiment (Reflexives: (1a) Wendy thought that Adam trusted himself before the mistake. (1b) *Adam thought that Wendy trusted himself before the mistake. Pronouns: (2a) Adam thought that Wendy trusted him before the mistake. (2b) #Wendy thought that Adam trusted him before the mistake.), followed by comprehension questions. They also completed offline tasks examining sensitivity to binding constraints and the gender associated with the names in the experiment; these tasks showed target-like performance overall. ERPs time-locked to the onset of the reflexive/pronoun were analyzed between grammatical and violation conditions in 500-900ms (P600) and 500-1400ms (Nref) time-windows. If L2 learners exhibit native-like processing, they should show a P600 in (1b) compared to (1a) (e.g., Harris et al., 2000) and either a P600 or an Nref to (2b) compared to (2a) (Nieuwland, 2014). Note that Chinese permits long-distance binding for reflexives, and studies have shown that L1 Chinese speakers elicit a P600 when retrieving a long-distance antecedent compared to a local antecedent (Li & Zhou, 2010), or an Nref when evaluating multiple antecedents in the discourse (Zhang et al., 2021). Therefore, if L1 transfer effects are present, L2 learners would exhibit either a P600 or an Nref in reflexive condition (1b) compared to (1a), while demonstrating native-like processing for pronouns (P600 or Nref) in (2b) compared to (2a). However, under the Shallow Structure Hypothesis, L2 learners may prefer

discourse-prominent subject antecedents for both pronouns and reflexives, showing a P600 to (2b) compared to (2a), but a reverse effect for reflexives with (1a) (Wendy/himself) showing a P600 compared to (1b) (Adam/himself). Results revealed that L1 speakers elicited P600s in response to the violation conditions for both reflexives and pronouns. In contrast, L2 learners exhibited an Nref for reflexives and a P600 for pronouns. These patterns suggest that L2 learners distinguished between reflexives and pronouns during online processing, rather than relying only on discourse prominence and treating them similarly. The Nref for the reflexive conditions potentially reflects L1 transfer, as L2 learners may have considered both antecedent positions, as permitted in L1 Chinese. Our results provide ERP evidence that is more in line with L1 transfer accounts than the Shallow Structures Hypothesis.

D26 - A Longitudinal Comparison of Phonological and Morphological Awareness Development in Chinese-English Bilinguals and Monolinguals: The Influence of Literacy on Development

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Previous research has shown a strong interconnection between phonological awareness (PA), morphological awareness (MA), and literacy skills. However, early exposure to two languages can affect the dynamics among these linguistic abilities. While most studies have focused on using PA and MA as predictors to investigate the effect of bilingualism on literacy development in young bilingual children, relatively few studies explore how literacy proficiency may influence bilinguals' development of PA and MA. Building on these findings, the present longitudinal study aimed to investigate how distinct levels of literacy proficiency and early bilingual experience interact to shape the changes on the abilities of PA and MA in Chinese within a two-year interval, respectively. Forty-eight Chinese-English bilinguals and 32 Chinese monolinguals, aged 6–7 years (Mean age at Time 1 = 6.65 and 6.78 years, respectively), participated in the study. Both groups completed a battery of standardized language assessments and the phonology and morphology tasks in Chinese at two time points over a two-year period. The assessments included measures of phonology, morphology, vocabulary, and literacy. For the Chinese phonology and morphology tasks, children heard three spoken words and were asked to determine the relationship between words. In the phonological task, children were asked to identify the two words sharing the same onset sound (Sunday-subway-Monday), whereas in the morphological task, they were asked to identify the two words better matched on meaning (classroom-bedroom-mushroom). Additionally, development in PA and MA was assessed by the change in task accuracy between the first and second time points. Regression analyses were conducted to estimate the contributions of vocabulary and literacy to the development of PA and MA, using verbal vocabulary, character recognition, and character reading scores respectively at Time 1 as predictors of changes in accuracy in PA and MA over time. The same regression models were applied separately to bilingual and monolingual groups. Regression analyses revealed that among various vocabulary and literacy

assessments, character recognition – measured as a literacy skill – was a stronger predictor of growth in MA ($\beta = -0.018$, $p = .021$) than in PA ($\beta = .002$, $p = .070$) among Chinese monolinguals. No significant findings were observed among Chinese-English bilinguals. These findings suggest that the development of MA in monolinguals relies more on literacy skills relative to bilinguals. Furthermore, monolinguals' literacy proficiency at Time 1 was negatively correlated with the development of MA ($\beta = -0.018$, $p = .021$), suggesting that monolingual children with lower vocabulary proficiency at the early time point may show greater improvement in MA performance over time. In conclusion, the current study highlights the effect of bilingual experience on the association between literacy skills and the development of morphological awareness, suggesting that this relationship is stronger in Chinese monolinguals compared to Chinese-English bilinguals. Specifically, among Chinese monolinguals, those with lower initial vocabulary skills tend to demonstrate greater improvement over time.

D27 Sandbox Series - Pupil indices of arousal predict trial-level performance during Mandarin tone category learning

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Spontaneous fluctuations in pupil size are coupled with activity in the cingulo-opercular network including the anterior cingulate and anterior insula with stronger coupling predicting better task performance (Breedon et al., 2017). Elevated activity in the cingulo-opercular network predicts improved speech recognition performance in demanding listening contexts, suggesting involvement of this network in monitoring performance and making adaptive adjustments to optimize task behavior (Vaden et al., 2013). In this study, we examined the relationship between fluctuations in pupil size and non-native speech category learning performance at the trial level. In line with Adaptive Gain Theory (Aston-Jones & Cohen, 2005), we hypothesized that trial-level learning performance would be optimal at medium pupil sizes as smaller pupil sizes would be associated with task disengagement and larger pupil sizes would be associated with higher distraction. We trained 17 monolingual English listeners on four non-native Mandarin tonal categories. Participants completed six blocks of categorization training with two talkers with feedback (40 trials per block) and a generalization test with stimuli from two novel talkers and no feedback (40 trials total). We recorded monocular left pupil diameter using an Eyelink 1000+ Desktop Mount with chin and forehead stabilization. Participants were required to fixate for 500 ms before the stimulus was automatically triggered. We calculated the average pre-trial pupil size within the 500 ms immediately preceding the presentation of the speech sounds. For each participant, we grouped the pupil size data into small, medium, and large bins such that one third of all trials fell into each bin for each participant. We calculated bins separately for early (blocks 1-3) and late (blocks 4-6) phases to understand how pupil size measures may change during speech learning. Overall, participants successfully learned the speech categories and performance improved from the early ($M = 34\%$) to late ($M = 46\%$) phases. In line with our hypothesis, speech learning performance significantly differed across participant-defined pupil size bins ($F(2, 32) = 3.69$, $p = .036$, $\eta^2 = 0.013$). However, the specific pattern did not match our hypothesis –

large pupil sizes ($M = 37\%$) were associated with significantly worse performance than both small ($M = 42\%$) and medium ($M = 41\%$) pupil sizes, which were not different from one another. This pattern did not differ across blocks. Overall, we found that within-individual pupil sizes relate to second language speech learning outcomes at the trial level. These results indicate that pupil indices of high arousal (relatively large pupil sizes) may reflect a disengaged neural state in which the monitoring of performance and adaptive control in the cingulo-opercular network is downregulated, resulting in impaired trial-level performance. These results present new avenues for state-dependent learning interventions, such as delivering key learning information during phases of optimal neural engagement.

D28 Sandbox Series - Tracking Learning: Eye-Gaze and Pupillary Responses Reveal How Language and Cognitive Control Influences Visual Statistical Learning

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Statistical learning (SL) is a domain-general, implicit learning strategy that children employ to track statistical dependencies in their environments to learn language and understand the visual world (Fiser & Aslin, 2002; Saffran et al., 1996). Even though SL is thought to be established in infancy and remains stable, some work argues that access to sound is a determinant for SL since deaf children perform worse on SL tasks; this view is central to the auditory scaffolding hypothesis (Conway et al., 2009). Other results have shown that deaf children with native American Sign Language (ASL) experience do not show deficits in SL, providing evidence for the language scaffolding hypothesis (Hall et al., 2017). Eye-tracking, especially anticipatory eye-gaze, offers a promising way to examine this relationship. For example, Monroy et al. (2017) demonstrated that toddlers made predictive eye movements while viewing action sequences, reflecting learning of statistical dependencies. Yet, little is known about how a visual language like ASL might influence such behaviors. Another factor potentially impacting SL is cognitive control. Studies have reported mixed findings, with some showing a negative association between cognitive control and SL (Park et al., 2020) and others suggesting a supportive link (Smalle et al., 2022). Pupil dilation response (PDR), a physiological marker of cognitive effort, may help clarify the role of cognitive control in SL (Zhang et al., 2018). This work asks two questions: 1) How does language experience, such as ASL use, shape looking behaviors during SL? 2) What can the PDR reveal about the relationship between SL and cognitive control in deaf children? This study is part of a larger project investigating auditory and visual SL in deaf and hearing children aged 4–7. Children completed four tasks: a visual SL task, an auditory SL task, a cognitive control task, and a receptive vocabulary test. The present analysis will focus on two of these tasks. The novel visual SL task presented cartoon images in consistent triplet sequences and fixed screen locations. Participants then completed 24 2AFC test trials. Cognitive control was assessed using a child-friendly AX-CPT. We will measure anticipatory eye-gaze as a proportion of correct fixations to the correct location out of the six possible regions during the learning trials. For pupillometric data, we will calculate

the PDR as the percentage of pupil diameter change from baseline (Lavin et al., 2014). Data collection is ongoing. Preliminary results show that hearing children ($n = 70$, mean age = 6.03) scored 58% accuracy on the visual SL test, above chance (50%). Webcam-based eye-tracking data from 13 children revealed increasing anticipatory gazes over time ($r = 0.43$, $p < .05$). We predict: 1) Children with early native language experience, including ASL, will show more accurate and faster anticipatory gaze latencies in visual SL; 2) Cognitive effort during the AX-CPT, as shown by increased PDR to the A probe, will be related to decreased learning during SL; 3) ASL users will show a faster decrease in PDR during visual SL, reflecting more efficient processing of spatio-temporal information.

D29 - Increased activation of frontal native-language areas after second-language learning: A precision fMRI study

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Second-language learning causes widespread changes in functional brain activation. However, whether increased responses to a newly learned language are seen in the same brain areas that are functionally selective for the native language remains unknown: Prior work investigating the brain bases of second language acquisition has predominately relied on group averages that obscure variation in local functional organization across individuals. Recent advances in precision neuroimaging enable investigations of the functional organization of the language network in individuals (Fedorenko et al., 2024). Here, we apply a precision neuroimaging approach to the question of second language learning, asking whether areas that are preferentially responsive to a participant's native language also become responsive to second languages after learning. We recruited two groups of participants who completed different training paradigms: One group ($n=41$) underwent a four-day laboratory-based training to learn a miniature artificial language (MAL). The MAL differed from English in its lexicon, word order, and inflectional morphology for noun class and verb agreement. The second group ($n=30$) underwent a month-long classroom-based training to learn Mandarin Chinese. We scanned participants before and after training using a language-comprehension task, in which they matched sentences they heard with pictures. All participants completed this task in English and both foreign languages. Before training, the MAL and Mandarin conditions were meaningless to all participants, and accuracy in both was at chance (vs. 90% in English). After training, participants understood the new language they had learned (80% accuracy), but the untrained language remained meaningless (chance performance). We identified subject-specific fROIs within 13 probabilistic language areas based on a population-level atlas (Lipkin et al., 2022): left and right aSTG, pSTG, IFG pars opercularis, IFG pars triangularis, precentral gyrus; left supplementary motor area and superior frontal gyrus; and right cerebellum. Language-selective fROIs were defined independently in each run of the pre-training data by contrasting activation to English vs. the average of the two unknown languages. We used these fROIs to independently sample activation from each condition during the other pre-training run and both post-training runs. We investigated training-related activation differences between conditions and groups within

each fROI using linear mixed-effects models. We found that, after training, core nodes of the language network exhibited increased responses to the learned language, but not the unlearned language. Interestingly, these changes were limited to left frontal areas and cerebellum, but not right frontal homologues or left or right temporal areas. This might suggest an important role for left frontal regions in facilitating the development of high-level comprehension of a second language at early stages of proficiency. Temporal regions may not have shown significant learning effects due to high levels of mean activation within those fROIs for all conditions during both scanning sessions. In further analyses with these data, we will investigate whether there are changes in local activation patterns to trained vs. untrained languages within temporal regions using MVPA. We will also examine whether there are dissociable changes specific to learning a tonal language like Mandarin, or more grammatically-complex languages like the MAL.

D30 Sandbox Series - The development of lexical access and linguistic prediction: Adapting story-based EEG tasks to understand comprehension in preschoolers

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Introduction. Language comprehension involves rapidly retrieving the meaning of each word as a sentence unfolds. In adults, this process is facilitated by prediction, or the pre-activation of representations before they appear in the input (Kuperberg & Jaeger, 2016). This facilitation manifests as smaller N400s (an ERP index of lexical processing) to predictable relative to unpredictable words (Federmeier & Kutas, 2011). EEG research has begun using more ecologically-valid stimuli to assess lexical processing in naturalistic contexts with adults (e.g., Brennan et al., 2016) and school-aged children (Levari & Snedeker, 2024). Here, we extend these paradigms to preschoolers to better understand the development of lexical access. Only a few studies have used EEG to investigate sentence processing in this age range, and they assessed preschoolers' neural responses to overt violations. The present study uses a story listening EEG paradigm with three-year-olds to understand the role of various word features and contextual cues during lexical access. Specifically, we ask whether the N400 is correlated with word predictability during naturalistic listening. Method. Children listen to audio recordings of picture books while EEG is recorded. We analyze the N400 to each of the 1,477 content words across centro-parietal electrodes (Cz, C3/4, Pz, P3/4, Fc1/2, Cp1/2). Pilot data exhibited a longer lasting negativity than the canonical N400 time window, thus, we analyze two time windows: earlier (350–550 ms) and later (550–850 ms). The current sample includes 12 three-year-old children (M age = 3.6, intended $n = 35$). We measured word predictability using a word-by-word cloze task, and collected frequency (SUBTLEXUS) and local semantic association (word2vec of each word with the prior content word) values. We control for phonological neighborhood density, concreteness, acoustic length, word position, and effects of immediately surrounding words. Preliminary results. We used linear mixed effects models to assess which word and contextual features best predict the N400 in each of our two time windows. In the first window we find significant effects of Frequency ($b = 0.4$, $SE = 0.17$, $t = 2.3$, $p < 0.05$) and Local Semantic Association ($b = 0.41$, $SE = 0.19$,

$t = 2.21$, $p < 0.05$). In the later window we find significant effects of Cloze ($b = 0.43$, $SE = 0.16$, $t = 2.66$, $p < 0.01$) and Local Semantic Association ($b = 0.43$, $SE = 0.17$, $t = 2.45$, $p < 0.05$). Thus, cloze significantly predicts the amplitude of the N400, in line with adult data patterns, but the effects of frequency and semantic association remain, in contrast to adult findings. Summary. These preliminary results suggest that lexical access is sensitive to word predictability as early as age three. This indicates that preschoolers are already engaging in lexical prediction during online language comprehension. In contrast to findings with older children and adults, we also find effects of local semantic association and frequency on the N400 to words in a rich context. Lexical access appears to therefore be driven by both top-down contextual features and bottom-up word features at early stages of language acquisition.

D31 - Comparing tDCS montages and their effects on speech motor learning

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Introduction. Learning new sound sequences like non-native consonant clusters is a difficult task at both the phonological and motor levels. Previous evidence from our lab suggests that applying tDCS over the motor cortex (M1) enhances learning 2 days after training (Buchwald et al., 2019). Here we expanded on these findings by investigating the interplay between stimulation conditions and aspects of speech sound learning. Specifically, we compared stimulation of a region involved in speech motor coordination (C5 in the 10-20 system) with a region involved in phonological processing (IFG, F5 in the 10-20 system) when paired with a speech motor learning task. We further probed the relationship between stimulation condition by manipulating tDCS polarity. **Method.** 76 unimpaired native English speakers completed a 2-day protocol. Participants were randomly assigned to one of the five groups: Motor-Anode (anode:C5, cathode:Fp2), Phonological-Anode (anode:F5, cathode:Fp2), Motor-Cathode (cathode:C5, anode:Fp2), Phonological-Cathode (cathode:F5, anode:Fp2), and a Sham group. All active stimulation groups received 1mA current using a 1x1 Soterix tDCS device for 20 minutes. Sham current ramped up to 1mA over 30sec and then back down. tDCS was paired with the practice session of a speech motor learning paradigm that targeted eight non-native onset consonant clusters (/gd/, /pt/, /fm/, /fn/, /vm/, /vn/, /zg/, /zb/). After a short pre-practice session with feedback, participants performed a practice session (~28 minutes) where they were presented with both auditory and orthographic models and asked to produce them as accurately as possible. Approximately half of the practice session occurred during stimulation (e.g., starting ~6-7 minutes after stimulation) and half after stimulation. Learning was evaluated based on changes seen at Retention 1 (R1; ~30 minutes after practice) and Retention 2 (R2; 2 days later). We measured cluster accuracy with acoustically-informed transcription (Buchwald & Cheng, 2023) as well as more fine-grained acoustic measures (burst-to-burst duration in stop-stop clusters). We used mixed-effects models (logistic for accuracy, linear for acoustic measures) with group*session interaction and random-intercepts for word and participant to evaluate change. **Results and Discussion.** All groups significantly improved cluster

production accuracy from baseline to R(etention)1 and R2 (all $ps > .01$). The improvement for the Motor-Anode group at R2 was ~2% greater than other groups but the interactions were not significant. For cluster duration, only sham, Motor-Anode and Phonological-Cathode groups showed significant decreases in duration reflecting a more cluster-like production (all $ps > .01$). This indicates that the conditions that down-regulate motor regions (Motor-Cathode) and up-regulate phonological regions did not exhibit changes associated with clusters. The Motor-Anode group decreases more than all other groups at R1 (all $ps > .01$), and more than the Motor-Cathode and Phonological-Anode group at R2 ($p > .05$). Taken together, these results suggest that measures of accuracy and of consonant cluster timing may tap into different aspects of cluster learning. All stimulation groups improve in accuracy but not in timing. Further, upregulating the motor cortex during training supports all aspects of learning, and particularly along the timing dimension where it leads to significant improvement over sham or down-regulation of the motor region.

D32 - Intact engagement of speech production regions during implicit linguistic learning in autistic adults

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Background: Autism spectrum disorder (ASD) is a neurodevelopmental disorder characterized by social, cognitive, and communicative challenges, with many individuals also showing motor abnormalities (Maffei et al., 2024). A recent review on oromotor deficits in autism (Maffei et al., 2023) found strong correlations between speech motor and language development in autism. This was partially supported by fMRI findings in autistic children with impaired phonological skills. These children exhibited atypical engagement of the speech production network during a nonword repetition task (O'Brien et al., 2023). The current fMRI study focuses on the role of the speech production network during an artificial language learning task. Our prior research suggests a strong relationship between artificial language learning abilities and natural language learning skills in autistic individuals (Hu et al., 2024). We expect typical engagement of these brain regions in autistic individuals who achieved typical-like language skills. **Methods:** 30 neurotypical adults (NT) and 19 autistic adults (ASD) participated in this study. We identified thirteen subject-specific speech production functional regions of interest (fROIs) from a speech production localizer task (Picture Naming > Picture Viewing; O'Brien, 2025) using the group-constrained subject-specific (GCSS) method (Fedorenko et al., 2010). We examined how these fROIs were activated during the artificial language learning task across two conditions: Structured (i.e., sequences including embedded triplet patterns) and Random (i.e., sequences with randomly ordered syllables). A subset of participants (ASD = 14; NT = 25) also completed a similar artificial language learning task outside the scanner. Participants were asked to detect a target syllable when listening to a continuous stream of syllables with embedded triplets. They subsequently completed a two-alternative forced-choice (2AFC) task for their recognition of the triplets. **Results:**

In both groups, we saw an overall effect of condition (NT: $p < .0001$; ASD: $p < .05$) with no group by condition interaction, confirming an intact engagement of the speech production network in autistic individuals. Both groups also showed similar regions sensitive to embedded linguistic patterns: left STG (NT: $p = .0209$; ASD: $p = .0145$), right planum temporale (NT: $p = .0015$; ASD: $p = .0065$), and right STG (NT: $p < .0001$; ASD: $p = .0075$). The right prefrontal cortex is engaged during statistical learning only for the NT group ($p = .0418$). Compared to NT, the ASD group showed reduced activation across both conditions in the right prefrontal cortex ($p = .045$) and left STG ($p = .0096$). There was no three-way interaction between group, condition, and parcel. In participants who completed the out-of-scanner learning task, we observed similar above-chance 2AFC performance between groups but a steeper learning slope in response time during familiarization in ASD than TD ($p = 0.01$). Conclusion: The convergence of behavioral and neural evidence suggests that the speech production system is similarly engaged in linguistic statistical learning in autistic and neurotypical adults, reflecting overlapping mechanisms. Future research will examine whether the engagement of the speech production network during learning varies with individuals' language skills and learning outcomes.

D33 - Spatiotemporal signature of morphosyntactic planning in English sentence production

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Fluent sentence production relies on the precise and timely coordination of content and structure building prior to motor execution, with morphosyntactic planning playing a critical role in this process. While previous research has explored the neural mechanisms underlying morphosyntactic planning using various neuroimaging methods, identifying key brain regions (e.g., Broca's area, posterior temporal lobe) and the neural timing before word production, the spatiotemporal dynamics of sub-processes of morphosyntactic planning within sentence production remain underexplored. This study addresses this gap by examining the locations and times of brain activity using MEG during sentence production, with a focus on delineating the subcomponents of sentence planning, namely lexical access, inflectional processes (which differ for nouns and verbs), and constituent assembly that lead to successful utterance production. In a novel overt picture naming paradigm, participants saw object or action pictures along with an icon that elicited one of the subcomponent sentence processes: lexical access, inflectional marking (plurals for objects, tense for actions), and constituent assembly (adjective + object or pronoun + action). This approach allows us to decompose different elements of sentence planning. In each trial, participants first viewed a fixation cross for 1000 ms, followed by an object or action picture for 400 ms, and then another fixation cross for 400 ms. Next, an icon was presented for 400 ms, immediately followed by an image serving as a speaking prompt, which cued participants to produce the utterance. Based on data from twenty native English-speaking right-handed neurotypical adults, our results (generated from volume source space vector-valued dipole currents using Hotelling's T-Square statistics and threshold-free cluster enhancement correction for multiple comparisons) revealed the following: 1)

Inflectional suffix and constituent assembly differ in activation time and strength compared to lexical access: Compared to the lexical access condition ("tree"), both the inflectional suffix condition ("trees") and the constituent assembly condition ("a blue tree") engaged the inferior frontal gyrus (IFG) around 400 ms after icon onset. Additionally, the inflectional suffix condition ("trees") showed prolonged activation compared to constituent assembly, while constituent assembly ("a blue tree") showed stronger left hemisphere activation around 400 ms than the inflectional suffix condition. 2) The combination of tense, inflectional suffix, and constituent assembly engages additional frontal regions: Compared to the lexical access condition ("cook"), the tense + constituent assembly condition ("she will cook") engaged the IFG at around 400 ms after icon onset and again at around 550 ms. The tense + inflectional suffix + constituent assembly condition ("she cooked") engaged additional frontal regions at around 800 ms post-icon onset, suggesting a higher cognitive load prior to speech initiation when more subcomponents need to be planned. In sum, we observed distinct spatiotemporal signatures associated with different subcomponents of sentence production, characterized by: 1) Differences in activation timing and strength for inflectional suffix and constituent assembly, separately. 2) Different timing of IFG region engagement when tense is involved. 3) Additional anterior/superior frontal region engagement prior to speech onset time when tense is involved.

D34 - Hominid Dominion via a Neocortical Quadrupling: The Neuronal Stepping Stones of Language

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HOMINID DOMINION: The quadrupling of chimpanzee neocortex (in hominids) is as powerful as it is mysterious. Each billion-neurons added had to confer immediate adaptive advantage: extra-bulbous heads and metabolic profligacy would not cut it on the African savannah. But we know scant details of language evolution: neither the how nor the why of our tremendous increase in cognitive capacity. The world of knowledge that humans can easily acquire today dwarfs chimp cognition: animals write no dictionaries. While language and writing are humanity's defining features, we have direct access only to the surface structure of human cognition: sentences. This linguistic capacity, however, is but a thin veneer that distracts from the opaque mystery of where thoughts (and eventually sentences) truly come from. LEVO: Language evolution most likely began early in the quadrupling and thereafter tracked the increasing skills and dominance of savannah hominids (Bickerton and Szathmari, 2011). We previously sketched a set of neuronal circuits needed to progress from proto-words to fully modern language/FML (O'Malley and Xue, 2025). This Neuro-Generative Grammar deploys: a linguistic-symbolic layer (elaborated by the arcuate fasciculus), Tag-Sequence Read-Out machinery, an expanded working-memory dedicated to symbolic sequences, Pattern Recognition Machinery (for morphosyntax), a Syntactic Translation System (STS; to translate semantic constructs into sentences) and Language-Chunk Assembly Circuits (for long-distance dependencies and such; part of STS). Roughly 15 billion neurons were added providing new neural territory within which to duplicate ancestral sequencing and pattern-recognition modules which could then be adapted in service of sentence production, sentence comprehension and the STS. Despite the

quantity of new neural machinery required to traverse the proto-words to FML divide, language is just the tip of our Cognitive Iceberg. COGVO: Herein Cognitive Evolution refers to the new cognitive machinery required for the progression of hominid cooperation, coordination and technology—beginning 2.5 million years ago with power scavenging and the Oldowan Industry. Words, in this context, are ultra-compact designators of rich semantic worlds. “Tool” is just an arbitrary pattern of three phonemes but one could write for hours about tools of every sort (stone, carpenters, scientific, auto-mechanics and so on). Similarly, the sentence “Choose the right tool” could be part of myriad semantic situations. We suggest that linguistic complexity might be a 20-dimensional or 50-dimensional space, in terms of the numbers of distinct syntactic constructs, arrangements and major rules needed (for morphosyntax, inflection, schemas and such). In contrast, semantic items operate in a 500-D or 1000-D semantic space, via the connectivities between semantic auto-associative networks. Some high-dimensional notions, lurking within our sub-conscious information processors, can be difficult to put into words. CO-EVOLUTION: We posit an early accrual of neuronal circuits that ultimately led to a massive semantic-constructive capability: it is impossible to teach theology to dogs or thermodynamics to chimps. Advanced thought-machinery required a co-evolving linguistic capacity aka our Language-Learning Organ (LLO). While our genetically-encoded LLO does not encode specific syntactic rules, it does constitute a Universal Grammar—a set of universal neuronal circuits that allows all hominids (and only hominids) to create and learn languages.

D35 Sandbox Series - Neural correlates of Apraxia of Speech and their functions in speech production: Evidence from Primary Progressive Aphasia (PPA)

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INTRODUCTION Theories of word production posit multiple levels of representation and processing. Speech motor planning is a critical process in speech production taking place after phonological/phonetic encoding and before speech motor execution. Apraxia of speech (AOS) is a disorder that affects speech motor planning that typically co-occurs with aphasia (higher-level language disorder) and dysarthria (motor execution disorder). However, there is no consensus regarding the neural substrates specifically underlying speech motor planning. While post-stroke AOS has been associated with lesions to left precentral gyrus (PrCG) (Basilakos et al, 2015, 2018; Takakura et al., 2019), AOS caused by neurodegeneration was associated with left premotor cortex and supplemental motor cortex (Utianski et al., 2018; Cordella et al., 2019). In addition, the specific processes involved in speech motor planning are often underspecified. In this study, we investigate AOS in Primary Progressive Aphasia (PPA, a neurodegenerative language disorder), a less studied population, to evaluate if the diffuse damage profiles can provide additional insights regarding speech planning processes. We aim to answer the following questions: 1) Which brain areas are uniquely associated with AOS? 2) What speech functions are supported by the identified brain areas? **METHODS** Participants were 34 right-handed individuals with PPA (12 logopenic, 12 nonfluent, 7 semantic, 3 mixed/unclassifiable; 19 females, mean

age = 66.8 years, SD = 7.46). Spoken production was assessed with spoken picture naming (Boston Naming Test, BNT) and single-word repetition (Apraxia Battery for Adults, subtest 2, ABA2). A certified, experienced speech-language pathologist (SLP) rated each PPA participant on the severity of 1) expressive language impairment, 2) AOS and 3) dysarthria, using audio recordings of the two tasks and connected speech. **Analysis 1:** Whole-brain voxel-based morphometry (VBM) on the T1-weighted images using FSL-VBM (Douaud et al., 2007) was conducted to identify voxels significantly correlated ($p < .05$) with each of the three SLP ratings, controlling for the other two. **Analysis 2:** Multiple linear regression analysis was conducted to test if each cluster of significant voxels accounted for unique variance in the SLP ratings of AOS. **Analysis 3 (ongoing):** Ongoing analyses attempt to identify the speech functions supported by each of the brain areas identified in Analysis 2. First, logistic mixed-effects regressions will identify, for each participant, the characteristics of the spoken words (e.g., phoneme length, lexical frequency, neighborhood density, phonological complexity) associated with accuracy in each behavioral task. Second, multiple linear regression will be used to evaluate if any of the characteristics are uniquely associated with specific brain areas. **PRELIMINARY RESULTS** **Analysis 1:** Expressive aphasia was significantly associated with bilateral, left-lateralized regions within the temporal lobes, and AOS was the left PrCG, postcentral gyrus (PoCG), angular gyrus (AG), and supramarginal gyrus (SMG). No voxels were associated with dysarthria ratings, likely due to small number of participants with dysarthria. **Analysis 2:** The sensorimotor PrCG/PoCG cluster ($p = 0.006$) and the parietal AG/SMG cluster ($p = 0.003$) both accounted for unique variance in AOS ratings, indicating that multiple processes contribute to speech motor planning.

D36 - Does Bilingual Experience affect Cortical Thickness in ADHD?

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Objective: Attention Deficit Hyperactivity Disorder (ADHD) is a prevalent neurodevelopmental disorder characterized by inattentive, hyperactive or impulsive symptoms and attributed to dysfunction of the cortico-striato-thalamo-cortical-loop (Barkley et al., 2006). Some studies have found less cortical thickness (CT) in children with ADHD (Silk et al. 2016; Shaw et al., 2006; Narr et al., 2009) in prefrontal, parietal, and occipital cortices, but others have not (Ambrosino et al., 2017; Wolosin et al., 2009; Bernanke et al., 2022; Sarabin et al., 2023; Baboli et al., 2022; Owens et al., 2021, with the four latter reports based on ABCD Study data). In a separate line of research, CT has been shown to differ in bilinguals (Pliatsikas et al., 2020; Vaughn et al., 2021, the latter report based on ABCD Study data). Given the purported modification of executive control in bilinguals (Bialystok et al., 2009), it is important to investigate the potential modulating role of bilingualism on CT in ADHD. Here we tested whether there is an interactive effect of ADHD and an early dual-language experience on CT. **Methods:** We selected children from the Adolescent Brain & Cognitive Development (ABCD) Study based on a standard score of around >70 on Matrix Reasoning and Picture Vocabulary tests. ADHD Group inclusion criteria was >65 on the Child Behavioral Checklist (CBCL)

Attention Syndrome Scale and Control Group < 65. Demographic surveys (Youth Acculturation Survey and Parent Demographics Survey) were used to select cultural early Spanish-English bilinguals and native English monolinguals. Next, propensity matching was used to equate all four groups on socioeconomic status (combined income), Matrix Reasoning, and Picture Vocabulary scores and resulted in 59 Bilingual ADHD, 56 Bilingual Control, 53 Monolingual ADHD, and 59 Monolingual Control participants (average age 9.9 years). Structural magnetic resonance images underwent surface-based morphometry in the CAT12 toolbox of SPM12 and a 2x2 ANOVA (with sex, study site, age, CBCL Anxiety/Depression Syndrome Scale, medication, as covariates of no interest) to test for the main effects of Diagnostic Group, Language Background, and their interactions (voxel-wise height threshold $p < .005$ uncorrected, cluster-level extent threshold $p < .05$ FDR). Results: There was no main effect of Diagnostic Group nor an interaction for Diagnostic Group and Language Background. The main effect of Language Background revealed less CT in bilinguals in left superior frontal, middle frontal, inferior frontal, middle frontal and middle occipital gyri, superior temporal pole, and supplementary motor area; and in the right middle frontal, postcentral, inferior temporal, middle temporal, and middle occipital gyri, precuneus, superior temporal pole and supplementary motor area. Conclusion: Our main effects results were as expected based on prior studies of ADHD and of bilingualism (in the ABCD data set): No CT differences in ADHD relative to Controls, while Bilinguals had less CT than Monolinguals throughout the frontal, temporal and occipital lobes of both hemispheres (including areas associated with executive control). Importantly, there was no differential effect for an early dual-language experience on CT in ADHD.

D37 - Bilingualism and Executive Control as continuous-multifaceted constructs: insights from younger and older Basque-Spanish bilinguals

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Despite extensive research, the relationship between bilingualism and executive control (EC) remains contested. A central assumption behind proposed bilingual advantages is that managing two co-activated languages—through selection, switching, and inhibition—enhances domain-general EC. While some studies report bilingual benefits, particularly in children and older adults, others fail to replicate such effects, producing inconsistent findings across tasks, populations, and methods. These inconsistencies may reflect both theoretical and methodological limitations, including a shift in how the cognitive effects of bilingualism are conceptualized—from early accounts based on domain-general transfer to more recent adaptive frameworks emphasizing experience-driven changes in control systems. This study aims to clarify the bilingualism–EC relationship by treating both constructs as continuous and multifaceted. We investigate whether age of acquisition (AoA), proficiency, language use, and frequency of language switch modulate performance across three EC functions—shifting, inhibition, and updating—in a uniform population of Basque-Spanish bilinguals. We tested 124 younger (YA; Mage=21.31, 18–35) and 98 older bilinguals

(OA; Mage=65.63, 60–79) spanning a continuum of AoA, proficiency, language use and frequency of language switch in Basque. Bilingualism was assessed using a combination of self-reports and objective measures (naming, lexical decision and Basque knowledge test for proficiency; voluntary switching task for frequency of language switch). We controlled for fluid intelligence (Raven-2) and screened OA's cognitive health (MMSE-37). Participants completed six tasks, each with verbal and non-verbal versions, targeting shifting (Verbal Fluency [VF]; Trail Making Test [TMT]), inhibition (Stroop; Flanker), and updating (Keep Track; N-back). The VF task included fixed- and alternating-category blocks, the Flanker included high/low monitoring blocks, and the Keep Track and N-back tasks followed a graded-difficulty approach (2–4 words; 2/3-back). We analyzed YA and OA together using mixed-effects regression models, including Raven's scores as a covariate. Consistent with prior research, OA exhibited slower RTs and reduced accuracy relative to YA, particularly under high cognitive demands. Interestingly, OA showed reduced Flanker conflict effects and matched YA performance in demanding conditions of Keep Track and VF. As for the role of the bilingual dimensions, in shifting, higher proficiency reduced interference in TMT ($p=.023$), and earlier AoA increased switching in VF ($p=.009$). In inhibition, Stroop effects were attenuated by frequent language use ($p=.0013$), and in Flanker, later AoA predicted greater conflict effects ($p=.003$), which increased under low-monitoring demands, while OA showed stronger conflict adaptation ($p<.001$). In updating, switching improved performance under low load in Keep Track ($p=.009$). In N-back, accuracy declined with load ($p<.001$), especially for targets ($p<.001$), and in YA the interaction of higher fluid intelligence and integrated language use enhanced performance ($p=.004$). Fluid intelligence also predicted TMT performance in OA ($p=.010$) and accuracy in Keep Track ($p=.008$). These findings show that bilingualism modulates EC in domain-specific ways, with different bilingual dimensions influencing performance across tasks and age groups. Notably, OA showed comparable performance to YA in demanding updating conditions and reduced conflict effects in inhibition. In these cases, fluid intelligence predicted OA performance, suggesting a potential compensatory reliance on domain-general cognitive resources, which may reflect a form of cognitive reserve shaped by lifelong bilingual experience, helping to sustain executive functioning in older age.

D38 - Bilingual adult neural processing of syntactically ambiguous sentences

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Language is full of ambiguity, from word-level (e.g., 'play' can be a verb or a noun) to sentence-level (e.g., "the man saw the woman with binoculars" can have two meanings, depending on who has the binoculars). When we hear an ambiguous sentence and unintentionally get the wrong meaning, it requires that we revise our interpretation. That revision is cognitively demanding and requires a great deal of cognitive resources. All speakers must deal with this ambiguity, but on top of this, bilinguals must also deal with potential cross-language interference due to parallel activation of both languages. This has led to the proposal that bilingual brains are adapted to handle conflict

more efficiently than monolingual brains. We test this proposal by having Hawaiian-English bilingual children (ages 5-10) and adults perform two syntactic ambiguity resolution tasks while in an MRI. In the action verification task, participants listen to a garden-path sentence, watch a character act out the sentence on the screen, then indicate if the action matches the sentence. In the picture selection task, participants select one of two illustrations that best matches a sentence containing a global prepositional phrase ambiguity. We also collect structural and diffusion weighted images to address the following broad goals: 1) are the brain networks that bilingual children and adults recruit different, and possibly less widespread, than monolinguals, and 2) do bilinguals show differences in white matter connectivity and gray matter volume in the conflict resolution network. This same project was presented at last year's meeting as part of the Sandbox Series and we now have adult data to present some results. In adults, we expected to find that conflict resolution areas, like LIFG and pre-SMA, are more active in the ambiguous compared to the unambiguous and filler conditions in both tasks, and this is what we find. Further, in the action verification task, we find that control regions are activated more following the disambiguating word compared to before, suggesting that adults use revision to reach their final interpretation of the sentence. In the picture selection task, we find a slightly different network of control regions activated in the ambiguous condition, suggesting that the global prepositional phrase ambiguity targets a different conflict resolution mechanism than garden-path sentence revision. We also find that the bilingual adults, while demonstrating no difference in behavioral responses, engage the conflict resolution network in a different way than the monolingual adults. Our finding that adult Hawaiian-English bilinguals engage control mechanisms in the brain to a different degree than monolinguals is consistent with a body of literature that demonstrates the same thing using speakers Italian, Dutch, English, and German. It also addresses our goal of broadening the scope of Hawaiian language research beyond pedagogical and grassroots movements to encourage families and educators to commit to speaking Hawaiian with their children to promote a bilingual Hawai'i.

D39 Sandbox Series - Does structural neural connectivity mediate the relationship between bilingual exposure and language/executive function outcomes in young children? A DTI study

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Extensive research finds that specific features of children's early language environments (e.g., number of adult words, conversational turns, etc.) strongly relate to their later language and cognitive outcomes (Hart & Risley, 1995; Weisleder & Fernald, 2013). There are also studies finding associations between monolingual children's language environments and functional activation in temporal and prefrontal cortical regions, thus, relating early language exposure to brain regions supporting children's language and executive functioning (EF) development (Garcia-Sierra et al., 2016; Romeo et al., 2018a). However, there is limited evidence on functional as well as structural connectivity in young bilingual children who are exposed to two and/or more languages. Given critical role of early language environments in shaping the neuroanatomy of key white matter tracts (e.g., superior longitudinal fasciculus

(SLF)/arcuate fasciculus (AF)) in monolinguals (Romeo et al., 2018b; Skeide et al., 2016), it is important to examine how early bilingual environments affect the microstructure of white matter tracts connecting the main language- and EF-related cortical regions. This study aims to examine how early bilingual experiences, independent of socioeconomic status (SES), relate to the microstructure of the SLF/AF. Specifically, we hypothesize that (1) SLF/AF might act as critical neuroanatomical mechanisms (mediation analysis) by which children's bilingual environments shape their language and EF skills. Furthermore, we hypothesize that (2) there might be specific regions of both SLF and AF that show microstructural differences (sub-tract analysis) in how they relate to early language development in bilingual children. Lastly, given the evidence on bilinguals' bilateral hemispheric recruitment of neuronal resources in language-based tasks as opposed to left-lateralized brain activation in monolinguals (Hull & Vaid, 2007), we will also conduct (3) exploratory analysis examining whether the structural architecture of SLF/AF in bilinguals is left-lateralized or hemispherically balanced (laterality analysis). Participants are n=47 4-6-year-old children from diverse SES, racial/ethnic, and linguistic backgrounds with usable DTI and LENA data. From the total sample (n=47), 25 children were categorized as bilingual based on their caregivers' responses to the LSBQ (Luk & Bialystok, 2013). Their LENA data were annotated for whether it contained only English, only non-English language(s), both English and non-English languages, or no speech. Thus, we derived a continuous measure of bilingualism such that 0 indicated equal amounts of English and non-English (balanced bilingual), and 1 indicated either fully English or fully non-English (monolingual). Upcoming DTI data analyses: data will be preprocessed using the robust QSIprep 0.12.1 pipeline (Cieslak et al., 2021). Hypotheses #1 and #2 will be tested using the Automated Fiber-Tract Quantification (AFQ; Yeatman et al., 2012; 2018). Lateralization (hypothesis #3) will be examined by creating an average fractional anisotropy index across bilateral SLF and AF, and, subsequently, estimating the leftward asymmetry of activation in SLF/AF correspondingly. This will be first, known to us, study examining how early bilingualism shapes the neuroanatomy of language-supporting white matter tracts in SES-, racial/ethnically-, and linguistically diverse children as young as 4-6 years old. The findings will deepen our understanding of white matter development during critical period of early childhood in bilingual children.

D40 - Resting-state electroencephalography and event-related potentials to lexical tone processing in bilingual Mandarin-English children

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Resting-state brain activity has long been used as an index of brain development in both neuroscience and clinical research. However, it remains unclear whether early individual differences in resting brain activity have meaningful predictive value for brain functions related to language experience. In this study, we employed a multi-deviant oddball paradigm and recorded event-related potentials using a 65-channel EEG system from Mandarin-English bilingual adults and children aged 5 to 10. The auditory stimuli consisted of bisyllabic nonwords, with the tone

of the first syllable set as either Tone 1 or Tone 2 in the deviant conditions, and Tone 3 in the standard condition. EEG data were collected from 17 adults and 35 children, with the child participants divided into two age groups: 18 children aged 5 to 7 and 17 children aged 8 to 10. We calculated theta power during the resting-state condition as well as from responses to the standard and deviant stimuli. In addition, we measured P1 amplitudes from the source-reconstructed waveforms. Correlational analyses revealed a significant relationship between resting-state theta power and theta power observed during speech processing. Furthermore, the P1 amplitudes from the source waveforms showed clear developmental changes and hemispheric differences. These findings offer new insights into the neural networks supporting speech development and suggest that resting brain activity may be meaningfully linked to language-related brain functions in early childhood.

D41 - A Computational Approach to How Bilinguals Reconcile Cross-Linguistic Categorization

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To categorize the world around us, we use labels that aid memory, recognition, and generalization. While some concepts have clear boundaries, others are more ambiguous, resulting in different category boundaries across languages—even for direct cross-linguistic translations. Bilinguals need to reconcile cross-linguistic differences in categorization, but how this process is carried out remains unknown. In this study, we investigated whether bilingual individuals have separate conceptual systems for each language—categorizing objects similarly to monolingual speakers of each language—or whether they develop a single, unified conceptual system whereby concepts are categorized along the same boundaries regardless of the language being used. 24 English monolinguals, 24 Mandarin monolinguals, and 25 Mandarin-English bilinguals performed a two-alternative forced choice (2AFC) task and were asked to categorize objects that gradually transitioned from one concept (e.g., bowl) to another (e.g., plate). Our results showed that even for concepts that had different monolingual boundaries, bilinguals categorized objects identically across languages and did not map their responses to each language's categorization rule. These findings confirmed that although categorization differs across languages for the two monolingual groups, it remains unified for bilinguals irrespective of the language used. Interestingly, the unified bilingual boundary did not reflect an even bidirectional influence of both languages. Theoretically, this could be due to several sociolinguistic factors, including Age of Acquisition, Proficiency, and Exposure in each language. Given the multilayered nature of the bilingual experience, these parameters are hard to control for (or parametrically vary) in longitudinal developmental studies. For this reason, we created a cognitively plausible deep-learning neural network model that was trained to perform the same 2AFC task and that could be used to characterize the influence of Language Exposure in a bilingual's conceptual space. Specifically, this neural network model was based on feature-based cognitive theories of categorization—which break down objects into their defining features—and learned to take in an image and predict its label. To simulate a bilingual with greater exposure to one language over the other we manipulated the ratio of Mandarin to English training examples across three conditions: Mandarin-dominant

(90%–10%), English-dominant (10%–90%), and balanced (50%–50%). Our model successfully replicated the behavioral results by converging on a single, blended category boundary as the optimal solution when guided by cognitively plausible constraints. Crucially, balanced language exposure led to a bilingual category boundary that lay exactly midway between the monolingual boundaries while unbalanced exposure biased the categorization boundary toward the dominant language. This demonstrated that although bilinguals rely on a single conceptual boundary across languages, where this boundary lies is causally shaped by Exposure. Taken together, our behavioral and computational results demonstrate that bilinguals flexibly navigate cross-linguistic category conflicts by developing a shared, yet dynamic, conceptual space across languages that is systematically influenced by exposure to each language.

D42 - How do artificial neural networks (ANNs) respond to audiovisual illusions such as the McGurk effect?

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Humans perceive speech by integrating auditory information from the talker's voice with visual information from the talker's face. Incongruent speech provides a useful experimental technique for probing multisensory integration. For instance, in the McGurk effect, an auditory "ba" paired with a visual "ga" (AbaVga) produces the illusory percept of "da". Recently, artificial neural networks (ANNs) have made remarkable progress in reproducing human abilities and may provide a useful model for human audiovisual speech perception. This raises the question of how ANNs respond to incongruent audiovisual speech such as McGurk stimuli. To answer this question, we presented McGurk and control (congruent) stimuli to human observers and the ANN Audiovisual Hidden-unit BERT (AVHuBERT), developed by Meta Corporation. Twenty different McGurk stimuli were tested, all consisting of the same "ga" video paired with a different "ba" recording (all from the same female talker). A three-alternative forced-choice design with response choices of "ba", "ga" and "da" was used for both human observers and AVHuBERT. To generalize to other incongruent stimuli, a less frequently used stimulus (recorded by four different female speakers) that contains auditory "ba" and visual "fa" (AbaVfa) was also tested in a two-alternative forced-choice setting between "ba" and "fa". Across human observers, substantial variability has been observed but AVHuBERT is deterministic. Therefore, to model individual differences in human perception, we constructed variants of AVHuBERT by adding Gaussian noise to the units in linear out-projection layers in the transformer encoder blocks of the model. Across twenty AVHuBERT variants, performance was high for congruent audiovisual speech (mean of 94%). For McGurk stimuli (AbaVga), human observers reported the McGurk percept of "da" on 33% of trials. For AVHuBERT variants, the McGurk response of "da" was reported on 32% of trials, similar to the rate found for human observers. In the AbaVfa experiment, "fa" was identified in 83% of the predictions from the same twenty AVHuBERT variants, compared to 76% of "fa" reported by human observers. We then conducted two Kolmogorov-Smirnov tests with the McGurk and "fa" responses respectively to distinguish the model variants from human observers as

different subjects. The test failed to separate the AVHuBERT variants from humans based on their performance, suggesting that the weight perturbation with Gaussian noise effectively created human-like perceptual variability in the deterministic AVHuBERT. The similar response of ANNs and human observers to incongruent speech stimuli suggests that ANNs may be a useful tool for interrogating the perceptual and neural mechanisms of human audiovisual speech perception.

D43 - Reconfiguration of “resting-state networks” during movie watching

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Introduction: Previous work suggests that naturalistic language processing, such as with movie viewing, induces changes in functional connectivity compared to resting-state fMRI. Here, we compared the whole-brain functional connectivity (FC) of three left hemisphere regions commonly used as seeds to identify resting-state networks during movie watching vs. task-free scanning. These regions included pars opercularis (language network; LAN), precuneus (default mode network; DMN), and DLPFC (executive control network; ECN). **Methods:** Data were obtained from the publicly available repository collected by the Cambridge Centre for Ageing Neuroscience (Cam-CAN). Participants (n=118) were included if they were right-handed (EHI>40), obtained the maximum possible score on cognitive screening, and had at least 5 minutes of usable data for both rest and movie (Alfred Hitchcock's “Bang! You're Dead” condense to 8 minutes). Data were preprocessed using the established Cam-CAN pipeline followed by analysis using AFNI/FSL. For both movie and rest, residual time series were obtained by regressing motion parameters and WM/CSF signal, then band-pass filtering (0.01-0.1 Hz). We extracted the eigenvariate time series from each ROI (identified using the Brainnetome atlas) and performed whole brain correlations across all other brain regions in the atlas (n=274), converting to z-scores to permit inter-subject comparison. We used three t-tests to identify significant FC differences for each region during movie vs. rest, including covariates (age, sex, education, handedness, duration of usable data) and applying FWE multiple comparison correction (3dClusterSim, voxelwise p=0.001, corrected p=0.01). **Results:** Visual inspection of resting-state functional connectivity confirmed that each of the three seed regions effectively identified the targeted network. During movie watching vs. rest, the pars opercularis seed (LAN) demonstrated significantly increased FC with a number of bilateral regions consistent with the DMN, including medial prefrontal cortices, precuneus/posterior cingulate, angular gyri with adjacent SMG. Greater FC was also observed for bilateral subgenual anterior cingulate, thalamus, cerebellum, and posterior ITG (L>R). The precuneus seed (DMN) demonstrated increased FC with a variety of bilateral sensorimotor regions (putamen, ventral precentral/postcentral gyri, anterior insula). Greater FC was also noted for language regions, including bilateral STG/STS/MTG (extending from IPL/TPJ nearly to the temporal poles; L>R) and left pars opercularis, along with vision-associated cortices in the bilateral occipital lobes and left anterior ITG. The DLPFC seed (ECN) yielded the most extensive increases in FC during movie watching, particularly in bilateral visual regions throughout the occipital lobes (including MT+) and fusiform gyri into the mid-ITG. Other regions with

greater FC included orbitofrontal cortex, DLPFC and inferior frontal sulcus, anterior/posterior MTG, IPL and intraparietal sulcus, precuneus/posterior cingulate, thalamus, and cerebellum. **Conclusions:** Although participants were not engaged in any active task requiring response, the rich visual, auditory, affective, and semantic experience of movie viewing prompted significant shifts in FC compared to rest. Some of these contrasts were suggestive of coupling with different networks, such as the pars opercularis with DMN, precuneus with LAN, and DLPFC with visual and dorsal attention networks. These findings indicate that so-called “resting-state networks” reconfigure dynamically based on context, suggesting investigations into the neurobiology of language be grounded in naturalistic tasks.

D44 - Auditory experiences impact semantic processing

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Prior studies indicate that visual imagery ability interacts with semantic processing. However, similar studies considering auditory imagery are rare, as are studies focusing on auditory expertise (such as musical ability). Here we look at the relationship between individual differences in auditory imagery and musical experience along with the ability to comprehend novel and conventional sound-related metaphors, as well as sound-word associations. Participants (N=76; age 18-40; 51=Female) completed online surveys, including the Bucknell Auditory Imagery Scale (BAIS) and the Frequency of Musical Perception subscale from the Music-Related Quality of Life questionnaire (MuRQoL). Participants also completed a novel word-association scale, where they had to rate along a 7-point Likert scale the perceived loudness of single words in isolation (e.g., “banana”, “stomp”, “love”). Finally, participants completed a multiple-choice questionnaire where they had to mark the meaning of novel and conventional sound-related metaphors, as well as control (color-related) metaphors. Statistical relationships were determined using Pearson correlation coefficients and student t-tests. Overall, associations from emotion-words (Mean=5.76±1.02) were perceived as significantly louder than associations from color-words (Mean=2.83±0.92, p<.001); and these same emotion-word responses were not significantly different from commonly loud sound-related words (e.g., “roar”, “thunder”; p=.56). As predicted, the perceived loudness of sound-related words was also influenced by individual differences in auditory imagery, as indicated by a significant positive correlation with Vividness scores from the BAIS. Specifically, individuals with more vivid auditory imagery were also more likely to report louder sound-related word-associations (r(74)=.34, p=.003). Further, there was a significant positive correlation between the accurate assessment of novel sound-related metaphors and individual differences in the vividness of auditory imagery. Specifically, individuals with more vivid auditory imagery were increasingly accurate with sound-related novel metaphors (r(74)=.26, p=.02), but not sound-related conventional metaphors. Similarly,

Musical Perception Frequency scores yielded a significant positive correlation with novel sound-related metaphor accuracy ($r(74)=.26$, $p=.02$), but not conventional sound-related metaphors ($p=.39$). These data indicate that individual differences in auditory imagery and auditory expertise (musical perception) impact one's ability to process both novel auditory metaphors and individual sound-word associations. These data are consistent with the view that one's sensory experiences (both lived and imagined) impact language processing. We are currently collecting data from hearing impaired and musician populations to better understand the effects of experience on semantic processing. Going forward, this behavioral paradigm may aid in the identification of cross-modal neural correlates involved in processing sound-related language, by providing salient stimuli for future MRI and EEG studies.

D45 Sandbox Series - Characterizing relationships between musical rhythm discrimination, prosody (speech rhythm), and speech-in-noise perception in older adults

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INTRODUCTION: Speech-in-noise (SIN) recognition, critical for functional independence, is commonly impaired in older adults, often coinciding with age-related hearing loss (ARHL). Despite growing behavioral (Coffey et al., 2017), epidemiological (Johnson et al., 2023) and genetic (Nayak et al., 2025) evidence linking musicality to hearing and speech outcomes, there is limited empirical data on how individual differences in music perception abilities relate to hearing in older adults. Furthermore, while musical and speech rhythm perception are implicated in auditory processing, their relative contributions to SIN recognition in older adults are underexplored. This study thus seeks to investigate whether individual differences in musical rhythm and speech rhythm perceptual sensitivity explain variability in SIN recognition among older adults, and evaluates their respective predictive roles. **METHODS:** Participants are adults ≥ 65 years with self-reported normal hearing ($N=28$ completed to date) who are taking part in the Musicality, Hearing, and Genetics (MyHearinG) study at Vanderbilt University Medical Center. Key assessments include speech-in-noise (SIN) recognition (Tamati et al., 2014), musical rhythm discrimination (Swedish Musical Discrimination Test; Ullén et al., 2014), speech rhythm/prosody perception (TOPsy; Nayak et al., 2022), peripheral hearing tests, and questionnaires (demographics, musicality). For this presentation, we will focus on preliminary data on musical rhythm perception, speech rhythm (prosody) perception, and speech recognition in noise abilities, accounting for demographic covariates and music training. **ANALYSIS PLAN AND HYPOTHESES:** First, to investigate whether musical rhythm sensitivity, speech rhythm sensitivity, and hearing in noise abilities are correlated in older adults, we will conduct bivariate correlations between these variables. Next, to examine whether individual differences in musical rhythm perception skills explain variability in hearing in noise abilities over and above covariates, we will conduct linear regression analyses with rhythmic discrimination ability as the predictor and SIN recognition ability as the outcome. To further

investigate whether speech rhythm sensitivity mediates the relationship between musical rhythm perception and hearing abilities, we will conduct mediation analyses expanding the model to include speech rhythm sensitivity as the mediator. All statistical models will include covariates to control for their potential effects: age, sex, and music training (years of formal instruction). We hypothesize that musical rhythm perception is a significant predictor of SIN recognition, with speech rhythm sensitivity mediating this relationship. **SIGNIFICANCE:** Findings will help address knowledge gaps related to improving speech recognition and comprehension in challenging listening environments; problems that can lead to social isolation, loneliness, and lower quality of life in older adults. Investigating differences between music and speech rhythm perception as they pertain to hearing abilities can inform future research on the nuanced roles of rhythmic processing and central auditory abilities in aging populations, potentially identifying promotive factors for better hearing outcomes. Future directions also include examining the relative contribution of cognitive individual differences (e.g. in verbal and non-verbal cognition or executive function skills), and whether patterns in older adults' hearing and speech outcomes differ at different levels of music engagement.

D46 - The perceptual chunking of French ambiguous sentences by native speakers and Chinese L2 learners: A demonstration using ERP

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Prosodic phrasing cues, characterized by pitch variations, final lengthening and pauses at sentence boundaries, play a crucial role in speech perception and disambiguation. Across languages, acoustic cues are utilized differently to indicate prosodic boundaries. The main inquiry in L2 speech acquisition pertains to how learners exploit L2 prosodic cues to segment speech flow and resolve syntactic ambiguities. This study examined the segmentation of syntactically ambiguous French structures by both native speakers and Chinese L2 learners. An event-related potential (ERP) study was conducted to explore the Closure Positive Shift (CPS) component, which is associated with the processing of prosodic boundaries. Fifty pairs of French sentences with local ambiguity, featuring two distinct prosodic structures (e.g., Early Closure condition (EC): "Whenever the snake was eating # the rat would hide." vs Late Closure condition (LC): "Whenever the snake was eating the rat # the rabbit would hide.") (alongside fifty filler sentences) were used to examine the neurocognitive processing of prosodic boundaries (indicated by "#"). EEG signals were recorded from 20 French native speakers and 40 Chinese L2 learners (comprising 20 intermediate and 20 advanced proficiency levels) while they listened to these sentences. Our analysis revealed that both EC and LC prosodic boundary processing triggered the CPS component in all participants, reaching its peak approximately 500-600 ms after the onset of the final syllable preceding the intonational phrase boundary. Additionally, a noticeable topographic difference was observed between native speakers and learners, with natives exhibiting a central-parietal concentration and learners showing a centro-frontal concentration in learners. The consistent processing of prosodic boundaries across all participants, irrespective of their L1 background or L2 proficiency level is likely attributed to the prosodic universals in the marking of prosodic boundaries

across languages. The subsequent cluster mass permutation test identified a significant cluster in the parietal region in the EC condition, distinguishing between native speakers and intermediate learners. However, no significant difference was found between natives and advanced learners. Moreover, in the LC condition, natives exhibited a “ramp-like negativity”, in response to the absence of early closure, indicating an anticipation of a late boundary based on preceding material and a top-down processing strategy. Interestingly, advanced learners displayed a reduced negativity, while intermediate learners did not show this effect. The lack of this negativity in Chinese L2 learners compared to native speakers suggests that learners’ prosodic processing relied solely on acoustic cues at final syllables before prosodic boundaries, indicating a bottom-up processing approach. This study is the first to replicate the CPS effect in native French speakers. The observed differences in CPS between natives and learners offer new insights into the neuroplasticity associated with the acquisition of French prosody by Chinese learners.

D47 - Neurobiology of multifunctional prosody: Scope and trajectory

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Prosody relies on variations in fundamental frequency (f0), intensity, and duration of auditory signals, and covers a variety of interconnected phenomena, inter alia, stress, tone, rhythm and intonation. Understanding human language from both phylogenetic and ontogenetic perspectives involves unraveling the processing of prosody. Biologically, prosody taps into precognitive abilities shared with our hominid ancestors, as reflected in similarities with great apes in high-arousal expressions like joy and anger. Likewise, its socio-ecological significance is evident in prelinguistic communication, as infants depend on prosody prior to acquiring symbolic language. Clinically, prosody plays a vital role in diagnosing and treating a range of communication disorders. Beyond its evolutionary, developmental and clinical relevance, prosody functions across multiple linguistic levels, from phonology to pragmatics. Some functions are language-specific such as distinguishing lexical meanings in Mandarin (e.g., mǎi ‘buy’ versus mài ‘sell’), while others are more universal, like marking questions versus statements or emphasizing key discourse information. This multifunctionality positions prosody as a promising entry point into understanding not only the origins of speech but also the structural and operational aspects of linguistic processing. However, this complexity also poses significant challenges. Since diverse functions are ubiquitous and closely intertwined physiologically and psychologically, it is challenging to determine how the brain processes prosodic cues from different sources. Despite growing neuroscientific interest, neural mechanisms underlying prosody’s diverse functions and their interactions remain poorly understood. This is partially due to incomplete data and prosody’s ill-defined status in neuroscience. It is, for example, not a searchable term in meta-analytic neuroimaging platforms like Neurosynth and BrainMap, limiting analysis to individual features like pitch (f0). Recent developments, however, provide valuable frameworks such as

the Functionnectome, capturing relationships between brain circuits and functions (Nozais et al., 2021, *Commun Biol*) and the Morphospace Predictive Framework, enabling statistical testing of functional clustering and predictability based on inter-function similarities (Pacella et al., 2024, *Nat Commun*). Notably, Pacella et al.’s meta-analytic map of cognitive functions omits prosodic features from the language branch. A necessary first step is, therefore, to map existing fMRI research on prosody within the morphospace and observe its positioning. We hypothesize that prosody may occupy a central position, integrating loosely defined functions across sensory and cognitive domains. Given humans’ sophisticated change detection mechanisms at sensory and cognitive levels, and prosody’s role in probing their neural substrates (Zora et al., 2023, *Int J Psychophysiol*), change detection offers an optimal starting point for exploring prosody in the morphospace. Accordingly, we identified 36 fMRI studies on prosodic change detection in Neurosynth. Since attentional mechanisms are integral to information processing and prosody likely engages a domain-general attentional network (Kristensen et al., 2013, *Cereb Cortex*), one key question is whether prosody clusters more closely with the salience network or the attentional network. One might expect a functional transition from the salience to the broader attentional network as linguistic complexity increases. By addressing this question, this ongoing work aims not only to establish neural foundations for understanding prosody but also to promote future research based on these structured approaches.

D48 - Speech rhythm sensitivity and reading skills: Investigating behavioral mediators and EEG resting-state functional connectivity

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Introduction: Sensitivity to speech rhythm cues, such as lexical stress patterns, is essential for effective oral communication. Additionally, growing evidence underscores its significant role in reading, showing predictive value beyond phonemic awareness in developing readers and revealing associated perceptual difficulties in individuals with dyslexia. Recent research also suggests that this connection to reading proficiency persists in older readers. However, the neural mechanisms linking speech rhythm processing to these complex reading skills remain less understood. This study explores the direct and indirect effects of speech rhythm perception on reading comprehension, considering the roles of word reading fluency and phonemic decoding skills. Moreover, we utilized resting-state EEG to examine associations between functional brain connectivity patterns and these reading abilities. Methods: Seventy-three native English speakers (ages 18-50) underwent assessments of word reading, reading comprehension, and lexical stress perception. An individual dyslexia risk index was derived from standardized performances in word reading and pseudoword decoding (higher scores = lower risk). Resting-state EEG (5 minutes, eyes closed) was also collected. We estimated functional connectivity between pairs of electrodes using the debiased weighted Phase Lag Index (dwPLI) in the delta (0.5-4

Hz), theta (4-8 Hz), alpha (8-12 Hz), and beta (12-30 Hz) frequency bands. Minimum Spanning Trees (MSTs) were constructed from the dwPLI values to analyze network topology. Results: Lexical stress perception significantly correlated with reading comprehension ($r = 0.24^*$) and dyslexia risk ($r = 0.56^{***}$). A GLM mediation analysis revealed that the relationship between lexical stress perception and reading comprehension was mediated by dyslexia risk (indirect effect: $B = 0.75$, $SE = 0.19$, 95% CI [0.44, 1.13]). Functional connectivity analyses showed that reading comprehension was associated with brain networks characterized by greater global integration and organization, particularly in the theta frequency band. Higher comprehension scores were linked to lower values of theta kappa ($r = -0.25^*$) and theta mean dwPLI ($r = -0.26^*$), suggesting reduced network randomness and a lesser dependence on central hub nodes. Conversely, comprehension was positively associated with theta mean betweenness centrality ($r = 0.24^*$) and network eccentricity ($r = 0.24^*$), consistent with more efficient information flow and broader network integration. Both dyslexia risk and lexical stress perception showed positive correlations with tree hierarchy in the alpha band ($r = 0.27^*$ and $r = 0.24^*$, respectively), indicating a more segregated and organized network linked to better stress sensitivity and lower dyslexia risk. GLM mediation analysis also suggested that the relationship between alpha tree hierarchy and dyslexia risk was indirect and mediated by lexical stress perception ($B = 25.42$, $SE = 11.5$, 95% CI [4.16, 44.38]). Conclusion: Lexical stress sensitivity indirectly impacts reading comprehension skills by influencing the risk of dyslexia. Adequate reading comprehension is linked to the efficient integration of theta network activity, while sensitivity to stress and a reduced risk for dyslexia are associated with a well-organized alpha network topology. These findings highlight the differential contributions of distinct frequency-specific networks to the reading process.

D49 - Readers extract syntactic and semantic information during Rapid Parallel Visual Presentation (RPVP) sentence reading: Evidence from event-related potentials (ERPs)

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The extent to which readers can extract semantic and syntactic information in parallel from short sentences presented as a single stimulus (Rapid Parallel Visual Presentation or RPVP) is a hotly debated topic. Most evidence both supporting and opposing parallel processing comes from behavioral studies where participants make retrospective judgments about well-formed sentences vs. the same words in a non-canonical order. Both response accuracy and speed differ by sentence type which is interpreted as evidence that readers rapidly extract and use high-level structural information to influence their judgments. However, Staub (2024) argues that such results may reflect sophisticated guessing strategies, whereby participants use elements of the sentence context to make educated guesses rather than engaging in parallel processing. This explanation is plausible given that sentence judgements occur long after stimulus presentation, giving participants time to at least partially buffer and then process the words serially. To examine whether parallel processing is reflected by online neural processing, we combined event-related potentials

(ERPs) and RPVP sentence reading. The temporal precision of ERPs allows us to determine whether parallel processing occurs early (within a few 100 milliseconds after sentence presentation) or later during the decision stage. Well-formed sentences ("The surfer rides a wave." or "The zombie eats the brains.") were compared to those containing one of four types of violations: (1) a syntactic verb agreement violation ("The surfer ride a wave."), (2) a syntactic word order violation ("The surfer a rides wave."), (3) a semantic verb anomaly ("The zombie sows the brains."), or (4) a final word semantic anomaly ("The zombie eats the escape."). Twenty-four English-speaking participants viewed five-word sentences presented for 200ms and performed an acceptability judgment task (Is this a good or bad sentence?). Single-trial ERP responses were analyzed in four consecutive 200ms windows between 400–1200ms post-stimulus, encompassing the N400 and P600 time windows. N400 and P600 mean amplitudes were analyzed using separate LMER models to examine the anomaly effects for each sentence type. Additionally, scores from spelling and reading comprehension tests were included as continuous variables. While the N400 and P600 ERP components have been shown to be sensitive to semantic and syntactic anomalies in numerous rapid serial visual presentation (RSVP) studies, they have not yet been examined in the RPVP paradigm. We predicted that if either component showed differential responses to anomalous versus control sentences, this result would be incompatible with a serial guessing strategy given that the type and location of the single-word change varied across the sentence conditions. We found robust N400 effects for BOTH middle and final word semantic anomalies, as well as word order anomalies. We also found P600 effects for verb agreement and word order violations. Both syntactic anomaly effects were modulated by reading ability, with better readers showing larger N400 and P600 effects. Since participants could not anticipate anomaly locations, these findings are incompatible with a simple guessing strategy and suggest that readers can extract and process semantic and syntactic information in parallel during RPVP sentence reading.

D50 Sandbox Series - Multimodal Investigation of Word Repetition Effects: Evidence from fNIRS and EEG

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Understanding the neural mechanisms underlying the repetition effect—where previously encountered words are processed differently from novel words—is fundamental to cognitive neuroscience. In this study, we investigated the repetition effect using a multimodal neuroimaging approach, simultaneously recording EEG and fNIRS data from 30 healthy native English speakers. EEG recordings were obtained from 31 electrodes covering frontal, premotor and motor, temporal, parietal, and occipital visual regions, while fNIRS data were collected from 134 channels across similar cortical areas, providing broad spatial coverage. Traditional EEG studies offer excellent temporal resolution but limited spatial localization. By integrating fNIRS, which provides better spatial specificity through hemodynamic measurements, we aimed to achieve a more comprehensive understanding of the neural dynamics underlying repetition effects. Participants performed a semantic judgment task, deciding whether a visually presented word referred to a living animal. Each participant completed four experimental runs, each containing five blocks of six words, with

one block consisting of novel words and the others repeated words from earlier trials. EEG data were preprocessed using standard pipelines in EEGLAB (Delorme & Makeig, 2004), and fNIRS data were processed using the NIRS Toolbox (Santosa et al., 2018). The results revealed significant neural differences between repeated and novel words. Event-related EEG analyses showed two distinct effects. First, novel words elicited an enhanced negativity around 170 ms compared to repeated words, corresponding to an N170 component associated with early stages of visual word form processing. Second, novel words elicited a pronounced positivity between 400 and 750 ms, consistent with the timing and polarity of a P600 component linked to semantic integration demands. Statistical analyses confirmed significant condition differences at multiple time points, highlighting the rapid and dynamic nature of repetition effects in neural processing. Complementary fNIRS analyses corroborated these findings. Activation maps revealed distinct hemodynamic patterns, with some cortical regions showing greater activation for novel words and others for repeated words. Critically, we observed a significant decrease in activation ($p < 0.05$) in Wernicke's area for repeated words, suggesting that repetition reduces the neural demands associated with semantic access and integration. This pattern aligns with theories of repetition suppression and enhanced neural efficiency during language processing. Together, the multimodal results demonstrate that repeated words engage partially distinct neural processes compared to novel words, reflected in both electrophysiological signatures and hemodynamic responses. The EEG findings capture both early perceptual effects and later semantic integration effects of repetition, while fNIRS provides complementary evidence of sustained regional blood flow differences. Integrating these modalities offers a more comprehensive understanding of the dynamic and distributed nature of repetition effects in the brain. In the next phase of analysis, we will correlate participants' behavioral response times with both EEG and fNIRS measures to assess how neural activity predicts performance in the semantic judgment task. This approach will help determine which modality—EEG or fNIRS—provides more precise localization of the cognitive processes supporting repetition effects.

D51 - Cross-Linguistic Activation Likelihood Estimation Analysis of fMRI and PET Studies of Reading: Similarities and Differences in English and Chinese Word Processing

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Neuroimaging studies of word reading produce conflicting evidence of neural universality across languages, especially for languages with very different orthographic systems, such as Chinese and English (Nakamura et al., 2012; Rueckl et al., 2015; Siok et al., 2004; Tan et al., 2005). Specifically, it is unclear whether each language recruits a distinct "language-specific" neural network, or instead relies on a common language system, but with the strength of recruitment varying across subregions depending on the differing demands of each language. To test these opposing hypotheses, we conducted a meta-analysis to directly contrast Chinese and English word reading, for the first time, across orthographical, phonological

and semantic processing. This direct-comparison approach provided a systematic evaluation of neural convergence and divergence. Specifically, we included 93 fMRI/PET studies of Chinese/English word reading (1990-2024) from PubMed. Inclusion criteria were: (1) studies reporting MNI or Talairach coordinates; (2) healthy adult native speakers; (3) single/two-character Chinese or multi-syllabic English word stimuli (excluding sentences or stories). A total of 223 contrasts were categorized into macro (all contrasts) and micro (orthographic/phonological/semantic processing) levels for cross-language comparison. GingerALE (Eickhoff et al., 2009) was used to estimate convergence across studies. Subtraction/conjunction analyses were conducted with $p < 0.05$ (10,000 permutation-corrected) and a minimum cluster volume of 100 mm³. The macro-level conjunction results indicated a universal reading network across both languages, showing a common underlying fronto-temporo-parietal reading system that was co-activated by both Chinese and English reading. Whilst the same underlying system was recruited by both languages, subregions of the network showed an increased likelihood for Chinese > English reading. Specifically, the subtraction analysis revealed more right hemisphere engagement in Chinese reading > English reading (e.g., right fusiform gyrus, STG), suggesting the involvement of additional cognitive source to process visuospatial and tonal information of Chinese words, as well as more recruitment of areas associated with semantic control (left IFG and pMTG) (Lambon Ralph et al., 2017). At the micro level, Chinese orthographic processing recruited visuospatial regions due to the stroke patterns of Chinese characters, while the medial frontal gyrus found in English possibly reflected higher orthographic complexity manipulated in the tasks. Chinese phonological processing additionally engaged semantic control regions (Lambon Ralph et al., 2017), supporting the deep integration of semantic and phonological processing in Chinese word reading shown in Chang and Lee (2018). English reading, on the other hand, was more likely to activate left-lateralized phonological areas (e.g., SMG, IPL, insula), consistent with its quasi-regular grapheme-to-phoneme structure. Indeed, at the micro-level, English phonological processing activated a broader fronto-temporal network, including right IFG, to support phonologically difficult tasks like pseudoword syllable judgment. Both languages revealed overlapping semantic processing regions with varying degrees of activation shaped by their linguistic features. Overall, our findings support a shared reading network across Chinese and English, consistent with the language universal view (Nakamura et al., 2012; Rueckl et al., 2015). Moreover, activation differences were modulated by language properties and task-related cognitive demands.

D52 Sandbox Series - The interplay between orthography and phonology in word reading: an MEG study of deaf skilled readers

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Deaf individuals often face challenges in achieving high levels of reading proficiency due to limited access to auditory

phonological information. This study focuses on a subgroup of highly skilled deaf readers to investigate the neural substrates of phonological and orthographic processing during successful reading in the context of deafness. Twenty-five prelingually deaf skilled readers of Spanish and 25 hearing controls matched on reading level participate in a magnetoencephalography (MEG) experiment: they silently read single words presented on a screen while performing a low-level perceptual task (asterisk-detection). The stimuli are phonologically or orthographically manipulated to fall into one of the following conditions: real words, consonant strings, pseudowords and either pseudohomophones, which sound the same as a real Spanish word (e.g. *abril*→*avril*), or transposed-letter pseudowords (e.g. *generoso*→*gerenoso*) depending on the type of manipulation. There are 100 stimuli for each condition and 80 asterisk trials. Analysis and final results will be presented at the SNL conference. We will compute the magnetic counterparts of N400 and N250 ERPs associated with each stimuli condition and compare relevant conditions within and across participant groups. We predict that deaf readers will show similar N400 effects for pseudohomophones and pseudowords, whereas hearing readers will show an attenuated N400 effect for pseudohomophones. This pseudohomophone effect (the difference between pseudohomophone and pseudoword conditions) in hearing readers reveals the role of phonological representations during word reading; the absence of this effect would suggest that deaf readers do not activate phonology, and that speech-based phonology is not necessary for proficient reading in this population. We expect orthographic processing to elicit earlier activity, reflected in the N250 ERP component. Previous work shows conflicting evidence regarding orthographic coding in deaf population. Hearing readers have flexible representations of letter position, as shown by the facilitatory effect of transposed-letter priming. In contrast, if deaf readers have more rigid orthographic representations, we expect stronger N250 effects for the transposed-letter condition compared to hearing-matched participants. We will also exploit MEG's spatial resolution to localize these effects at source level. Single-word reading activates, in both deaf and hearing readers, a left lateralized network that includes the inferior frontal gyrus, the superior temporal sulcus, and the inferior temporal gyrus. Previous research has shown that abstract orthographic representations in both groups of readers activates the left visual word form area (VWFA). We expect deaf readers to also show recruitment of the corresponding region in the right hemisphere. The temporal resolution of MEG and the sensitivity of ERPs to distinct orthographic and phonological mechanisms will allow us to detect subtle aspects of online linguistic processing that behavioral studies alone cannot reveal. If deaf readers show more rigid orthographic coding, this could reflect heightened orthographic sensitivity as a compensatory strategy for reduced access to auditory phonology. Our findings will add to the debate on the relative contributions of phonology and orthography to reading in the context of deafness and will help uncover alternative neural mechanisms leading to high levels of reading performance in this population.

D53 - Neuroplastic mechanisms underlying the emergence of VWFA over reading acquisition

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Introduction. The ventral temporal cortex (VTC) supports high-order visual processes through topologically organized, category-selective functional parcel, such as the fusiform face area (FFA) and the visual word form area (VWFA). These parcels exhibit distinct developmental trajectories, offering a window into neuroplasticity in the VTC. For example, the face-selective responses in FFA are present in infancy and continue to develop throughout childhood, whereas the neighboring VWFA with word-selectivity emerges only after reading instruction. The relationship between these two regions remains elusive. Competing theories of VTC neuroplasticity propose that the VWFA may emerge from previously face-selective cortex (i.e., "strong competition"), constrain continued FFA development (i.e., "blocking" model), or develop independently of the FFA (i.e., "no competition"). **Methods and Results.** To investigate these hypotheses, we collected functional MRI from 69 children performing an audiovisual matching task involving faces, words, letter and colors. Participants were scanned at reading onset (T1, 65.8 ± 6.0 months, n=35) and/or after at least one year of reading experiences (T2, 93.7±14.1 months, n=56), with 22 children participating at both time points (i.e., longitudinal sample). For each participant, FFA and VWFA regions were defined based on face-selective (faces > [words + colors]) and word-selective (words > [faces + colors]) contrasts. We first characterized group-level category-selectivity in VTC over development. In both longitudinal and full samples, bilateral FFA was evident at both time points (all p < 0.025), whereas word-selective activation appeared only in the left-hemispheric (LH) VWFA at T2 (all p < 0.05), and not at T1 or in the right hemisphere (RH, all p > 0.09). Crucially, the left VWFA defined at T2 showed no category selectivity at T1 in the longitudinal sample. Next, we examined the individualized topological lateralization for both categories. In both samples, FFA showed consistent right topological lateralization (i.e., more face-selective voxels in RH than LH) at both timepoints (all p < 0.002), while VWFA exhibited left lateralization only at T2 (T1: all p > 0.07; T2: all p < 0.015). Notably, FFA right-lateralization (i.e., voxel number in RH versus LH) correlated significantly with VWFA left-lateralization at T2 (longitudinal sample: r = 0.75, p < 0.001; full sample: r = 0.49, p < 0.001), but not at T1 (both p > 0.09). Finally, we analyzed topological changes in the left FFA relative to VWFA emergence in the longitudinal sample. We observed that voxels selectively responsive to faces at T1 but not T2 (i.e., "disappearing FFA") were spatially closer to the emerging VWFA at T2, compared to voxels with consistent face selectivity at both time points (i.e., "stable FFA"; t20 = -2.34, p = 0.03). **Conclusion.** Our results show that face selectivity in both hemispheres precedes the reading-associated development of word selectivity in the left hemisphere. However, the VWFA does not arise from previously face-selective cortex, challenging the strong competition theory. Instead, the emergence of the left VWFA is associated with a topological shift of the left FFA away from the developing VWFA and increased right-hemispheric lateralization of the FFA, supporting the "blocking" model over the "no competition" account of VTC neuroplasticity.

D54 - Shared neural representations of visual speech across modalities are related to reading ability in deaf and hearing individuals

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Learning to read provides access to life-long educational and vocational opportunities. Some, but not all, deaf children find learning to read challenging due to reduced access to both signed and spoken language. Understanding what drives variation in reading outcomes and the neural processes underpinning it is important for developing neurobiologically informed reading interventions. Speechreading (or lip-reading) is positively associated with reading ability in deaf and hearing readers (Kyle et al., 2016). This suggests that visual speech may provide representations of spoken language that support reading development. At a neural level, a recent study with hearing adults showed that the perception of words presented in auditory alone and visual alone conditions evoked similar neural patterns in the bilateral superior/middle temporal cortex (STC/MTC) (Van Audenhaege et al., 2024). Here, we identified shared sublexical neural representations of visual speech in deaf and hearing adults. Further, we tested the hypothesis that the strength of shared encoding of sublexical features is linked to reading ability. We scanned 22 severe-to-profoundly deaf adults and 25 hearing adults with fMRI in 3T. Before scanning, participants completed the Vernon-Walden Reading Test. During scanning, the hearing group attended to 8 words sharing initial, vowel and final consonants. These were presented in visual alone and auditory-alone conditions. The deaf group were presented with the same words as visual speech (visual alone) or dynamic text (cursive text revealed letter-by-letter) to encourage sublexical processing. Accuracy on an occasional 1-back monitoring task was high across groups and stimulus type. We used the cross-validated Mahalanobis distance to quantify dissimilarity between neural patterns evoked by each word in each stimulus type and tested these distances against two models: (1) a lexical model in which each word was predicted to be maximally and equivalently dissimilar to all other words and (2) a sublexical model reflecting dissimilarity driven by number of shared sublexical units (this model only included off diagonal distances to exclude dissimilarity comparisons to the same word). We used a searchlight to find regions in which there were reliable within stimulus distances and tested the models against the within and across stimulus distances in these areas, as we assumed that within stimulus sublexical representation would be necessary for common across stimulus representation. In hearing participants, consistent with previous findings, we found shared neural patterns for visual and auditory speech in bilateral STC/MTC. This reflected lexical dissimilarity in the left and sublexical structure in the right STC/MTC. Importantly, the extent of shared sublexical structure correlated positively with reading ability. In deaf participants, common sublexical representations for text and visual speech were found in the left STC/MTC. Again, the strength of this encoding correlated positively with reading ability. In summary, we found shared lexical and sublexical structure in the STC/MTC in deaf and hearing individuals. In both groups, the strength of encoding of shared sublexical representations of visual speech related to reading outcomes, in left STC/MTC in the deaf and in right STC/MTC in the hearing group. These findings provide neurobiological evidence that visual speech supports reading development.

D55 Sandbox Series - Neural Correlates of Visuospatial Working Memory and Chinese Reading: An fMRI Study

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Baddeley's working memory (WM) model emphasizes the importance of maintaining and manipulating verbal, visual, and spatial information in complex cognitive tasks such as reading (Baddeley, 2003). In alphabetic writing systems, reading relies heavily on the phonological loop as the letters are mapped onto phonemes. However, reading the Chinese logographic script requires a more precise visuospatial analysis of strokes, radicals, and structural configurations during reading, where visuospatial WM plays a crucial role (Kim, 2022; Yang et al., 2021). Although prior research has examined visual processing skills such as visual discrimination (Yang & Meng, 2020) and visual search (Liu et al., 2015), as well as the interaction between visual processing and verbal WM (Liu et al., 2024), the specific role of visuospatial WM in Chinese reading remains underexplored. This study aims to investigate the relationship between visuospatial WM and Chinese reading by employing fMRI to examine their neural correlates. Thirty-six healthy native Chinese speakers (Mean age = 21.2, 15 females and 21 males) underwent fMRI scanning while performing an orthographic task and two visuospatial WM tasks (block and digit). In the orthographic task, participants compared and determined whether the two Chinese characters shared the same components. The study employed two visuospatial WM task designs featuring both memory (passive storage) and manipulation (active visuospatial transformation) conditions, allowing direct comparison between basic and complex visuospatial WM processes. The first, simple design asked participants to view the checkerboard patterns and either memorize them for subsequent recognition or mentally transform them by rotation or flipping, testing basic visuospatial storage and manipulation without verbal processing. The second, more complex design replaced shaded blocks with digits of varying sizes, requiring simultaneous memory for digit identity (verbal processing), size (visual processing), and spatial location. This three-feature task additionally captured the multi-dimensional processing characteristic of real-world cognitive tasks like logographic character recognition by engaging verbal, visual, and spatial systems. Preliminary results reveal that all tasks robustly activate the bilateral frontoparietal network, including the inferior parietal lobule and the middle frontal gyrus/inferior frontal junction. The manipulation condition additionally engages the mental rotation network, notably the dorsal caudate and the cerebellum. The block-visuospatial task elicits stronger activation in visual-motor integration areas (including the superior occipital gyrus, inferior temporal gyrus, and precentral gyrus) compared to the digit-visuospatial task. Activation overlapping between the block-manipulation and the orthographic tasks is evident, despite the orthographic task showing enhanced extra-cortical activation, suggesting the complexity of orthographic processing. The left fusiform gyrus is activated exclusively in the digit-manipulation and the orthographic tasks, suggesting its role in the mental representation of visually presented verbal materials (Dietz et al., 2005; Zhao et al., 2017). Ongoing analyses employ a novel Bayesian method for characterizing community structure-based latent brain states (Bian et al., 2021). Neural metrics such as mutual information will be correlated with behavioral measures of Chinese reading to functionally characterize the community-

based brain dynamics. Overall, the study holds significant potential to advance understanding of the visuospatial WM network dynamics and Chinese reading.

D56 Sandbox Series - Neurophysiological correlates of opaque and transparent word-processing in English speakers

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Languages differ in their orthographic depth and in turn this might shape how readers access and process words (Katz and Feldman, 1983). For example, languages like Spanish, for which the sounds composing words are represented by unique graphemes, are considered as having a shallow orthographic system. Differently, languages with multiple pronunciations per grapheme, like English, are considered as having a deep orthographic system (Seymour, Aro, & Erskine, 2003). It is thought that deep, or opaque orthographies are based mostly on lexical processing, and thus can feature holistic coding, that is words are read through a holistic route, rather than via individual letters. Differently, shallow or transparent orthographies based mostly on individual phoneme processing depend on smaller processing windows (Grainger & Ziegler, 2011). Aims: This study aims to measure and compare the electrophysiological signatures of transparent (i.e., candy, level) and opaque (i.e., knight, yacht) English words using Event related Potentials (ERPs) in native speakers of English and compare them to processing non-words (e.g., gibbs, kint, freth). Two main predictions are cast: 1. It is predicted that Non-Words will elicit a greater N400 compared to Real Words (transparent and opaque combined) (Kutas & Federmeier, 2011). 2. In line with previous findings looking at orthographic transparency (Simon et al., 2006), we expect to observe a larger frontal negativity for opaque words around 320 milliseconds (N320) signaling increased cognitive workload involved in grapheme-phoneme conversion and processing (Bentin et al., (1999). Method: 23 English monolingual speakers (mean age: 22.1) were tested. Participants completed an EEG based lexical decision task composed of 50 English Non-Words, and 50 Real English words subdivided into transparent words (n=25), and opaque words (n=25). Results: Non-Words elicited a larger N400 relative to Real Words. Regarding the processing of opaque and transparent words, there was an emerging frontal negativity for opaque words compared to transparent words around 320 milliseconds, signaling increased cognitive workload involved in grapheme-phoneme conversion and processing (Bentin et al., (1999), and Left frontal activation has been previously linked to conversion of orthography to phonology (Simone et al., 2006). Conclusions: These EEG results replicate the well-known effect of an enhanced N400 for non-words relative to words (Kutas & Federmeier, 2011). In addition, the observed larger N320 for opaque words is in line with previously reported data generated in similar orthographic transparency studies (Simone et al., 2006). While the available literature varies in findings, this component may illustrate an increased cognitive workload involved in grapheme-phoneme conversion and processing (Bentin et al., (1999).

D57 - Using EEG to Examine the Cognitive and Neural Mechanisms of Action Semantics in Primary Progressive Aphasia and Parkinson's Disease

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The extent to which gesture and language access a common repository of semantic representations or separate stores of semantic knowledge remains a topic of theoretical debate (e.g., Leshinskaya & Caramazza, 2016). Within this debate, there is further disagreement concerning the involvement of sensorimotor brain regions in semantic representations. Investigating the relationship between gesture and language comprehension across neurodegenerative populations with and without prominent motor deficits will further inform these debates. The current study uses EEG to explore the role of action semantics in the comprehension of nouns and verbs in Primary Progressive Aphasia (PPA), a neurodegenerative disease without prominent motor deficits characterized by language impairment, and Parkinson's Disease (PD), a neurodegenerative disease with prominent motor deficits. For the purposes of the current project, action semantics is defined as long-term knowledge about actions (e.g., manual gestures) that is accessible to language and is activated during the execution, observation, and mental simulation of actions. Specifically, this study examines neurophysiological and behavioral evidence that the observation of gestures facilitates language comprehension in at least some individuals with PPA and PD. Our experiment uses an event-related paradigm to investigate whether observing a video of a manual gesture facilitates the comprehension of a semantically related, auditorily presented noun or verb. Participants are asked to indicate via keypress whether the gesture and word match or mismatch. We present data from a total of 10 individuals with PPA, 10 individuals with PD, and 20 age-matched neurotypical controls. To examine whether sensorimotor disruption affects gestural facilitation in these populations, we evaluated event-related desynchronization of the β oscillation and μ rhythm as indicators of sensorimotor aspects of action semantics (e.g., Schaller et al., 2017). If the sensorimotor aspect of action semantics is intact, we expected to observe greater event-related desynchronization of the β oscillation or μ rhythm in response to a matching gestural prime and target word. If this desynchronization is reduced or absent, then this would suggest sensorimotor disruption may contribute to any observed action semantics deficits. We examined the N400 as an index of semantic priming across gesture and target word, as well as how this effect relates to behavioral evidence for priming (e.g., faster response time to matching gestural primes and target words). We expected individuals with impaired comprehension to exhibit a reduced response time (RT) benefit for trials where a matching gesture precedes the target word and a reduced or absent N400 effect in response to mismatches. Data collected to date demonstrate that individuals with semantic impairment exhibit faster RT for trials with a matching gestural prime and target

word relative to mismatch trials. Conversely, individuals with intact semantic abilities demonstrated equally fast RT on trials with matching and mismatching gestural primes. Additionally, the behavioral differences appear to be associated with individual differences in N400 amplitude and location as well as differences in desynchronization of the β oscillation and μ rhythm. Finally, we consider differences in the EEG components of interest across neurodegenerative populations.

D58 - Functional neuroanatomy of sign language production: An Activation Likelihood Estimation meta-analysis

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Introduction: Sign languages are natural languages in the visual-kinesthetic modality (Kusters et al., 2020) which use the hands, body, facial expressions like eyebrow movement and eye gaze, mouthing, and mouth gestures as articulators (Hodge, 2020). Despite differences in the production channels, neuroimaging studies of sign production have identified similarities with the functional neuroanatomy underlying speech production (e.g., Emmorey et al., 2003, 2016, 2021; Kassubek et al., 2004; Buchsbaum et al., 2005; MacSweeney et al., 2008; Campbell et al. 2008; Hu et al., 2011; Okada et al., 2016). However, no prior work has provided a statistical synthesis of this available data on sign language production. Here, we fill this gap by reporting the results of the first Activation Likelihood Estimation (ALE) meta-analysis of the published neuroimaging literature on sign language production. **Methods:** We searched all major databases to identify relevant literature and included studies based on pre-defined criteria: (1) Participants were healthy deaf or healthy hearing users of any sign language; (2) the study focused on overt sign production and reported foci from relevant contrasts from the whole brain; and (3) imaging was performed using PET or fMRI. Individual contrasts in relevant papers were included in analysis if they involved sign language production in any capacity. The final sample comprised 14 studies with 168 participants and 553 foci. We first performed an ALE analysis (Eickhoff et al., 2012; Turkeltaub et al., 2012) with conservative thresholds (cFWE $p < 0.05$) which yielded only two significant clusters. Therefore, we conducted a second ALE analysis with more lenient thresholds (uncorrected cluster forming threshold $p < 0.001$) yielding 13 significant clusters. We then performed Jackknife analysis to ensure the observed clusters in either ALE analysis were not driven by a single study. Finally, to further characterize the functional nature of clusters surviving Jackknife analysis, we employed multi-analytic connectivity modeling (MACM) using the BrainMap database, which contains data only from studies with hearing non-signers. **Results:** Three clusters survived Jackknife analysis. These were located in the left inferior frontal gyrus (BA 45, 46, 47) extending into the left anterior insula (BA 13), left middle frontal gyrus (BA 6), and the medial and right cerebellum. Interestingly, the cerebellar cluster was limited to lobules IV and V, contrasting recent work on

spoken language (Todorovic et al., 2024; Parker Jones et al., 2024). Our MACM analysis confirmed that all our identified clusters observed for sign language production are also primarily recruited for language processing in hearing non-signers with the exception of the cerebellar cluster which was primarily linked to action execution. **Conclusion:** Our findings provide support for the notion that core regions involved in language production are involved in the externalization of linguistic signals, regardless of the alternative language production channels between signed and spoken language. We also observe involvement of the cerebellum in sign production across studies, which has not previously been consistently reported. In sum, our work complements prior studies on (sign) language comprehension and production to provide a more refined, modality-independent understanding of language in the brain.

D59 - Influence of testing language and aging on verbal list learning in deaf ASL-English bilinguals.

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Evaluation of memory function is a key component of many neuropsychological assessments, yet there is no standardized list memory task that has been widely adopted for use with deaf ASL-English bilinguals. Further, while it is known that testing hearing bilinguals in their non-dominant language yields worse performance and may lead to false positive diagnosis of cognitive decline, it is not known how language of testing affects free recall in deaf bilinguals, particularly in older deaf individuals. The current study investigated how testing language and age impacted recall performance on a word list learning task in deaf ASL-English bilinguals. Thirty-two young (ages 20-45) and 32 older (ages 65-84) deaf ASL-English bilinguals were included in the study. All participants reported daily use of ASL as a primary language, and the older and younger groups did not differ in years of education or in self-ratings of ASL or English proficiency. Participants completed two list memory tasks, one with visually presented ASL stimuli (videos) and one with visually presented English stimuli (printed words). The order of language presentation was counterbalanced across participants. Participants saw a list of 10 ASL signs and a list of 10 English words (unrelated to the ASL signs) for immediate recall over three learning trials with items presented in different orders for each learning trial. They then completed a delayed recall trial, which occurred about 10 minutes after the third learning trial. All but one participant preferred to recall items in ASL, both when recalling lists presented in ASL and lists presented in written English. Thus, deaf bilinguals preferred to translate English words into ASL, rather than use spoken or fingerspelled English responses for list recall. In addition, all bilinguals (but one) mouthed during signed productions of lists in both languages, which represents a form of code-blending. Older bilinguals recalled fewer items than young bilinguals on all learning trials. Older bilinguals also showed reduced primacy scores on Trial 1 in both languages, recalling fewer items in the first three list positions than younger bilinguals. An analysis of

forgetting showed that young bilinguals learned and then forgot the same number of items in both languages after a delay, but older bilinguals exhibited a more complex pattern in which English seemed to benefit learning, but ASL reduced forgetting. That is, older bilinguals recalled more English items than ASL items on Trial 3, but subsequently recalled fewer English than ASL items after a delay. Finally, testing language order did not impact overall learning or primacy scores, but it did affect forgetting scores with participants forgetting more items in whichever language was tested second. Given the importance of delayed recall in differential diagnosis, our results indicate that it may be critical to test memory in ASL rather than English for older deaf bilinguals. However, additional research is needed to determine which language of testing will maximize diagnostic power in this population, and to determine why older bilinguals exhibited greater effects of testing language than young bilinguals.

D60 Sandbox Series - The role of predictive processing in American Sign Language fingerspelling

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Learning is often highly embedded within social interactions, and this prototypical form of learning may be conceptualized as a shared cooperative activity, as proposed by Bratman (1992), during which the interactive co-development of conceptual or situational models aids knowledge-sharing. Advancements in the methodologies and modeling of neurobiology open the field to asking new questions about interactive learning, specifically through its most ecologically valid modality: communication. One such methodology, hyperscanning, also known as dual-brain scanning, allows for analyzing spatio-temporal interbrain relationships between two interacting participants. Successful communication demands that we move beyond merely encoding and decoding utterances and carefully attempt to align linguistic proclivities (e.g., rate of production & attention) and content (e.g., predictability & register) with our partners' intent, knowledge, and emotions (Snedeker & Trueswell, 2003; Verga & Kotz, 2013; Doyle & Frank, 2016). Resulting in alignment: an increased similarity of behaviors among communicating dyads. Prior findings suggest that neural activation patterns converge across participants as behavioral alignment increases (Menenti et al., 2012). However, it remains unclear what cognitive mechanisms support this neural coupling and how it relates to behavioral similarities observed, particularly, how plastic such an effect may be, and if findings persist in signed languages, much like in spoken languages. To address this, we propose a dual-electroencephalography (EEG; 64-channel) hyperscanning study to assess real-time phonologic alignment during American Sign Language (ASL) fingerspelling. We hypothesize, in line with prior models of fingerspelling, that both top-down and bottom-up predictive processing mechanisms influence fingerspelling perception and production, as reflected in behavioral and neural alignment. We will recruit signing adult dyads (N = 30 dyads) from Gallaudet University. Dyads will take turns producing phonologically predictable and unpredictable fingerspelling segments and matching their partner's production to a set of potential responses (e.g., predictable: cheerios, churros, cheezits, cheetos; unpredictable: chanrkes, cholus, chemotes, chitres). This task was chosen to increase feelings of cooperation and goal-driven behavior, known to prompt alignment. Participants will also complete background surveys

and assess their partner's fluency and likability. While performing the task described above, we will record electroencephalography (EEG) signals from a single 64-channel BrainVision cap positioned to fit the 10-20 system split evenly between the participants (i.e., 32/participant; Jasper, 1958; Douglas et al., 2023). Neural alignment will be assessed via a wavelet coherence analysis—with specific interest in the alpha, theta, and beta oscillatory bands (Pérez et al., 2019)—which provides a measure of cross-brain synchrony, i.e., time-locked neural events between specific regional pairs. This will result in a measure of alignment assigned to an electrode pair across participants (i.e., each participant's Cz), allowing us to assess differences due to role (i.e., fingerspeller/perceiver), fluency (i.e., skilled fingerspellers/novice), and condition (i.e., predictable/unpredictable). We predict that all dyads will show more neural alignment during the predictable condition. If neural alignment is a neural proxy for mutual intelligibility, we expect dyads to perform more accurately as wavelet coherence increases, regardless of condition. Preliminary data analysis from the hyperscanning paradigm will be shared at the 2025 SNL meeting.

D61 - Individual Differences in Language Lateralization among Deaf Signers

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A canonical trait of language neurobiology is its left-lateralization. At the same time, laterality is modified by genetic and experiential factors, suggesting the right hemisphere is equally able to support language processing at birth (Bates et al., 2001; Newport et al., 2022). Some studies suggest sign languages are as left-lateralized as spoken languages (MacSweeney, 2002; Yang et al., 2024), while others report a more bilateral profile (Hickok et al., 2002; Newman et al., 2002), possibly due to the visuo-spatial properties of sign languages. Recent evidence suggests reading in Deaf individuals also engages the right hemisphere more (Sehyr et al., 2020), possibly driven by absence of early speech or auditory experience (Poeppel, et al., 2003). Here we asked how language modality (spoken vs. signed), age of first language access (native vs. delayed), and hearing status (deaf vs. hearing) contribute to language lateralization by working with Deaf native signers (n=20), Deaf non-native signers (n=15), and hearing native signers (CODAs; n=18). We used fMRI to measure language lateralization during Polish Sign Language (PJM) processing using two paradigms: a sentence comprehension localizer (Exp1; adapted from Fedorenko et al., 2010; Newman et al., 2015) and a naturalistic story (Exp2). (Exp1) Participants passively viewed PJM sentences and a motion-matched scrambled control, responding to occasional catch trials. (Exp2) The same participants passively watched a 20-minute naturalistic PJM narrative. While prior studies focused on group-level comparisons, we measured individual-level lateralization to test whether laterality varies more across Deaf signers than hearing speakers. All groups recruited the classic fronto-temporal language network, including bilateral middle temporal gyrus (MTG) and inferior frontal gyrus (IFG) for sentences versus control condition. We quantified hemispheric dominance using laterality indices (LIs), calculated as the proportion of activated voxels in the left versus right hemisphere, as well as separately in classic language regions. At the group level, both

Deaf samples showed bilateral responses to language (mean = -0.17, CI = [-0.336, -0.005]). However, this group-level result masked substantial individual variability: Deaf participants' LIs ranged from -1 (fully right-lateralized) to 1 (fully left-lateralized), with half showing right-lateralized activation in both native and non-native signers. In contrast, CODAs showed consistent left-lateralization, with LIs significantly greater than zero and significantly less individual variability than Deaf signers (mean = 0.13, CI = [0.032, 0.240]). To assess the reliability of hemispheric dominance across the localizer and naturalistic narrative, we defined laterality in the narrative as the normalized difference between left and right hemisphere intersubject correlation (ISC). Deaf signers showed a significant correlation between narrative-based LIs and those from the sentence localizer, indicating stable individual differences. No such correlation was observed in hearing signers, likely due to more uniform laterality patterns across individuals. We identified a fronto-temporal language network engaged in sign language (PJM) comprehension. Sign language processing was left-lateralized in hearing signers. In contrast, among Deaf signers, we observed stable individual differences in hemispheric dominance with an average bilateral profile. Our results suggest bilateral responses are not inherent to sign languages, but rather related to changes in early auditory or speech experience.

D62 - Area 55b's association with speech and pitch processing in chronic stroke: A resting-state fMRI study

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Recent studies of speech production and music perception have identified regions beyond the typical dual-stream speech processing network that are sensitive to both pitch motor control and pitch perception, including area 55b in dorsal premotor cortex. The present study uses resting-state functional MRI to investigate the connectivity of area 55b with the dual-stream speech network and how it may be related to aphasia symptomology. Eighteen chronic stroke survivors (12 with aphasia) and 32 matched control participants completed a series of speech, language, and cognitive assessments (including multiple auditory attention, working memory, and pitch repetition measures), in addition to structural and resting-state functional MRI acquisition. Results indicate that in the control group, left and right area 55b are significantly connected to both dorsal and ventral streams of the dual-stream speech network, and that left 55b connectivity with the left ventral stream, left dual-stream network, and the whole dual-stream network were significantly lower in the stroke group than in the control group. Multiple regression models in the stroke group revealed that performance on some aphasia and cognitive measures were significantly predicted by left or right 55b connectivity to portions of the dual-stream speech network. For example, fluency was significantly predicted by right 55b connectivity with left dual-stream network regions, while naming was significantly predicted by left 55b connectivity with left dual-stream network regions, particularly with the left ventral stream. Auditory orienting attention was significantly predicted by left 55b connectivity with the whole dual-stream network, particularly left dual-stream regions. Overall, these findings suggest that premotor speech control regions such as area 55b are highly

connected with the dual-stream speech network, and that their connectivity with the ventral stream may be particularly impaired in individuals with aphasia. Understanding area 55b and dorsal premotor speech regions is a promising direction to better understand the neurobiology of speech and the neural resources available to stroke survivors during aphasia rehabilitation.

D63 Sandbox Series - Preliminary Study Exploring Corrective Responses to Task Relevant and Task Irrelevant Errors in Speech Production

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The Speech Motor System (SMS) monitors the auditory feedback to detect speech output errors and maintain speech production accuracy (Houde & Nagarajan, 2011). When the SMS detects an error, it generates Corrective Responses (CR) to adjust for the error within the same production and Adaptive Responses (AR) to adjust for the error in the subsequent production (Daliri, 2021). The brain evaluates errors based on relevance and responds more to errors possibly attributed to our actions (Daliri et al., 2020). We previously showed that Adaptive Responses are smaller for task-irrelevant errors, i.e., errors that do not correspond with the participant's speech, in comparison to task-relevant errors, i.e., errors that were related to the participant's speech, in an Adaptation paradigm, wherein errors are continuously applied (Daliri & Dittman, 2019). This study aims to explore if there is a difference in Corrective Responses between task-relevant errors and task-irrelevant errors in a Compensation paradigm wherein errors are applied randomly. We recruited 10 participants for our preliminary study. We experimentally introduced errors by manipulating the participants' auditory feedback based on their speech-formant frequencies. We applied two types of participant-specific formant perturbations: (i) Formant Shift – task-relevant errors (ii) Formant Clamp – task-irrelevant errors in two directions: ϵ -to- æ and ϵ -to-outside the vowel space, for three magnitudes: 0.5, 1, 1.5 along the $/\epsilon\text{-}\text{æ}/$ line. The experimental session included 7 blocks of ϵ -to- æ perturbations and 7 blocks of ϵ -to-outside the vowel space perturbations, and each block either had ϵ -to- æ perturbations or ϵ -to-outside the vowel space perturbations. Each block had 120 trials, out of which there were 108 word trials ($/\text{h}\text{æ}\text{d}/$, $/\text{h}\text{e}\text{p}/$, and $/\text{h}\text{e}\text{c}\text{k}/$) and 12 sentence trials, such that 2 sentence-trials were presented after every 18 word-trials. The 108 word-trials were categorized into 72 unperturbed trials and 36 perturbed trials. Out of the 36 perturbed trials, 18 trials had Formant Shift perturbations (6 trials per perturbation magnitude: 0.5, 1, 1.5 along the $/\epsilon\text{-}\text{æ}/$ line) and the other 18 trials had Formant Clamp perturbations (6 trials per perturbation magnitude: 0.5, 1, 1.5 along the $/\epsilon\text{-}\text{æ}/$ line). The study used a compensation paradigm wherein formant perturbations were randomly applied to the word-trials. Our preliminary results show that the Corrective Responses to task-relevant errors are similar to task-irrelevant errors. This could imply that the brain possibly evaluates both task-relevant and task-irrelevant errors similarly when randomly introduced. Overall, this study explores the basic mechanisms underlying the speech motor system from the purview of error relevance and correction.

D64 Sandbox Series - Investigation of speech-induced sensory modulation using multimodal neuroimaging

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Fluent speech requires the brain to predict the sensory consequences of self-produced sounds. A key marker of this predictive coding is speech-induced sensory modulation (SISM), typically indexed by suppression of auditory cortical responses during speech relative to passive listening¹. While studied using EEG/MEG and, to a lesser extent, electrocorticography, its anatomical specificity, underlying mechanisms, and cerebellar contributions remain unclear. This study combines ultra-high field 7T fMRI and EEG to investigate the neural substrates of SISM, including the cerebellum's role in predictive coding. Participants (right-handed English speakers, aged 18–49) complete a multi-session protocol including hearing assessments, EEG, and 7T fMRI. During EEG, they produce vocalic syllables (“ah”) and passively listen to matched recordings. Event-related potentials time-locked to sound onset are compared across conditions to assess auditory suppression (e.g., N1 attenuation). In fMRI, participants alternate between producing and listening to individual syllables and full sentences. During production, stimuli are visually cued and spoken aloud. In listening blocks, they hear either their own productions (LISTEN-SELF) or matched recordings from others (LISTEN-OTHER), enabling comparison under different predictive contexts. Speech is recorded and played back with minimal delay using MRI-compatible audio systems. T1-weighted MP2RAGE images are collected at 0.55 mm resolution. BOLD fMRI is acquired at 1.5 mm isotropic resolution using a multiband EPI sequence and custom Tic Tac Toe RF coil. We hypothesize that auditory cortical regions—including planum temporale, posterior superior temporal gyrus, and posterior superior temporal sulcus—will show distinct modulation patterns. We expect both increased and decreased BOLD responses during speech, consistent with intracranial findings². While EEG suppression is often linked to cortical inhibition, corresponding fMRI changes may vary with neurovascular dynamics. By comparing EEG and fMRI within subjects, we aim to determine whether suppressed evoked potentials reflect localized increases, decreases, or mixed BOLD patterns. This study also examines the cerebellum's role in speech prediction. The cerebellum may implement forward models generating inhibitory predictions for expected feedback^{3–4}. We expect speech-related activity in Lobule VI and test whether BOLD signal predicts auditory cortex modulation. Subset analyses using 0.8 mm scans will explore depth-dependent modulation and cerebellar-cortical connectivity. To date, 7T fMRI has been rarely used in speech production studies. Its enhanced resolution and signal-to-noise ratio provide a unique opportunity to investigate predictive mechanisms at the individual-subject level⁵. We present this work as part of the Sandbox Series to solicit input on design, analysis, and interpretation of multimodal and cerebellar involvement in SISM. References: 1) Ford, J. M., Roach, B. J., & Mathalon, D. H. Assessing corollary discharge in humans using noninvasive neurophysiological methods(2010). 2) Eliades, S. J., & Wang, X. Neural substrates of vocalization feedback monitoring in primate auditory cortex. *Nature*(2008). 3) Knolle, F., Schröger, E., Baess, P., & Kotz, S. A. The cerebellum

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D65 - Chunking Constrains Prediction during Language Comprehension

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Spoken language is a rapid sequence of auditory information that can incorporate complicated internal structures. Prediction and chunking are two possible mechanisms for the brain to process speech efficiently, and they are often viewed as separate or even opposing mechanisms. Here we investigate whether the two mechanisms interact and hypothesize that the chunk (constituent) structure in spoken language modulates how the brain predicts basic linguistic items, e.g., morphemes, the basic unit of meaning in language. In three magnetoencephalography (MEG) experiments, we characterize the neurally manifested prediction of morphemes using the neural response to morpheme surprisal, and we analyze how this response is modulated by chunks, i.e., the linguistic constituent structure. We demonstrate that the MEG surprisal response is significantly stronger for morphemes within an ongoing chunk than morphemes across a chunk boundary. This chunk-boundary effect on morpheme prediction is further modulated by the certainty of a chunk boundary. The findings are then confirmed by analyzing a dataset of ECoG responses to English narratives. These results establish that the brain employs a chunk-based prediction mechanism and more precisely predicts sequential items within a chunk.

D66 Sandbox Series - Decoding phonetic cue weighting from electroencephalography responses to naturalistic speech

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Although multiple acoustic cues influence listeners' phonetic categorization, their relative impact is often unequal. Inappropriate perceptual weighting of acoustic cues can cause second language learners' challenges in phonetic categorization. For example, past research has suggested that Japanese learners' difficulty in discriminating American English /r/ and /l/ result from their overweighting second formant (F2) onset and underweighting third formant (F3) onset (Iverson et al., 2003). Thus, assessing learners' cue weighting is critical to develop more targeted and effective phonetic training. The current behavioral methods of estimating cue weighting, however, are subject to variabilities in post-perceptual processes. To circumvent overt responses, we propose a novel method based on representational similarity analysis of electroencephalography (EEG) data. This method first involves calculating the pairwise distances between EEG epochs time-

locked to different phonetic categories. The resulting pattern of distances, i.e., the representational dissimilarity matrix (RDM), is considered the representational geometry of the phonetic categories. Analogous RDMs are constructed for the acoustic cues under investigation. The next step is to relate the RDMs based on EEG data and acoustic cues. Considering the possible non-linear mapping between neural responses and acoustic cues, dissimilarity values in each RDM are submitted to rank-rank regression (Wilhelm & Morgen, 2023). Specifically, the rank of EEG dissimilarity is the response variable, and those of acoustic dissimilarities are the predictors. The output regression coefficients are taken as relative perceptual weights of acoustic cues. We will test the proposed method on 19 native English listeners' EEG responses to an audiobook version of "The Old Man and the Sea," annotated with timestamps of phoneme boundaries (Di Liberto et al., 2023). To evaluate whether our method generalizes to acoustic cues with different temporal alignments, two phonemic contrasts will be examined: (1) /r/ versus /l/ and (2) prevocalic voiced versus voiceless stops (e.g., /p/ versus /b/). In both cases, the EEG epoch length and channel(s) will be optimized by nested cross-validation. For the contrast between /r/ and /l/, F2 and F3 values will be measured at the onset of phonemes and exemplify synchronous cues. On the other hand, the contrast between voiced and voiceless stops has two asynchronous cues: voice onset time (VOT) aligned with the stop onset and fundamental frequency (F0) aligned with the following vowel. Based on previous behavioral studies on cue weighting for the /r/-/l/ contrast (Iverson et al., 2003), we predict that the regression coefficient for F3 onset would be larger than that for F2 onset. Similarly, the regression coefficient for VOT is expected to be larger than that for F0 (e.g., Whalen et al., 1990). We also speculate that the optimal EEG epoch length for synchronous cues (F2 and F3 onsets for /r/-/l/) will be shorter than asynchronous cues (VOT and F0 for voiced-voiceless stops) because synchronous cues can be integrated instantly.

D67 Sandbox Series - Impact of Auditory Training on Cortical Neural Tracking of Rapid Speech in Aging and Hearing Loss

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The ability to understand rapid speech relies on the capacity of the auditory system to process fine-grained temporal features of the acoustic signal. Aging and hearing loss can disrupt this precision and increase difficulty in recognizing time-compressed speech. Age-related changes are associated with altered cortical temporal dynamics, including exaggerated and delayed representations of speech. These patterns are likely related to compensatory neural mechanisms that emerge in response to degraded input but often fail to restore speech perception fully. Such mechanisms may influence processing across multiple levels, from early sensory encoding to higher-order cognitive and linguistic representations. The present study investigates whether auditory training for rapid speech (i.e., time-compressed speech) can improve behavioral performance and cortical processing and whether these changes can be detected for both linguistic neural representations and sensory representations. A total of 94 participants were recruited, comprising younger normal-hearing (YNH), older normal-hearing (ONH), and older hearing-impaired (OHI) adults. All

listeners completed pre- and post-training sessions, including a behavioral assessment of time-compression thresholds for 50% keyword recognition, and electrophysiology (EEG) recordings (cortical envelope tracking) of continuous speech under unprocessed and time-compressed conditions. All participants completed six sessions of adaptive training in time-compressed speech after a pre-session. The training increased or decreased in difficulty by adjusting the time-compression rate based on participant performance. Results showed a significant training effect on behavioral measures, with both ONH and OHI groups demonstrating improved performance at the post-test. While younger listeners maintained the highest overall performance, post-training thresholds in the ONH group approached pre-training levels of the YNH group. These findings suggest partial restoration of rapid speech recognition through targeted training, particularly for older adults with normal hearing. Cortical EEG data will be analyzed using a Temporal Response Function (TRF) framework to evaluate training-related changes in neural encoding. TRFs will be modeled at multiple sensory and linguistic levels: acoustic feature, phoneme, word, noun phrase, verb phrase, and sentence onsets will be used as predictors. Previous findings showed exaggerated cortical tracking responses in older adults, which may reflect maladaptive cortical plasticity. We aim to investigate whether auditory training reduces this exaggeration and results in more efficient cortical encoding of time-compressed speech. This work was supported by NIA P01AG055365.

D68 Sandbox Series - Effects of Cancer-Related Cognitive Impairment on Cortical Tracking of Speech in Noise

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Cancer-related cognitive impairment (CRCI) is an often debilitating consequence of cancer and its treatments, affecting domains such as attention, memory, and executive function. While prior research has examined the behavioral and neural underpinnings of CRCI, its impact on real-life communication – particularly in challenging listening environments such as conversations in noise – and its neural correlate, cortical speech tracking, remains underexplored. Cortical tracking of speech, reflecting the brain's ability to synchronize with the temporal dynamics of speech, is crucial for speech comprehension and communication. This is particularly true in noisy environments, where the brain must selectively enhance relevant auditory information while suppressing background noise. Effective speech tracking in noise relies on attentional and predictive mechanisms, which may be compromised in individuals with CRCI, leading to increased listening effort and reduced speech intelligibility. Importantly, visual cues, such as lip movements and facial expressions, have been shown to facilitate the decoding of auditory stimuli under noisy circumstances. We hypothesize that individuals with CRCI exhibiting difficulties in cortical tracking of speech, will show improvements when provided with accompanying visual stimuli. To investigate this, we recorded electroencephalography (EEG) responses as part

of a longitudinal study involving three groups of participants: (1) breast cancer patients assessed before starting chemotherapy and again at its completion (approximately 4–6 months later); (2) breast cancer patients assessed shortly after completing treatment, and re-evaluated six months later; and (3) age and education-matched healthy controls assessed at baseline and again after six months. During each session, participants listened to brief (1-minute) clips across three conditions – audio-only, video-only, and audiovisual – with background multi-talker noise added to the auditory conditions to increase task difficulty. After each clip, they answered a comprehension question, allowing us to also assess behavioral performance. We then analyzed speech–brain coupling using techniques such as temporal response functions (TRFs) to assess how neural tracking is affected by CRCI. These findings may contribute to a better understanding of CRCI-related changes in neural speech processing, approaching a very ecological scenario in which these patients can show processing difficulties. They may also inform interventions aimed at improving management of symptoms, and recovery in affected individuals.

D69 - Acoustically degraded speech slows prediction in online sentence comprehension: evidence from the visual world paradigm and pupillometry

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Many individuals with severe to profound hearing loss use cochlear implants (CIs) to interact with the auditory world. These implants, arranged tonotopically on the basilar membrane of the cochlea, directly stimulate the auditory nerve and can often restore the percept of sound. However, the acoustic clarity of the signal transmitted through a CI differs markedly from typically perceived speech. Despite this, many CI users perform well on tasks such as word and sentence recognition in clinical testing environments. Less understood is why CI users, even those who perform well on such clinical tests, report that keeping up with everyday listening is difficult and exhausting. We suggest that clinical tests of word and sentence perception are insensitive to the continual temporal demand of listening in everyday life. The possibility exists that even when speech perception is successful, increased difficulty due to the degraded clarity of the speech may delay the predictive processes necessary for fluid semantic integration. This study addresses this question by employing the visual world paradigm to index the speed at which a listener can predict a word within a sentence using eye gaze, using a simulation of CI signal. Forty young adult listeners with age normal hearing were presented with predictable sentences that were either heard in clear speech or processed to sound like a CI using noise-band vocoding (6 channels). To manipulate temporal demands, sentences were either heard at a normal rate or at 50% of their original playing times using time-compression. Eye gaze movements were tracked in order to determine an early predictive point in the sentence at which the listener understands the sentence sufficiently to correctly predict how the sentence will end. The latency to which the participants used the computer mouse to click on the selected word was taken as an index of their confirmatory decision. Additionally, listeners' pupil size was tracked at and after the onset of the sentence-final-word to measure differences in the trajectories of cognitive effort between conditions. Results demonstrate that prediction of the sentence-final-word was delayed when speech

was vocoded to sound like a CI or increased in speech rate using time compression. When speech was both vocoded and time-compressed, the ability to predict the sentence-final-word was especially late, occurring around the same time as the onset of the sentence-final-word. Pupillary results indicate that cognitive effort remained higher for an extended period of time after the sentence was heard in the more difficult conditions. Results are interpreted as reflecting a processing delay between the input of the speech signal and the comprehension of the sentence's meaning for those who face auditory challenges.

D70 Sandbox Series - Language-specific phonological patterning shapes neural encoding of phonetic categories

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Linking neurophysiology and linguistic theory requires understanding how representational primitives are encoded in the brain (Embick & Poeppel, 2015). Advances have been made in identifying where the brain integrates acoustic information to encode phonetic categories (Yi et al., 2019), but little is known about how encoding the same phonetic categories differs based on language-specific phonological patterning (Monahan et al., 2022; Mai et al., 2024). We test how the neurophysiological encoding of the flap [r] is shaped by English and Korean phonology, using mismatch negativity (MMN), which is widely used to probe phonetic and phonological categories, and phoneme-related potential (PRP), an ERP time-locked to the onset of phonemes, with greater PRP similarity reflecting closer groupings in feature space (Mesgarani et al., 2014; Khalighinejad et al., 2017). Although [r] is allophonic in both languages, in English, it patterns with [t] as allophones of /t/, contrastive with /l/; whereas in Korean, [r] patterns with [l] as allophones of /r/, contrastive with /t/. We observed an MMN asymmetry consistent with phonological patterning, while PRP similarity aligned with phonetic features. Methods: English speakers (n = 21) participated; data collection from Korean speakers is ongoing. Stimuli were three CV syllables: [ata], [ala], and [ara]. The MMN block adopted a roving-standards paradigm, where participants heard randomly presented stimulus trains each consisting of repetitions of either [ala] or [ata] as standards followed by the deviant [ara]. This design allows direct comparison of the same deviant in different standard contexts. MMN amplitudes for [ara] were computed for both standard contexts by averaging over frontocentral electrodes within the time window (160-324ms) identified by a temporal cluster-based permutation test. In the PRP block, 70 repetitions of each of the three syllables were randomly presented. PRPs across all electrodes from 100 to 400ms were submitted to hierarchical clustering using Euclidean distance to assess neural similarity. Predictions: If phonetic encoding is shaped by language-specific phonological patterning, English listeners should show a larger MMN for [ara] following [ala] (phonological contrast) than following [ata] (allophonic variation), and greater PRP-based similarity between [ta] and [ra]. For Korean, we expected the reverse MMN asymmetry and a PRP clustering grouping [la] and [ra]. Results (English): MMNs were elicited for deviant [ara] in both standard contexts, with a significantly larger MMN when [ara] followed [ala], consistent with [r] patterning phonologically with [t] in English. Nonetheless,

PRP-based clustering showed greater neural similarity between [la] and [ra], with [ta] forming a distinct cluster, consistent with findings that PRP tracks phonetic features, particularly manner of articulation (Khalighinejad et al., 2017). The results suggest that language-specific phonological patterning shapes phonetic encoding (as indexed by MMN) but does not neutralize the influence of phonetic features (as indexed by PRP). If this pattern holds, we expect a reversed MMN asymmetry in Korean, with a larger MMN for [ara] following [ata] than following [ala], while PRP continues to show a greater neural similarity between [la] and [ra]. Together, these findings support the view that different levels of linguistic representation are underpinned by distinct neural processes.

D71 - Cochlear-scaled entropy predicts robust neural coding of speech envelopes

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During processing of connected speech, such as sentences or spoken narratives, low-frequency cortical oscillations synchronize in phase with amplitude fluctuations in the broadband speech envelope. The degree of synchronization between brain and envelope oscillations is modulated by higher-order cognitive factors, such as attention and memory, independently of the acoustic signal. This suggests that real-time encoding of speech envelopes reflects more than mere sensory transduction of fluctuations in signal amplitude. Previous research has proposed that neural tracking of the speech envelope reflects the parsing of speech primitives, such as phonemes, syllables, or peaks in the envelope derivative (rapid envelope changes, e.g., Oganian & Chang, 2019). Here, we propose neural coding of temporal speech patterns is better predicted by spectrally-local changes in relative energy within the temporal fine structure—operationalized by cochlear-scaled entropy (CSE). This metric reflects the fact that sensorineural systems respond predominantly to change. Notably, prior research (Stilp & Kluender, 2010) has shown that speech intervals with higher CSE are more critical for intelligibility than those with lower CSE. To evaluate our hypothesis, we analyzed EEG data (32 channels) from 15 native English speakers as they listened to 36 randomized repetitions of 30 sentences. Each sentence was segmented into non-overlapping time frames ranked from high to low CSE. First, we tested whether amplitude modulation is more robustly tracked during the presentation of high-CSE frames, low-CSE frames, or peak-derivative frames (time frames conveying greater and positive envelope changes per time unit). Neural tracking was assessed by correlating the speech envelopes of high-CSE, low-CSE, or peak-derivative frames with the low-frequency EEG oscillations evoked during their presentation. High-CSE frames elicited stronger neural tracking than both low-CSE and peak-derivative frames (linear mixed-effects: t -ratios > 17.24, $ps < .001$). Next, we examined the neural tracking of envelope signals reconstructed via compressed sensing from sparse temporal representations of the original sentence envelopes. Reconstructions were derived from small percentages (20%, 35%, and 50%) of high-CSE, low-CSE, peak-derivative, or randomly selected time points. We found that reconstructed envelopes based on high-CSE frames elicited significantly stronger neural tracking than those derived from the other conditions (linear mixed-effects: t -ratios > 15.73,

$ps < .001$). Together, our findings demonstrate that spectrally-local changes in relative energy of speech can drive robust cortical encoding of speech envelopes. These results support a model of temporal sparse coding in which the brain selectively enhances the processing of speech segments that convey greater informational value. By prioritizing high-CSE segments—those most critical for intelligibility—this encoding strategy enables listeners to maximize neural encoding bandwidth while minimizing intelligibility loss. References: Stilp, C. E., & Kluender, K. R. (2010). Cochlea-scaled entropy, not consonants, vowels, or time, best predicts speech intelligibility. *Proceedings of the National Academy of Sciences*, 107(27), 12387-12392. Oganian, Y., & Chang, E. F. (2019). A speech envelope landmark for syllable encoding in human superior temporal gyrus. *Science advances*, 5(11)

D72 Sandbox Series - Encoding of Grammatical Case in Human Hippocampus

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Grammar allows us to compose complex meanings out of simpler lexical elements. Formally, operations like case declension alter semantic representations that modify meaning while preserving features of the underlying concept. To understand the neural basis of case declension, we analyzed responses of several hundred hippocampal neurons in humans listening to narrative English speech. We found that case declension corresponds to a specific and consistent translation of the population semantic vector. Critically, these effects persist even after controlling for confounds such as semantic features that predict case (e.g., animacy and agentivity), word order, syntactic depth, word duration, opening nodes, closing nodes and f0. Moreover, the brain uses similar rotations for noun and pronoun declension, indicating that these processes are at least somewhat consistent across semantic category. Finally, we found that the brain uses specific distinct semi-orthogonal subspaces for different grammatically marked forms; this coding scheme allows for unambiguous semantic shift while maintaining referential consistency. We confirm these results also reflect how these grammatical compositions work in embeddings within layers derived from LLMs. Together these results offer a specific neural coding-based solution to the problem of grammatical composition.

D73 Sandbox Series - Altered phonetic representation in tumor-afflicted auditory cortex during speech perception

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Glial brain tumors form electrical and chemical synapses with healthy neurons to accelerate tumor proliferation, potentially altering local neural computations. Prior work has shown that glioma-infiltrated cortex remains similarly active during speech production but with decreased entropy, suggesting reduced information processing capacity. The current study investigates

how tumor presence affects auditory information processing in the human superior temporal gyrus (STG) during naturalistic speech perception. Subdural electrocorticography (ECoG) data were collected from tumor patients during neurosurgery. Task-related changes in high-gamma power (HGP, 70-150 Hz) were used to measure neural selectivity for phonetic features. Distributed changes in population responses were quantified by the classification accuracy of support vector machine (SVM) classifiers trained to decode phonetic categories from HGP. Preliminary results show that while tumor-afflicted areas achieve a comparable mean decoding accuracy to normal-appearing regions, they exhibit greater variability in decodability, suggesting a noisier phonetic representation. These findings align with previous research on phonetic feature encoding in human STG and provide new insights into speech information processing in the human auditory cortex. This work highlights the partial preservation of neural computation in tumor-infiltrated auditory regions, which is both scientifically and clinically significant as it offers a foundation for further understanding the mechanism of altered neural decodability as well as perceptual outcomes in patients following surgical resection.

D74 Sandbox Series - The good-enough listener: A visual world paradigm reveals the interaction between prediction and bottom-up input

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Introduction: Efficient language comprehension involves anticipating upcoming input, but unexpected input can be costly to process. Studies show that this processing cost is reduced when the unexpected word is phonologically related to the predicted word, compared to when it is unrelated. The mechanisms behind this facilitation remain unclear. According to the Spreading Activation Hypothesis, activation of a predicted word may spread to phonologically related alternatives, facilitating the retrieval of unexpected but related input. In contrast, the Misperception Hypothesis suggests that high phonological overlap between the predicted and unexpected word may lead comprehenders to retrieve the predicted word instead of the actual unexpected input, forming a “good-enough” representation. The present study tested these accounts by examining responses to phonologically related versus unrelated unexpected words in a visual-world paradigm. We found evidence for the Misperception Hypothesis. **Method:** Participants ($n = 44$) listened to Chinese sentences while viewing a display of six Chinese words. The sentences strongly predicted a specific word (“book” [书 shu1]) but continued with an unexpected, anomalous word that was either phonologically related to the predicted word through rhyme overlap (“pig” [猪 zhu1]; Experimental condition) or unrelated (“cotton” [棉 mian2]; Control condition). The visual display contained the three critical words and three unrelated distractors. The target word in the Experimental condition was used as the Control in another sentence item, ensuring that the same set of words were used across both conditions. The Spreading Activation Hypothesis predicts facilitated recognition of phonologically related words and thus more fixations on the target in the Experimental condition than in the Control condition. In contrast, according to the Misperception Hypothesis, listeners are expected to persist

with their top-down prediction until sufficient evidence overrides it, so it predicts fewer fixations on the target in the Experimental condition than in the Control condition. **Results:** More fixation on the predicted word prior to target word onset indicated prediction based on prior contextual information. Following target word onset, participants shifted their gaze away from the predicted word towards the target. Critically, this shift was slower in the Experimental condition than in the Control condition. A cluster-based permutation test was conducted in the post-target-onset (0-1500 ms) time window, using the log ratio of fixations on the target versus the predicted word as the dependent variable. The analysis revealed a significant main effect of condition in the 300-1500 ms interval (cluster mass = 406, $p < .001$), with lower log ratios observed in the Experimental condition than in the Control condition. No significant differences in log ratios between conditions were found prior to target onset. **Conclusion:** Using a visual world paradigm, we found that listeners were less likely to fixate on the target (and more likely to fixate on the predicted word) when the presented target was phonologically related to the predicted word than when it was unrelated. This finding suggests that strong top-down predictions can override bottom-up input, leading to inaccurate representations when the input is confusable with a more predictable alternative.

D75 - Revisiting Laurel vs. Yanny: insights from an online experiment and an FFR experiment

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In May 2018, a short audio clip went viral on social media, sparking widespread debate over whether it said “Laurel” or “Yanny.” The acoustic basis for this perceptual ambiguity was quickly identified as an unusually strong resonance that drops from 3 kHz to below 2 kHz, which can be interpreted either as the third formant of /ɔ/ in “Laurel” or as the second formant of /i/ in “Yanny,” depending on the listener. The basis of this perceptual variability between listeners and change within listeners remains unclear. In this study, we revisited the viral phenomenon to examine the factors contributing to these perceptual differences. A total of 598 participants took part in this online experiment. Following the approach of Pressnitzer et al. (2018), we used an 11-step audio continuum, created by mixing highpass- and lowpass-filtered versions of the original clip at varying amplitude ratios. The sixth step in the continuum corresponded to the unaltered original sound. During the main task, participants listened to each of the 11 stimuli three times in a random order and reported whether they heard “Laurel” or “Yanny” on each trial. They also reported their demographic information, whether they had previously heard the “Laurel/Yanny” clip, and, if they had, what they had heard at the time. We found a significant effect of both age and sex on the likelihood of perceiving the ambiguous sound as “Laurel.” Older participants and men were more likely to hear “Laurel” than younger participants and women. Audio equipment also played a role: participants using in-ear earbuds or over-ear headphones were more likely to perceive “Laurel” than those using computer speakers. Interestingly, among the 26 participants who had previously heard the original clip as “Yanny” only, 38% perceived it as “Laurel” in the current study. In contrast, of the 55 participants who had previously heard “Laurel” only, just one

switched to hearing “Yanny.” These findings suggest that auditory perception is shaped by a combination of stable individual traits and changing factors such as age, listening environment, and experience. In a separate part of the study, we recorded frequency-following responses (FFR) from 32 young adults listening to four versions of the stimulus: the viral clip, the original “Laurel” recording from vocabulary.com, and its highpass- and lowpass-filtered versions. Both the envelope and the temporal fine structure of the neural responses were cross-correlated to each of the four stimuli. No significant differences in neural response patterns were observed between participants with different perceptual experiences of the clip. Overall, our findings highlight the complexity of auditory perception and demonstrate how it can be influenced by a variety of biological, environmental, and experiential factors.

D76 Sandbox Series - Phonetic Encoding and Sentence Predictability in Continuous Speech

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Listeners readily use fine-grained phonetic detail—such as millisecond differences in voice onset time (VOT)—to distinguish between isolated words (e.g., GOLD vs. COLD; McMurray et al., 2002). However, in everyday speech, words typically unfold within continuous sentences. While previous work agrees that top-down predictions shape phonetic encoding during sentence comprehension, they diverge regarding the exact mechanisms. One possibility is that listeners leverage prior information from high-predictability (HP) sentential context and attend less to actual phonetic input, resulting in less veridical phonetic encoding (Manker, 2019). Alternatively, HP context helps listeners pre-activate lower-level representations, making the phonetic encoding of upcoming words more accurate (Broderick et al., 2019). To test these possibilities, this study investigates whether and how listeners dynamically adjust the precision of phonetic encoding as speech unfolds based on sentence predictability. We first manipulated English words with word-initial voiced stops (e.g., /g/ in GOLD) to create three levels of VOT ambiguity—No, Some, and Maximal—pre-selected based on a norming experiment using synthesized VOT continua of minimal pairs contrasting in voicing (e.g., GOLD-COLD). Selected VOT tokens were then spliced into audio sentences with high (e.g., The treasure hunter found a GOLD necklace) or low (e.g., The young man found a GOLD necklace) predictability context, with target word surprisal determined using GPT2. 61 native English speakers recruited from Prolific completed a cross-modal identity priming task. Participants listened to auditory sentences while making lexical decisions on visual strings, presented at the offset of the voiced target word within each sentence. There were 72 critical trials—equally distributed across three types of real-word visual strings: identical voiced targets (e.g., GOLD), voiceless competitors (e.g., COLD), and unrelated controls (e.g., RULE)—and 144 filler trials which included 36 real-word and 108 non-word visual strings. Participants were instructed to respond as quickly as possible while the auditory sentence continued. Comprehension question probes were randomly interleaved to ensure attention to the auditory sentences. A GLMM model (3 Visual Word Type*3 VOT Ambiguity Level*Target Word Surprisal) on the reaction times (RTs) of critical trials revealed a significant identity priming effect, with faster RTs for identical vs. unrelated

visual words ($\beta = -142.27$, $p < .001$). RTs for identical words were slower with: (1) increased VOT ambiguity (Some vs. No: $\beta = 107.31$, $p < .05$), and (2) higher target word surprisal ($\beta = 10.16$, $p < .05$). Crucially, a three-way interaction showed that the slowing effect of VOT ambiguity (Some vs. No) was attenuated for identical words when surprisal increased ($\beta = -13.71$, $p < .05$). These findings suggest that listeners are more sensitive to fine-grained phonetic detail in HP context, supporting the pre-activation hypothesis that top-down predictions facilitate phonetic processing. Nonetheless, contrary to this hypothesis: (1) RTs for identical words were unaffected by Maximal ambiguity in VOT, and (2) RTs for competitor words did not decrease with greater VOT ambiguity, which should enhance activation of voiceless competitors. The current finding extends prior work on spoken word recognition and calls for attention between bottom-up and top-down influences on the perception of continuous speech.

D77 - Why do children struggle with subject-experiencer verbs? A neurobiological investigation

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Introduction: Until the age of about five-and-a-half, children acquiring English have difficulty processing passive-voice sentences with subject-experiencer (SE) verbs (e.g., “hate,” “remember,” “love,” “see”), as in “Sharks are feared by Mary.” We suggest this delay is a product of neurodevelopment, such that the timing of changes in a child’s grammatical capacities can be related to developmental changes in the child’s brain. We further propose that passivizing an SE verb requires a “semantic coercion” operation on the verb’s meaning and hypothesize that this operation is supported by some region outside canonical language areas that is associated with ongoing maturational change between ages five and six. **Linguistic Analysis:** Arad (1998) argues that the default conceptualization of an SE verb can be described with a spatial contact metaphor. In our example, the experiencer MARY is “located with” a mental object FEAR, and the target of that FEAR is SHARKS. Landau (2010) argues that locative arguments are normally VP-internal; if so, this yields a syntactic structure where the experiencer is projected as a VP-internal argument. Verbs can only be passivized if they project a VP-external argument (Baker et al., 1989), meaning the default conceptualization of the SE verb blocks passivization. We suggest that one can passivize an SE verb by applying semantic coercion to obtain a more sophisticated conceptualization of the verb’s meaning, acknowledging that the mental object (FEAR) is actually something that the experiencer (MARY) possesses. The resultant syntactic derivation projects a VP-external argument (i.e., the possessor; Kratzer 1996), allowing for passivization. **Methods:** We tested our hypothesis using an fMRI study with English-speaking adults (N=32). Participants performed a fixed-pace reading task wherein they encountered sentences varying in both voice (active / passive) and verb type (SE / actional) as well as anomalous sentences. Comprehension questions followed 50% of trials. Participants also completed functional

localizer tasks to identify the language and multiple demand networks (Fedorenko et al., 2011). Results: Behaviorally, participants exhibited worse comprehension of passive sentences than active ones and worse comprehension of sentences with SE verbs versus those with actional verbs. Crucially, we found that the online processing of SE passives compared to actional passives was linked to increased activation in a relatively late-maturing region of the brain: ventromedial prefrontal cortex (vmPFC). This same region emerged in a contrast of SE passives > anomalous sentences; thus, our effect was not driven by semantic violations per se. No voice x verb type interactions were observed in regions identified by the localizer tasks, indicating that the neural correlates of SE passive processing lie outside both canonical language regions and multiple demand regions. Discussion: Notably, vmPFC has been implicated in other forms of semantic coercion (e.g., Pykkänen, 2008) and is still undergoing structural maturation between the ages 5 and 6. Thus, our findings are consistent with the proposal that comprehending SE passives involves semantic coercion of the verb's meaning. To our knowledge, this is the first study to find a "signature" of children's developmental stages in adults' functional localization for language.

D78 Sandbox Series - Now you see it... ? : Agreement sensitivity in 'at-a-glance' reading in Spanish

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[INTRODUCTION] Theories of language processing have focused on 'word-by-word' processing. How do we process language 'at-a-glance'? Whole sentences displayed for 200–300 ms are identified faster than word lists, non-word letter strings, or scrambled sentences, and EEG/MEG responses diverge 150–400 ms post-sentence onset. Proposed mechanisms include parallel activation of lexico-syntactic features, detection of basic constituent structure, or 'filtering' the percept using top-down expectations. This neural 'sentence superiority effect' (SSE) is insensitive to agreement errors in English (nurses {clean/*s} wound), which are robustly detected in EEG/MEG. This suggests 'at-a-glance' readers build less detailed syntactic parses. However, English subject-verb agreement frequently requires detection of a visually non-salient morpheme (–s, –Ø), and is a complex dependency between two phrases, dependent on an integrated sentential parse. We present pilot EEG data from a two-word parallel vs. serial presentation experiment on Spanish noun-adjective concord, a local relation marked on both words. Many nouns in Spanish inflect for gender overtly (chic-o 'boy', chic-a 'girl') while others do not (hombre 'man'), but all trigger concord on following adjectives (chic-o alt-o 'tall boy', hombre alt-o 'tall man'). Evaluating gender concord in non-transparent cases requires retrieval of the lexeme's gender. Are agreement errors in Spanish noun-adjective pairs 'noticed' in 'at-a-glance' reading? If so, does 'noticing' agreement errors occur only for transparently marked nouns (before lexical access) or also for opaque nouns (concurrent/subsequent to lexical access)? [METHODS] Spanish speakers (N = 8) read 44 sets of noun-adjective pairs; brain data recorded by 256ch MagStim EEG. We have a 3X3 design. We manipulated Transparency on word one: TRANSPARENT nouns with canonical gender inflections

(aut-o 'car' [MASC]); OPAQUE nouns without (coche 'car' [MASC]), and PSEUDOMARKED nouns ending in a vowel typically corresponding to the other gender (moto 'motorcycle' [FEM]). We manipulated Concord on word two: CONCORD, NO-CONCORD adjectives (auto rápido/*rápida 'fast car') or another noun for a LIST condition (auto camión 'car, truck'). Stimuli were presented in parallel (300ms, 500ms ISI) and serially (300ms/word, 500ms ISI) in separate blocks. Participants judged whether a second word pair matched the first (50% mismatch). [RESULTS] Spatio-temporal cluster-based permutation tests were conducted on sensor data 100–300ms from onset of word pair (parallel presentation) or adjective (serial presentation), with $p < 0.05$ threshold. During the N100-N170 complex, anterior and midline sensors showed a non-significant positivity for TRANSPARENT/CONCORD trials compared to the two ungrammatical TRANSPARENT conditions in parallel trials 100–300ms ($p = 0.07$), and in serial trials 200–300ms ($p = 0.3$). Similarly, during the N100-N170 complex, posterior midline and left lateral sensors showed a non-significant positivity for OPAQUE/CONCORD compared to the two ungrammatical OPAQUE conditions 100–150ms in parallel trials ($p = 0.2$), and a significant positivity 100–200ms ($p = 0.05$) in serial trials. No effects were observed for PSEUDOMARKED nouns. [CONCLUSION] Spanish readers may notice noun-adjective concord errors 'at-a-glance' in both transparent and opaque nouns, suggesting this occurs after or concurrent with lexical access. Failure to observe gender concord errors in pseudomarked cases, however, suggests that form-based inflectional processes and lexical access can conflict.

D79 Sandbox Series - LAN effects signalling memory retrieval in wh-islands: An experiment proposal

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Introduction: There has been a debate whether island constraints are due to language processing constraints. D-linking effects in wh-islands provide an opportunity to examine this issue. It is observed that the use of D-linked wh-phrases ameliorates wh-island violations. To account for this phenomenon, it is proposed that wh-islands are the result of retrieval interference in working memory and D-linking reduces the degree of similarity-based interference (Atkinson et al., 2016 etc.). If that is the case, D-linking is expected to modulate the ERP component - Left Anterior Negativity (LAN) which is suggested to reflect working memory load during sentence processing (King & Kutas, 1995 etc.). Therefore, it is proposed to conduct an ERP experiment to examine if the use of D-linked wh-phrases in wh-islands modulates LAN effects elicited in filler-gap dependencies. Method: 25 UCSD students who are English native speakers will be recruited to join the ERP experiment. The stimuli consist of five conditions as shown below. Participants will be presented with the stimuli in pseudo-randomized order. For each stimuli, one word will be presented at a time for 300ms followed by 300ms of a blank screen (SOA=600ms). Baseline: Did you decide whether you should tell the boss about it before the meeting? Non-island with Bare wh-phrase: What did you decide that you should tell the boss about _ before the meeting?

Non-island with D-linked wh-phrase: Which problem did you decide that you should tell the boss about _ before the meeting? Wh-island with Bare wh-phrase: What did you decide whether

you should tell the boss about _ before the meeting? Wh-island with D-linked wh-phrase: Which problem did you decide whether you should tell the boss about _ before the meeting? Proposed data analysis: To make sure the proposed experiment design can properly elicit LAN, a linear-mixed model will be used to compare the 300-600ms time window after the onset of the preposition “before” in the Baseline condition vs. the Non-island with bare Wh-phrase condition. A significant interaction between Condition and Anteriority will indicate the current experimental design can replicate LAN effects reported in previous studies. To examine whether D-linking effects in wh-islands modulates LAN effects, another linear-mixed model with the factors Structure Type, Wh-phrase Type and Anteriority as main factors will be fitted with ERP responses during the 300-600ms time window after the onset of the preposition “before” across four conditions except the Baseline condition. Expected results and implications: A three-way interaction indicating that using D-linked wh-phrases additionally reduces LAN in sentences containing a wh-island is expected. This result is parallel to the finding that D-linking modulates the degradation in acceptability of wh-island violation sentences (Villata, 2017), supporting the idea that D-linking effects are the result of facilitation of working memory retrieval. This study will provide additional evidence for accounts ascribing island constraints to language processing constraints. Moreover, it will demonstrate that LAN signals working memory retrieval underlying language processing.

D80 Sandbox Series - Neural correlates of semantic and pragmatic NPI Processing in English

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Negative polarity items (NPIs) are items such as “ever” or “any” in English which may only be grammatical in negative or non-positive contexts. For example, contrast sentences (1a) and (1b) with sentence (1c) below: (1a) No beginner pilots have ever flown that route; (1b) Only beginner pilots have ever flown that route; (1c) *Most beginner pilots have ever flown that route. In sentence (1c) above, the NPI “ever” is ungrammatical because the quantifier “most” is positive. In contrast, in sentence (1a), the NPI “ever” is grammatical given the presence of the negative operator “no”. In sentence (1b), the truth value appears “true” on the surface (beginner pilots have flown that route), but negation is introduced via negative implicature, namely “beginner pilots and no others have ever...” Therein, negation in (1b) can be considered “pragmatic” or provided by more implicit or pragmatic computation (Giannakidou, 2006). Few studies have investigated the processing of NPIs in English using electrophysiological methods such as ERPs, and only one has compared the effect of different licensors (“no”, “only”, “few”, etc.) on NPI processing. Xiang et al. (2016) compared constructions with an “explicit licensor”, i.e., “no/few/only” (collapsed over individual licensors) to an implicit licensor, i.e., “She was surprised that third graders had ever seen one before” (Xiang et al., 2016, p. 76) where negation is introduced via negative implicature, i.e., “she thought no third graders had ever...”. Xiang et al. observed a reduced N400 effect at “ever” for both the explicit and implicit conditions compared to ungrammatical sentences; NPIs under the implicit negation condition elicited a P600 effect compared to the “explicit” negation conditions. The present study seeks to investigate the processing of NPIs in English in native English speakers (n=21;

data collection ongoing) by directly comparing two different licensing conditions: a semantic condition (e.g., 1a above) vs. a pragmatic condition, where negation is introduced via negative implicature (e.g., 1b). In this sense, this study follows Xiang et al. (2016), investigating the neural differences between traditional NPI licensing under overt negation (1a) vs. “rescuing” i.e., “pragmatic licensing” by means of negative implicature (1b) (Giannakidou, 2006). Unlike Xiang et al. (2016), we directly compare the effect of two individual licensors, where (1b) should still be considered pragmatic or “implicit” in nature. We include an ungrammatical baseline condition (1c). Our predictions were twofold. First, we predicted that participants would exhibit larger N400 or P600 amplitudes in response to NPIs under the “only” condition than the “no” condition, reflecting more difficulties with licensing via negative implicature. Second, we predicted larger N400 or P600 amplitudes on ungrammatical conditions (e.g., 1c) than the two grammatical conditions collapsed over each other (e.g., 1a, 1b). Data collection is ongoing.

D81 Sandbox Series - Relationship Between Grammar and Schizophrenia: A Systematic Review and Meta-Analysis

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Background: Schizophrenia significantly impairs everyday communication, affecting education and employment. Such communication difficulties may arise from deficits in syntax—understanding, and generating grammatical structures. Research on syntactic impairments in schizophrenia is underpowered, with inconsistent findings, and it is unclear if deficits are specific to certain patient subgroups, regardless of symptom profiles, age, sex, or illness severity. Methods: A pre-registered search using PubMed, Scopus, PsycInfo, and Web of Science databases up to May 1, 2024, for all studies investigating syntax comprehension and production in schizophrenia vs. healthy controls. Excluding studies on those <18 years of age and qualitative research, we extracted Cohen's d and log coefficient of variation ratio and used Bayesian meta-analysis across 6 domains: 2 in comprehension and 4 in production in patient-control comparisons. Study quality was evaluated with a modified Newcastle–Ottawa Scale, with moderators (age, sex, study quality, language) tested via meta-regression. Results: From 45 studies (n=2,960 participants, 64.4% English, weighted mean age(sd)=32.3(5.6)), Bayesian meta-analysis show strong evidence of syntactic deficits in schizophrenia across all domains (d=0.65–1.01, overall random-effects d=0.86, 95% CrI [0.67–1.03]), with syntax comprehension being most affected, with weak publication bias.

Patients show increased variability in comprehension and production of long and complex utterances ($\ln\text{CVR}=0.21$, 95% CrI [0.07–0.36]), hinting at subgroups with differing performance. Conclusions: Robust impairments in grammatical comprehension and production in schizophrenia suggest opportunities for targeted interventions focusing on syntax, a rule-based feature amenable to cognitive, educational, and linguistic interventions.

D82 Sandbox Series - Probing LLM-brain alignment when structure dissociates from statistics

Junyuan Zhao¹, Jonathan Brennan¹; ¹University of Michigan

[Introduction] Recent proposals consider large language models (LLMs) as compelling computational models of human language processing (Goldstein et al., 2022; Schrimpf et al., 2021; Tuckute, Kanwisher, et al., 2024). Yet, structural representations which are not explicitly encoded in LLMs capture additional variance in behavioral and neural patterns above and beyond LLM-based surprisal (Huang et al., 2024; Stanojević et al., 2023). Current data appear mixed because structural factors can be largely confounded with statistics language data (Slaats & Martin, 2023) and also due to different LLM-derived measures being probed across studies (hidden layers: Schrimpf et al., 2021; surprisal: Stanojević et al., 2023). Here, we test if LLM-brain alignment in structural (syntactic and semantic) computations extends to low predictability sentences where statistics and structural well-formedness are de-confounded. To this end, we manipulate syntactic and semantic composition in English sentences while minimizing predictability. Then, we compare layer-wise LLM activation with EEG recordings as a proxy of LLM-brain alignment. [Design] We recorded 32-channel EEG while native English-speaking participants ($N = 35$) read English sentences in a rapid serial visual presentation experiment. The materials involve six conditions: (1) normal [low surprisal, +syntax, +compositional semantics, +associative semantics]: grammatical, meaningful sentences (e.g., Bright colorful flowers bloom richly), (2) syntactic prose [high surprisal, +syntax, +compositional semantics, -associative semantics]: sentences that follow English grammatical rules but lack a coherent meaning (e.g., Colorless green ideas sleep furiously), (3) Jabberwocky [+syntax, -compositional semantics, -associative semantics]: sentences that only contain (inflected) English pseudowords (e.g., Rupe sleen althes rore smountly), along with conditions 4-6 that are derived by shuffling words from 1-3. We match conditions 2-6 in terms of GPT2-xl-derived surprisal (Radford et al., 2019); $F(5, 395) = 1.60$, $p = 0.177$. Each condition has 80 items, yielding 480 critical items alongside 400 filler sentences to balance acceptability in the stimuli. Our design allows stepwise comparisons of the role of different structural factors in LLM-brain alignment. For example, comparing jabberwocky [+syntax, -compositional semantics, -associative semantics] and its surprisal-matched, shuffled counterpart [-syntax, -compositional semantics, -associative semantics] sheds light on the role of syntax in brain-LLM alignment. [Proposed Analyses] LLM-brain alignment is evaluated with a linear encoding model from LLM activations to EEG signal (Tuckute et al., 2024). The goodness of fit of this model quantifies the similarity between them. We hypothesize that if the brain and LLM similarly represent a certain linguistic factor, then goodness of fit should be similar in both the presence and absence of that factor. We

will also examine effects in time-locked EEG signal, in both the time and frequency domains (Hahne & Jescheniak, 2001; Kaufeld et al., 2020). Pilot validation analyses ($N = 10$) indicate (1) an N400 component for normal sentences vs. syntactic prose, (2) a P600 component for Jabberwocky vs. normal sentences and syntactic prose, and that (3) hidden layers of the GPT-2 model (note it is a smaller version) reliably encode information about syntax (original vs. shuffled) for all conditions, as revealed by LLM-probing (Liu et al., 2019; Marvin & Linzen, 2018).

D83 - Syntax modulates the neural response to prosody in continuous speech

Cas W. Coopmans^{1,2}, Andrea E. Martin^{2,3}; ¹New York University, ²Donders Institute for Brain, Cognition and Behaviour, ³Max Planck Institute for Psycholinguistics

In order to understand the structure and meaning of spoken language, the human brain relies on prosody. While this idea is both formally and empirically well-established, how the brain uses prosody and syntax together remains elusive. We analyzed brain activity during naturalistic spoken language comprehension to investigate both how prosody modulates the neural encoding of syntax, and how knowledge of syntax shapes encoding of prosody. For each word in 49-minutes of Dutch audiobooks, we computed two syntactic features: the number of phrases that were opened ('node opening') and closed ('node closure'). Moreover, we derived a word-based measure of prosodic boundary strength using the Wavelet Prosody Toolkit. We found a probabilistic relationship between prosody and syntax in speech: words with strong prosodic boundaries are primarily phrase-closing words, whereas weakly marked words are generally phrase-opening words. Thus, prosody probabilistically cues syntactic function, which has implications for language processing: a speaker's prosody might be able to inform the listener when to integrate a phrase, and their syntax can inform the listener when prosody will be informative for structure building. Twenty-six Dutch-speaking participants listened to the audiobooks while their brain activity was measured with magnetoencephalography. We regressed the syntactic and prosodic features onto sensor-level MEG data using forward encoding models, which controlled for the acoustic and statistical properties of the stimuli by explicitly modeling several additional features (i.e., acoustic spectrogram, acoustic onsets, word onset, frequency, surprisal). To test the interaction between syntax and prosody, we marked each word in terms of its syntactic function (phrase-opening vs. phrase-closing) and in terms of having a strong or a weak boundary. The unique variance explained by each feature was quantified via hierarchical model comparison. Both syntactic features explain unique variance over bilateral frontal-temporal sensors, consistent with neural encoding of syntax across time. The prosodic feature instead did not improve model fit, suggesting that there might not be a stable, unitary response to prosody. In a first test for interactions between syntax and prosody in the neural response, we found that node opening effects were not modulated by prosodic marking. In contrast, node closure was predictive only for words with strong boundary marking: when words are prosodically weakly marked, the brain barely responds to a word's integrative demands. A second test showed that the neural response to boundary strength was enhanced for phrase-closing words compared to phrase-

opening words. This supports the idea that the brain responds to prosody in a heavily context-dependent way: the extent to which the brain encodes prosodic features of speech depends on the potential relevance of these features for broader goals of comprehension – i.e., establishing a structured meaning in context. In sum, speech features a probabilistic relationship between syntactic phrase closure and prosodic boundary marking. Our results show that the brain utilizes this statistical correspondence for the processing of both syntax and prosody: the brain attempts syntactic integration primarily when a word is prosodically strongly marked, and it weights prosodic marking especially heavily when this marking can be syntactically informative.

Poster Session E

Sunday, September 14, 11:00 am - 12:30 pm, Field House

E1 - Language as “assistive technology” for programming: perisylvian language network encodes meaning of Python programming algorithms

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Computer programming is a recent cultural invention without specific neural adaptations. A key outstanding question is whether the language system is “recycled” by programming, and if so, what role does it play? We and others have shown that the language system is not robustly active during code comprehension. Instead, fronto-parietal reasoning systems are active when programming experts understand and write code. However, despite low activation levels, some studies found that multivariate neural patterns in perisylvian language cortices distinguish between different “control structures” (i.e., “for” loops and “if” conditionals). Here, we aim to replicate and extend this effect. Specifically, we asked whether the language network encodes format-independent representations of algorithms. We recruited Johns Hopkins undergraduate students (n=30) who completed one semester of introductory Python course. During the scan, students read either Python code or “pseudocode” passages. The pseudocode passages had similar algorithmic meanings to Python code but were written in plain English. After each stimulus presentation, participants got an input to the algorithm and a potential output, and participants judged whether the output was correct. Participants also performed matched code and pseudocode memory control tasks. We used independent functional localizers to identify the language and reasoning networks in individual participants. Univariate analysis replicated previous findings that Python code reading engaged the reasoning much more so than the language network. Pseudocode also produced stronger activity in the reasoning network relative to its control task. Despite the overall low activation in the language network, we found that neural responses to both code and pseudocode peaked earlier in the language network than in the reasoning network. Moreover, in multivariate pattern analysis (MVPA), we observed significant decoding of “for” versus “if” algorithms in individual-subject language-selective regions of the lateral temporal cortex, for both code and pseudocode. Whole-brain searchlight analyses further showed cross-decoding (trained on code and tested on pseudocode, and vice versa) in two regions associated with high-level language processing: the superior temporal sulcus

(STS) and angular gyrus (AG). These findings indicate that the language network may represent the meanings of programming algorithms in a format-invariant manner. Building on these findings, we propose that the language network may generate early, abstract “gist” representations of Python code algorithms. These “gist” representations may facilitate subsequent detailed processing in reasoning regions.

E2 Sandbox Series - MEG–fMRI Integration in Naturalistic Speech Comprehension for High Spatial and Temporal Resolution

Beige Jerry Jin¹, Leila Wehbe¹; ¹Carnegie Mellon University

Speech comprehension is a complex process that recruits multiple subprocesses – including lexical access, syntactic parsing, and semantic integration – that unfold on the order of milliseconds yet are distributed across cortical regions. Researchers have traditionally studied speech comprehension using various neuroimaging techniques. For example, MEG affords high temporal resolution, whereas fMRI provides high spatial resolution. However, a high-fidelity portrait that preserves both resolutions remains elusive. We present a transformer-based encoding framework that combines MEG and fMRI within a naturalistic language experiment to estimate latent brain source responses with high spatiotemporal resolution. We collected whole-head MEG while participants passively listened to more than 10 hours of “Moth Radio Hour” stories. A participant-specific 3 T fMRI scan was also obtained for repeats of one anchor story. To obtain fMRI responses for the remaining stories, we projected a public dataset collected on identical stimuli (LeBel et al.) onto each participant’s cortical surface via surface-based alignment and vertex-wise ridge regression. We built a transformer-based encoding model whose output represents a fixed set of cortical sources. A sliding-window self-attention enables the encoding model to leverage the preceding 10s of stimulus features, including semantic embeddings, phonemes, and acoustic spectra. Predicted source activations are (i) mapped to MEG sensors through each subject’s lead-field matrix and (ii) convolved with a canonical hemodynamic response to yield fMRI predictions. The network is trained end-to-end with a joint MEG and fMRI loss. On held-out stories, our model performs on par with single-modality baselines while simultaneously offering high spatial and temporal resolution. We validate our model with simulation experiments that show more accurate recovery of source locations than classical minimum-norm estimates. When we train our model with real data, the model learns time-locked source patterns following word onset that are a function of the word’s contextualized features. Thus, by combining the power of naturalistic experiments, MEG, and fMRI with a transformer-based encoding model, we propose a practical route to millisecond-and-millimetre brain mapping. This framework opens new avenues for non-invasively probing the dynamics of language and cognition without sacrificing either spatial or temporal fidelity, and it will be released as a package along with the MEG dataset.

E3 - Contrasting Audio and Text Transformers Reveals Unique Paralinguistic Maps in Human Cortex

Subha Nawer Pushpita¹, Leila Wehbe¹; ¹Carnegie Mellon University

The availability of new large naturalistic fMRI datasets is now letting us investigate questions about how language is processed in a realistic setting where other modalities, such as visual or auditory input, are simultaneously being perceived. In this work, we wanted to tease apart linguistic and paralinguistic information (emotion, prosody, speaker identity, conversational turn-taking, non-speech sound effects) in continuous speech and analyze the contribution of each kind of content to the brain by exploiting two sibling models that share the architecturally identical 7B-parameter LLM: Qwen2-7B-Instruct and Qwen2-Audio-7B-Instruct. Although both models share the same 7B-parameter decoder, Qwen2-Audio-7B-Instruct has an audio encoder and undergoes an extra round of audio-language alignment task learning. Its curriculum involves learning automatic speech recognition, speech-to-text translation, emotion and speaker recognition, sound-event detection, vocal sound classification, and music captioning, giving the model broad auditory exposure. Training spans 30-plus multilingual datasets, each framed with natural-language instructions that specify the task and target language, so the model learns to flexibly align sound and text under a prompt-based interface. For every episode of the Courtois NeuroMod Friends dataset (six participants, whole first season; ~9.6 h fMRI), we use the audio model (Qwen2-Audio-7B-Instruct) to transcribe the dialogue, then feed that exact transcript through the language model (Qwen2-7B-Instruct) so that both models have access to the same linguistic content, while the audio one also has access to auditory cues important for comprehending the sitcom. The procedure yields two matched feature spaces: Language space - text embeddings that capture lexical, syntactic, and semantic content. Audio-enriched space - embeddings generated by the very same decoder after it has been jointly conditioned on a spectrogram encoder and further fine-tuned on 30+ audio-language tasks. Because the decoder now co-processes acoustic features, these embeddings weave in speaker identity, prosody, emotion, non-speech sound effects, and conversational turn-taking cues alongside the lexical, syntactic, and semantic information. After anatomically + functionally aligning all brains, we build voxel-wise ridge-encoding models for each feature space and (ii) their conjunction, and perform variance-partitioning to estimate the unique explained variance of each space. The joint model predicts activity across a bilateral, symmetric network encompassing superior temporal cortex, inferior and medial frontal areas, high-level visual cortex, temporo-parietal junction, and precuneus. Crucially, the language features explain no unique variance, whereas the audio-enriched features uniquely predict responses in large swathes of temporal cortex and posterior parts (the high-level visual cortex, the temporo-parietal junction, and the precuneus). These results hint at two hypotheses: (a) paralinguistic cues—speaker, affect, prosody—are represented independently of lexical content in both language-related regions and other association regions, and (b) such cues may either provide richer scene-level context or covary with visual or other information processed in the same areas. These cases are not mutually exclusive. Our matched-backbone, transcript-controlled framework delivers a clean dissociation of “who is speaking” and “how they sound” from “what they say” in natural dialogue, and offers a general recipe for disentangling modality-specific versus modality-general signals in multimodal brain datasets.

E4 - Brain-Informed Fine-Tuning of Language Models Leads to More Powerful and Generalizable Models of the Brain

Isil Poyraz Bilgin^{1,2}, Marie St-Laurent², Lune Pierre Bellec², Leila Wehbe¹; ¹Carnegie Mellon University, ²University of Montreal

Recent work has shown that large language models (LLMs) can predict brain activity, as measured by fMRI, during naturalistic stimuli such as movies or stories (Wehbe et al., 2014; Schrimpf et al., 2021; Caucheteux et al., 2021). These studies typically use pre-trained LLM embeddings to model neural responses. However, the reverse direction, using brain recordings to guide the learning of LLMs, remains largely unexplored. This raises important questions: Can brain activity improve language model alignment? Does biologically informed training enhance linguistic performance? We address this gap using a large-scale fMRI dataset from six participants watching the first six seasons of the TV show Friends (Boyle et al., 2021). The data were collected in a within-subject design and preprocessed with fMRIPrep. Season 3 was held out as a test set to evaluate generalization to unseen neural responses, but we also used the Movie10 dataset (Boyle et al., 2021) for additional out-of-sample generalization. Each fMRI time point was aligned with the preceding language context using transcripts and a canonical hemodynamic response function (HRF). We developed a brain-aligned training framework using GPT-2 and compare three training regimes: (1) a baseline model with fixed GPT-2 embeddings aligned with a linear ridge regression encoder; (2) a brain-finetuned model, where the layers of transformers were adapted using Low-Rank Adaptation (LoRA), a parameter-efficient fine-tuning method and only the final six layers were finetuned using the brain data; and (3) a train-from-scratch model, where GPT-2 randomly initialized and trained solely on brain data. Our results demonstrated that the brain-finetuned model consistently outperformed both the baseline and the scratch model in predicting held-out brain responses. Importantly, performance improved as the amount of training data increased, indicating that brain signals offer a scalable and meaningful supervision signal. Specifically, scaling up to a training set of twenty hours of brain data led to a significant jump in performance in large parts of the cortex (including bilateral temporal and frontal), to a level that is not matched by the baseline linear model, whose performance reaches a drastically lower plateau at ten hours. Further, these results were generalized to different audiovisual stimuli from the Movie10 dataset. We note that having a dual loss (a brain prediction and a next-word prediction loss) appears essential to preserve or promote good perplexity scores, as evidenced by our observation that not including a next-word prediction loss leads to a bad perplexity score for both the scratch and fine-tuned models. These results indicate that the brain-prediction training signal is at least in part different from the next-word prediction training signal, hinting that there is a potential benefit of learning new representations when combining both. These findings support the hypothesis that brain activity encodes information that can influence LLM adaptation, but also highlight that it is not trivial to integrate this information constructively. Further, this work resulted in predictive models of brain activity that are far more accurate than those obtained using the established encoding methodology and that generalize well to out-of-training distribution stimuli.

E5 - Subcortical lesions in the left middle temporal gyrus are associated with increased overall severity of aphasia

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[Introduction] Aphasia affects multiple domains of language, including auditory comprehension, speech, repetition, reading, and writing. While lesions in widespread areas of the left hemisphere can lead to aphasia, the severity of impairment in each language domain varies among individuals. The overall severity of aphasia is a useful index to represent the extent of language dysfunction across multiple domains. However, the critical brain regions that influence the overall severity of aphasia are not yet fully understood. The aim of the present study is to identify brain regions associated with the overall severity of aphasia using voxel-based lesion-symptom mapping (VLSM) analysis. [Methods] Participants were patients registered between 2016 and 2024 at the associated hospital. Inclusion criteria were defined as follows: patients were diagnosed with aphasia, the underlying disease causing aphasia was their first ischemic or hemorrhagic stroke, the lesion was restricted to the left hemisphere, and language test results were available. A total of 39 aphasic patients were included. The Standard Language Test of Aphasia (SLTA) was used as the language test, and the overall severity of aphasia for each participant was assessed using the SLTA general score, where a lower score indicates greater severity. For patients who underwent the SLTA multiple times during the therapy, the most recent score was used for analysis. A lesion mask image for each patient was created on the standard brain template (MNI152) using MRICroGL software. All lesion mask images were visually confirmed by a certified neurologist. To explore brain regions affecting the severity of aphasia, VLSM analysis was conducted using NiiStat software. In the analysis, the following variables were used as covariates: the number of days from birth to the SLTA examination, the number of days from disease onset to the SLTA examination, and lesion volume. Voxels in which at least four patients had lesions in the left hemisphere were analyzed. The significance threshold in the VLSM analysis was set at $P < .05$ (corrected using the Freedman-Lane permutation test). Finally, neural fiber connections with the voxels identified by the VLSM analysis were estimated using BCBToolKit software. [Results] The participants' mean age was 76.6 (SD = 10.2). Their mean SLTA general score was 6.7 (SD = 3.0; range: 0–10). VLSM analysis showed that lesions in subcortical regions of the left middle temporal gyrus significantly increased the overall severity of aphasia. Voxels identified by the VLSM analysis showed dorsal and ventral neural fiber tracts extending into the frontal and parietal lobes. [Discussion] Previous studies associated lesions in the left middle temporal gyrus with auditory comprehension disorder (Bates et al., 2004). The findings of the present study, which demonstrated associations between lesions in subcortical regions of the left middle temporal gyrus and greater overall severity of language impairments, may primarily reflect deficits in auditory comprehension caused by damage to this region. Additionally, such damage may disrupt not only language comprehension but also speech, repetition, reading, and writing due to disconnection between this region and other language-related areas in the frontal and parietal lobes.

E6 - A five-factor decomposition of narrative speech in chronic aphasia and its neural correlates using lesion symptom mapping

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Introduction Narrative speech is representative of daily language use and therefore may provide insights into brain-behavioral relationships of realistic speech and language use in aphasia. Prior studies have applied dimensionality reduction to discourse samples to identify underlying deficits in narrative speech. For example, Alyahya et al. (2020) found three components (verbal quantity, verbal quality, motor speech), while Casilio et al. (2024) found four (paraphasia, logopenia, agrammatism, and motor speech). Both prior studies implicated the precentral gyrus, temporal, and frontal regions as loci associated with their respective components, with some variability in exact localization. Here we attempt to reconcile some of these differences in prior work by applying principal components analysis (PCA) on our own large dataset, followed by voxel-based lesion-symptom mapping of the resulting components. Methods We analyzed 59 controls (31M/28F; mean age 59.9 years) and 95 left-hemisphere stroke survivors (55M/40F; mean age 60.1 years; median lesion volume 74.95 cm³, mean time-since-stroke 43.3 months, mean Western Aphasia Battery-Aphasia Quotient 76.76). All participants described the WAB-R Picnic Scene and the Cookie Theft scene. For each participant, we tabulated core lemmas (based on controls), closed class words, pseudowords, unique nouns, unique verbs, other open class words (open class words minus nouns and verbs), and grammatical morphemes— all per utterance, per minute, and total. These 21 variables were reduced using PCA, with varimax rotation (patients and controls together). Anatomical lesions were traced from high-resolution MPAGE/FLAIR scans. Multivariate lesion-symptom mapping was used to examine lesion correlates of each principal component (corrected voxelwise $p < .005$ and clusterwise $p < .05$, based on 5000 permutations). Results Dimensionality reduction produced five components, which we interpret as 1) speech quantity (totals of measures), 2) speech rate/fluency (primarily measures calculated per minute), 3) grammar (primarily measures calculated per utterance), 4) phonological processing (pseudowords per minute, per utterance, and total), and 5) intricacy of speech (other open class words per minute and per utterance). When components were submitted to LSM, two were significant. “Speech quantity” yielded a significant cluster ($p = .04$, vol = 6.15 cm³, MNI $x = -39.9, y = -13.5, z = 42.3$) spanning the precentral gyrus, from the hand area through the frontal operculum. “Speech rate/fluency” yielded a significant cluster ($p = .03$, vol = 7.94 cm³, MNI $x = -29, y = -7.9, z = 5.4$) overlapping the basal ganglia and posterior insula, plus the white matter between them. Summary These findings capture additional important dimensions in discourse compared to prior studies of aphasia (for instance intricacy, representing adverb and adjective usage). Our lesion findings are partly consistent with prior studies associating the precentral gyrus with speech quantity and the basal ganglia and surrounding white matter with motor speech deficits in narrative speech. The subcortical lesion

results suggest involvement of white matter pathways in a discourse network. Future steps will be to explore structural connectivity related to our PCA findings.

E7 - Superior temporal lobe lesions are associated with typed spelling deficits in chronic left hemisphere stroke

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Acquired agraphia is common after left-hemisphere stroke. Recent work has focused on localizing specific components of a brain network associated with written language production. During spelling-to-dictation, auditory phonological input may be converted to graphemes, or matched to a long-term store of phonological/orthographic word-forms either directly or indirectly via semantics. Lesion studies of agraphia have largely focused on distinguishing components of orthographic long-term vs working memory through lexicality manipulations (real vs pseudoword). These studies have implicated the fusiform gyrus and frontal lobe in orthographic long-term memory, and phoneme-to-grapheme conversion with the angular and inferior frontal gyri. These processes are influenced by psycholinguistic characteristics of individual words, which are well-studied in reading but less in spelling. A large-scale study of psycholinguistic influences on agraphic errors has not been conducted. Here we examine psycholinguistic characteristics influencing spelling errors and their lesion correlates in a large cohort of chronic left-hemisphere stroke survivors. We studied 73 chronic left-hemisphere stroke survivors and 69 healthy controls. Anatomical lesions were traced on MPRAGE/FLAIR scans. Participants completed a typing-to-dictation task consisting of 32 real words presented auditorily (balanced for frequency, imageability, regularity). Logistic mixed-effects models examined whole-word accuracy as a function of group (patient vs control) and psycholinguistic properties (e.g. high vs low frequency) plus interactions, controlling for education, with random effects of participant and item. Multivariate lesion-symptom mapping examined lesion locations associated with accuracy, plus tails of the psycholinguistic effects (e.g. high covarying for low), controlling for lesion size and education (voxelwise $p < .005$, clusterwise $p < .05$, 10000 permutations). Accuracy was lower in patients (controls: 90%, patients: 58%; $\beta = -2.52$, $p < .001$). There were main effects of both frequency (high: 79%; low: 68%; $\beta = -1.12$, $p < .001$) and imageability (high: 78%; low: 69%; $\beta = -1.02$, $p = .017$) but no interaction by group. There was a trend of overall regularity (regular: 75% irregular: 72%; $\beta = -0.788$, $p = .089$), with an interaction of group ($\beta = 0.639$, $p = .004$). There was no frequency $\times$ regularity or frequency $\times$ imageability interaction in either group. Overall accuracy was associated with a lesion cluster encompassing mid/posterior superior temporal gyrus, including supramarginal gyrus, and underlying white matter (MNI=-54, -24, 1, volume=21.7cc). Imageability (low, controlling for high) was associated with a cluster encompassing supramarginal and superior temporal gyrus (MNI=-51, -40, 18, volume=3.4cc). We found superior temporal lesions associated with spelling errors, potentially due to disruption of semantic and phonological contributions to spelling. This contrasts with prior findings of

agraphia associated with parietal lesions, which may relate to differing task demands (here, typing-to-dictation). Psycholinguistic characteristics influenced errors similarly between patients and controls, with patients more sensitive to irregular words. We found no interaction effects of psycholinguistic features, however there were few words per category. An exaggerated imageability effect was associated with lesions to STG/SMG, suggesting low imageability words place extra emphasis on auditory-phonological representation. In the future we will examine more sensitive measures like Levenshtein-distance, examine error types and self-corrections, and apply connectome-based lesion-symptom mapping.

E8 Sandbox Series - Comprehension of action metaphors by individuals with Primary Progressive Aphasia: An ERP study in progress

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Primary Progressive Aphasia (PPA) is an atypical variant of Alzheimer's Disease, characterized by gradual and progressive deterioration of language functions (Mesulam, 2001). In the logopenic variant of PPA (lvPPA) different levels of semantic deficits can be observed alongside word finding impairment (anomia) and impaired verbal working memory. These deficits impact more complex language functions, such as combinatorial processing in sentences. One type of combinatorial process is metaphor, which involves complex association between semantically distant concepts and so far has not been explored in this population. This project aims to investigate whether the semantic deficit in lvPPA extends to metaphorical language. Past event-related potential (ERP) studies in typical younger adults (Lai et al., 2023) showed that metaphoric expressions (e.g., she grasped the idea) elicited more negative N400 than their literal matches (she understood the idea). This N400 effect, when parietally distributed, is typically associated with semantic processing. But when the effect is more frontal, it is associated with concreteness. Studies additionally reported later effects, including late positivity (LP), likely reflecting meaning integration, or late negativity (LN), thought to reflect working memory processes. The behavioral and electrophysiological data will help us to understand the level at which semantic deficit occurs in lvPPA. We hypothesize that if lvPPA process metaphor as a semantic anomaly, we should observe an enhanced parietal N400 effect. However, if individuals with lvPPA show impaired conceptual integration of metaphorical meaning, the N400 effect may be reduced or delayed. Further, in order to specifically discriminate between possible N400 effects due to concreteness (instead of semantic effort), we include a concreteness manipulation. We plan to recruit 20 adults diagnosed with lvPPA and 20 neurotypical controls, all native speakers of English aged 60 to 80. We will use 264 sentences from Lai et al. (2019), which consist of 88 sentences in 3 conditions: (1) metaphorical (The church bent the rules), (2) literal-abstract (The church altered the rules), and (3) literal-concrete (The bodyguard bent the rod). The abstract and concrete verbs were matched in word length and frequency, and conditions were matched for familiarity and predictability. Participants will read sentences word-by-word on a computer screen and respond if they make sense or not. Stimuli will also include 20 semantically anomalous filler sentences for the nonsense behavioral responses (Kiear et al., 2015). We are

starting data collection this early May. Behavioral data (accuracy to sensicality judgement task) and ERPs time-locked to the critical verbs will be analyzed in a Mixed Measures ANOVA of 2 (group) x 3 (condition). We expect that our results will clarify 1) the level at which complex conceptual deficit occurs in IvPPA, and 2) whether individuals with IvPPA process metaphors as anomalous or instead show decreased or delayed cross-domain conceptual representation. This study will offer valuable insights into figurative language processing in healthy, neurotypical older adults, and especially in individuals with PPA.

E9 - Different responsiveness to a phonological intervention in Chinese children and adults with reading disability

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Phonological intervention has been found to be effective in improving reading, however, most of the intervention studies only targeted children with reading disability (RD). However, evidence suggested that phonological deficit persists into adulthood. Therefore, it is necessary to investigate the similarities and differences in the effectiveness of phonological intervention in adults with RD compared to children with RD. This study aims to explore how age modulates the effectiveness of phonological intervention in Chinese children and adults with RD, by comparing the changes of brain activity patterns and behavioral improvement. In the current study, a four-week phonological training program (total training hours = 20) was designed which focuses on enhancing phonological awareness and improving the conversion from orthography to phonology. Participants were divided into an intervention group (21 5th-grade children and 23 adults) and a waiting control group (19 5th-children and 20 adults). Behavioral performances were measured three times: including pretest, posttest and follow-up session (three-months after the intervention) to track the development patterns. Brain activity during an auditory rhyming and a visual spelling task were recorded using fMRI before and after the intervention. We found a significant time by group interaction effect in reading including reading fluency, character naming, and 1-minute character reading; phonological awareness; and rapid naming in digits and pictures, with the intervention group showing greater improvements than the control group, sustained up to three months post-intervention. However, adults and children showed a distinct improvement pattern in a 1-minute reading fluency test: although both age groups showed significant improvement from week 1 to week 3, the improvement from week 3 to week 4 was only found in adults. Adults showed more immediate improvements in 1-minute character reading (from pre-intervention to post-intervention), while children exhibited delayed improvement in the follow-up session. Regarding brain changes, multivariate pattern analysis revealed an age by group interaction in the left IPL, driven by greater intervention effects in adults than children, suggesting greater changes in brain activation patterns in this region following intervention in adults than in children. Further investigation showed that behavioral improvements were positively correlated with activation changes in the left MTG and right FFG in adults, while in the left IFG in children, suggesting age-dependent mechanisms in response to intervention. In conclusion, even though this study confirms the efficacy of phonological intervention in Chinese adults and children with

RD, it further suggests greater responsiveness in adults than children with RD.

E10 - Neural predictive coding during naturalistic listening comprehension in dyslexia

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It is well established that learners with dyslexia typically have difficulties with phonology and sound-to-letter mappings that affect their reading ability, but deficits in listening comprehension are also common in individuals with dyslexia. While those with dyslexia effectively communicate verbally, complex linguistic tasks often reveal processing challenges beyond phonology, extending to listening comprehension. However, the sources of variability in listening comprehension deficits in individuals with dyslexia remain unclear. Guided by the phonological deficit hypothesis of dyslexia, we predicted that even during naturalistic listening comprehension, children with dyslexia may exhibit differences in the engagement of brain regions associated with phonological processing. Prior research with traditional single-word phonological assessments (e.g., rhyme judgment) has consistently shown hypoactivation in left temporo-parietal regions in children with dyslexia, relative to typical readers. Here, we explored if these traditional phonological task-based findings extend to naturalistic listening contexts. Children with dyslexia (n=73) and typically developing children (n=95), ages 7–12 (all native English speakers) listened to a naturalistic audiobook during fNIRS neuroimaging. The large, pre-trained artificial neural network GPT-2 was used to quantify each word's predictability within the audiobook context (surprisal), and we correlated the model-predicted brain activity based on surprisal with children's fNIRS-recorded brain activity to identify brain regions that were sensitive to surprisal—one reasonable way to pinpoint the complex, expectation-based processes involved in language comprehension. Using this approach, we evaluate differences between the brain activity of typically developing children vs. children with dyslexia during naturalistic listening comprehension. Results from our novel, participant-friendly and ecologically valid naturalistic listening protocol are consistent with decades of prior neuroimaging work on dyslexia that used isolated word tasks (e.g., rhyme judgment). Typically developing learners exhibited a stronger left temporo-parietal response, whereas those with dyslexia exhibited a stronger bilateral frontal and right temporo-parietal response. The findings are in line with past work and the phonological perspectives on language comprehension in dyslexia, with hypoactivation in phonology-related regions and stronger activation in frontal and right-hemisphere regions that may be compensatory. Additional insights were afforded through a forecast analysis to determine how far ahead brain regions were making linguistic predictions. Both groups' brains showed short-range language predictions (~12 words ahead), but this was detected in the left STG of typical learners and in the left IFG of those with dyslexia. Typical learners also exhibited long-range language predictions (~18 words ahead) in

the left IFG, mirroring neurotypical adults (Caucheteux et al., 2022). In contrast, children with dyslexia only demonstrated short-range prediction. Previous research has linked dyslexia to functional and anatomical deficits in left temporal regions. Despite appearing fluent in conversation, our findings suggest that children with dyslexia rely more, though not entirely, on frontal regions to compensate for inefficiencies in temporal lobe function. The study of variation in individuals' ability to predict words from verbal context at the neural level may provide new insights into the language comprehension challenges associated with dyslexia.

E11 Sandbox Series - Mismatch Negativity Responses to Speech Contrasts in Adults With and Without Developmental Language Disorder

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Developmental Language Disorder (DLD) is a neurodevelopmental disorder where individuals have ongoing difficulties with learning and using language, even though their hearing and intelligence are within normal limits and there is no obvious brain injury. While DLD has been widely studied in children, much less is known about how it affects adults, especially in how they process native speech sounds at the brain level. Understanding speech processing in adults with DLD is important because language difficulties often persist into adulthood and can impact education, employment, and social communication. Mismatch negativity (MMN), a component of event-related potentials (ERPs), is a useful tool for studying how the brain automatically detects changes in sounds. In this study, we measured MMN responses to native speech sound contrasts in adults with and without DLD to investigate possible differences in their brain processing of speech. We are recruiting participants into two groups. Thus far we have 45 typically developing (TD) adults and 10 adults with DLD. DLD classification was based on a combination of language history, and the methods described by Fidler et al., (2011, 2013; modified token task and spelling performance entered into an equation derived from a discriminant function). EEG data were recorded, using a 32-channel ActiChamp system. MMN was measured in response to within-category (e.g. /bu1/ vs. /bu2/) and between-category (/bu/ and /gu/) English speech sound contrasts presented in an oddball paradigm. ERP responses were analyzed in two time windows: MMN (100–250 ms) and LDN (300–550 ms), across 29 scalp electrodes. Results from linear mixed-effects models showed that, for MMN, there was a significant main effect of speech sound Type, indicating stronger responses to between-category contrasts compared to within-category contrasts. However, there was no significant effect of Group (DLD vs. TD) and no significant Group × Type interaction for MMN, suggesting that both groups detected speech sound changes similarly in the early time window. In contrast, LDN results revealed both a significant main effect of speech sound type and a significant Group × Type interaction. Specifically, TD adults showed larger MMN responses to between-category contrasts compared to within-category contrasts, while adults with DLD showed a reduced differentiation between the two types of contrasts. To further explore these group differences, paired-sample t-tests were conducted separately for each group. The TD group showed a significant difference between within- and between-category contrasts, reflecting strong sensitivity to speech sound differences. In contrast, the DLD

group did not show a significant difference, suggesting reduced or absent sensitivity to speech contrasts at this later stage of processing. While we are still in the process of recruiting for our DLD sample, this study shows that adults with DLD exhibit reduced neural sensitivity to speech sound contrasts compared to typically developing adults. While typically developing adults showed significantly stronger MMN responses to between-category than within-category contrasts, adults with DLD showed no significant difference between the two. These findings suggest that difficulties in discriminating phonological categories persist into adulthood in DLD, potentially contributing to ongoing language challenges.

E12 Sandbox Series - Auditory prediction and neural synchronization in dyslexia: Individual variability in mismatch negativity and auditory steady-state response linked to behavioral and genetic profiles

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Developmental dyslexia is a complex neurodevelopmental disorder characterized by persistent difficulties in fluent and accurate word recognition and reading. While group-level deficits in phonological and auditory processing are well-documented, fewer studies have examined intra-individual variability in neural processing that may underlie distinct neurobiological subtypes of dyslexia. This study investigated whether auditory evoked potentials, specifically mismatch negativity (MMN) and auditory steady-state responses (ASSRs), reveal distinct neurobiological profiles among individuals with dyslexia and whether these profiles relate to individual differences in behavioral performance and genetic variation. Based on allophonic perception and temporal sampling theory, high-density EEG recordings were collected from 27 adults (dyslexia: n = 10; control: n = 17; mean age (SD) = 20.10 (1.28) years). MMN was elicited using an oddball paradigm with the English vowel /æ/ as standard and its allophone as deviant stimuli. Difference waveforms (deviant minus standard) were averaged across 19 frontocentral electrodes. ASSRs were elicited using amplitude-modulated white noise at 2 Hz, 20 Hz, and 40 Hz. Spectral amplitude at each frequency was extracted via Fast Fourier Transform (FFT), and z-scores normalization was applied to standardize target frequencies relative to background EEG activity at 19 frontocentral electrodes. Behavioral assessments included standardized measures of phonological processing, verbal working memory, rapid automatized naming, and word and nonword reading. Repeated measures ANOVA was used to evaluate group difference and condition effects. Bonferroni correction was applied for post hoc comparisons. Correlation coefficients analyses were calculated to assess the associations between EEG indices and behavioral scores. For each participant, trial-level variabilities in MMN and ASSR responses are calculated using intra-individual SD across trials. Whole-exome sequencing (WES) was conducted on all participants. Variants were filtered based on allele frequency, predicted pathogenicity (e.g., CADD scores), and inheritance patterns. All variants were visually validated using the Integrated Genome Viewer (IGV 1.3.) Candidate genes were categorized into high-confidence (HC) and low-confidence (LC) sets based on the American College of Medical Genetics and Genomics (ACMG) guidelines. Visual inspection and z-score distributions showed substantial intra- and inter-individual variability in MMN amplitude and ASSR amplitudes. While some participants with

dyslexia demonstrated attenuated responses, consistent with impaired auditory prediction or synchronization, others exhibited intact or even enhanced responses, indicating dissociable auditory profiles not captured by group-level analyses. Correlation patterns suggested that heightened auditory change detection was associated with weaker phonological awareness and verbal working memory, whereas reduced neural entrainment was linked to slower naming and word reading fluency. Preliminary genetic findings indicated that these neural phenotypes may correspond to distinct sets of gene variants involved in synaptic signaling and neural hyperexcitability. Further variant analyses will investigate association between EEG-derived subgroups and genetic variants implicated in predictive coding, synaptic plasticity, GABAergic signaling, and cortical oscillatory regulation. These findings support the presence of neurobiological subtypes within dyslexia and MMN and ASSR as complementary markers of auditory processing differences. By integrating EEG, behavioral, and genetic data, this study provides a multidimensional understanding of dyslexia and supports efforts toward biologically informed classification and intervention strategies.

E13 - White matter correlates of attention and hyperactivity in children with Developmental Dyslexia and Attention-deficit/Hyperactivity disorder

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Introduction: Developmental Dyslexia (DD) and Attention-Deficit/Hyperactivity Disorder (ADHD) co-occur in about one-third of affected children, yet the neural basis of this co-occurrence remains poorly understood. Both conditions present with differences in white-matter (WM) organization, but it is unclear whether they affect similar or distinct pathways. We investigated the relationship between diffusion-derived metrics and measures of inattention, hyperactivity, and reading comprehension in a large cohort with a range of reading and attentional abilities. We tested (i) which WM tracts are associated with inattention, hyperactivity, and reading comprehension, and (ii) whether these tracts show microstructural differences across diagnostic groups. **Methods:** 166 participants (7–16 years) met the criteria for DD-only (n=80), DD + ADHD (n=52), ADHD-only (n=12), and typically developing (TD, n=22). Participants completed a neuropsychological battery including reading, language, attention, and executive function assessments, and underwent a 3T diffusion-weighted MRI scan. The following WM tracts were reconstructed using the pyAFQ: direct and posterior arcuate fasciculi (AF, pAF), superior longitudinal fasciculi (SLF), frontal-striatal and -aslant tracts, anterior and superior frontal callosal segments. Linear regression models were used to predict parent-reported BASC-3 Attention and Hyperactivity scores and GORT-5 Reading Comprehension scores using mean fractional anisotropy (FA) as imaging metric. All models controlled for age, sex, and intracranial volume. Planned contrasts were conducted

to assess group differences. **Results:** Group comparisons showed that the ADHD-only and DD + ADHD groups had significantly higher inattention ($F=29.09$, $p<.001$) and hyperactivity ($F=23$, $p<.001$) than both TD and DD-only groups. Compared with TD, the ADHD-only, DD-only, and DD + ADHD groups all had significantly poorer reading comprehension ($F=12.54$, $p<.001$), with no differences between the dyslexic groups. Across the cohort, greater inattention was linked to lower FA in the left ($t=-2.05$, $p=.04$) and right SLF ($t=-2.89$, $p=.004$). Hyperactivity was associated with lower FA in the anterior frontal callosal tract ($t=-2.15$, $p=.03$) and right frontal-aslant tract ($t=-2.42$, $p=.01$). Better reading comprehension was associated with higher FA in the left ($t=1.96$, $p=.05$) and right pAF ($t=3.07$, $p=.002$), left SLF ($t=2.04$, $p=.04$), and superior frontal callosal section ($t=2.09$, $p=.03$). Significant group differences in FA emerged in the right ($F=3.17$, $p=.02$) and left SLF ($F=4.25$, $p=.006$), with lower FA in participants with DD + ADHD and ADHD-only compared with TD. **Discussion:** Our analyses reveal partially dissociable WM substrates for inattention and hyperactivity, and reading comprehension in DD. Lower FA in the right SLF (and to a lesser extent, the left) was linked to inattention. This reduction was most pronounced in the co-occurring DD + ADHD and ADHD-only groups, supporting the idea of a dorsal-attention bottleneck, possibly due to delayed myelination or pruning. Hyperactivity mapped onto microstructural variation in the anterior-frontal callosal segment and right frontal-aslant tract, which may suggest involvement of inter-hemispheric and premotor control loops. Reading comprehension was associated with higher FA in key nodes of the dorsal language network, highlighting the functional separability of language and attention circuitry. These findings lay groundwork for delineating circuit-specific associations of DD and ADHD, and may inform the development of neurobiologically-grounded interventions to support the affected children.

E14 Sandbox Series - Mapping Behavior to Lesion Location in Neurolinguistics: History and The Illusive Methodology

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Lesion-to-symptom mapping (LSM) correlates brain damage location in patients with cognitive function, providing crucial evidence for understanding the neurobiology of language. Today, voxel-based lesion-symptom mapping (VLSM) using manual lesion segmentation is widely used, with automatic segmentation gaining popularity. However, there is a lack of training resources for the segmentation process. Herein, we survey the history of LSM techniques, highlighting the need for broader documentation and training materials in our field. The development of aphasiology began with research analyzing brain lesions to identify language-related cortical regions. Early researchers like Paul Broca, Carl Wernicke, and Ludwig Lichtheim used case data and autopsy correlations to link brain damage with language functions. However, their work omitted systematic methodological descriptions, limiting reproducibility. Jules Dejerine and Joseph Jules Montier made more detailed lesion observations, but much of their work remains poorly documented by modern standards. Overall, early aphasia research focused on clinical symptoms rather than precise

anatomical localization, a trend that continued into early neuroimaging. Brain imaging started with the advent of X-rays in 1896, allowing researchers to examine damage in living patients. X-rays pass through tissues, with dense structures like bone appearing white and softer tissues darker. However, X-ray images are grainy, 2D, and limited in localization, with higher radiation risks. Nearly a century later, imaging technologies like PET, CT, MEG, and MRI revolutionized clinical neurology. PET scans, developed from radioactive imaging techniques and first used by scientists at CERN, detect radiation from a tracer injected into the body to highlight metabolic activity. CT scans, invented by music industry engineer Godfrey Hounsfield, use a rotating X-ray beam to capture cross-sectional images, which can be combined into 3D images. MEG detects brain activity via tiny magnetic fields using sensitive Superconducting Quantum Interference Devices (SQUIDS). MRI uses a magnetic field to align hydrogen protons in the body, then uses radio waves to temporarily knock them out of alignment. As the protons relax, they emit signals that are detected and processed into detailed images. Functional MRI (fMRI), introduced in the 1990s, measures blood-oxygen-level-dependent (BOLD) signals to map brain activity with improved spatial resolution. VLSM involves outlining brain lesions on patients' MRI scans, then correlating lesion locations with cognitive deficits. Each technique offers superior soft tissue contrast compared to earlier methods, but with distinct advantages and limitations. PET scans provide insights into metabolic activity but involve radiation and have lower spatial resolution. CT scans are fast and effective for bone imaging but expose patients to radiation and offer poor soft tissue contrast. MEG provides excellent temporal resolution but is expensive and has limited spatial resolution. MRI delivers high spatial resolution and excellent soft tissue contrast without radiation but is slow, sensitive to movement, and unsuitable for individuals with metal implants. With advancements in neuroimaging, lesion-based study methods have become more complex. However, modern lesion mapping techniques still have limited documentation and training protocols, highlighting the need for dedicated literature on best practices. By reflecting on the historical challenges in technological improvements, we can improve current methodological practices and accessibility.

E15 - Chinese individuals learning English vowels: a hyperscanning paradigm

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Introduction Children typically have an advantage over adults when learning a new language, particularly in pronunciation. Previous researchers proposed that children's brains are more plastic and less influenced by their native language, allowing them to process non-native speech more effectively than adults. However, the neural mechanisms underlying this advantage remain unclear. Most prior studies on speech processing have adopted a single-brain approach, focusing solely on activities within individual brains and have overlooked potential neural coupling between brains. Children's proficiency in processing non-native speech might be reflected in the coupling between their neural activities with those of native speakers', resulting in higher inter-brain synchronization with native speakers. **Method** In this study, two native speakers (a Chinese native speaker and an English native speaker) and 45 participants (20 adults and

25 7-year-old children) underwent pseudo-hyperscanning fNIRS. 8 Chinese CV (consonant-vowel) syllables and 8 English CV syllables were used as stimuli. Brain activity and responses of native speakers were collected while they were listening to or speaking their respective native languages. Participants were required to complete two listen sessions (listen to materials/recordings of native speaker) and an imitation session for each language. The interpersonal neural synchronization (INS) between participants and native speakers were calculated during tasks where both parties were listening (listen-listen), both were speaking (speak-speak), or participant was listening to the recordings of the native speaker while the native speaker was speaking (listen-speak). Results Acoustic analysis showed that children imitated English syllables more closely to native speakers than adults did. Participants generally showed higher INS with a native speaker for their native language (Chinese) than foreign language (English). The linear mixed model indicated distinct patterns for Chinese and English across the three tasks. In Chinese, participants exhibited increased INS for the speak-speak and listen-speak condition than the listen-listen condition. Conversely, INS tended to decrease in the speak-speak and listen-speak condition than the listen-listen condition. Further analysis using channel-wise repeated measure ANOVA revealed that adults showed significantly greater INS between the right superior frontal gyrus (SFG) and the left superior temporal gyrus (STG) of the native speaker than children for the listen-listen condition in English, but not for the speak-speak or listen-speak condition in English. **Conclusion** The current study suggests that speaking involves greater INS than listening between the two partners when it is the native language. However, speaking a foreign language is characterized by reduced INS with the native speaker compared to listening to the language. Furthermore, children showed less INS than adults for listening the foreign language but not for speaking it. From an INS perspective, we revealed neural mechanism of foreign speech learning and how it is different in adults and children.

E16 - Speakers and typers adapt their planning strategies to meet sentence production demands

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Introduction. Sentence production in both healthy and clinical populations remains understudied relative to sentence comprehension. In particular, models of supramodal planning and control mechanisms employed during sentence production remain elusive. Here, we employ a novel task--the (Non-)Sentence Repetition Task (NSRT)--which uses a multi-phase trial design to assess supramodal syntactic competence and sentence production planning in both spoken and typed production. **Background.** Within language production research, sentence repetition tasks have revealed the Sentence Superiority Effect (Snell & Grainger, 2017)--where a sequence of words is more accurately recalled if it is a well-formed sentence than if it is not--providing a window into grammatical encoding. Furthermore, sentence planning is sensitive to demands on cognitive load (Ferreira & Swets, 2002). Repetition of ungrammatical sentences thus demands increased control relative to grammatical ones. Additionally, production modality places different demands on fluency, which can in turn impact cognitive load. **Methods.** Trials (N=60) in the NSRT occur in 3

phases: 1) auditory presentation of a sentence to judge as grammatical (N=30) or ungrammatical (N=30); 2) verbatim production of the presented sentence regardless of grammaticality; and 3) reproduction of the corrected sentence if it was judged to be ungrammatical. The stimuli used three types of morphosyntactic violations. Productions were made either via typing (N=23) or by speech (N=38). The data provide a rich corpus of language production behaviors including pauses, errors, disfluencies, and repairs. Here, we focus on two main measures of production difficulty: onset latency, and words per minute (WPM). Prior work has found that onset latency indexes the scope or difficulty of advance planning (Smith & Wheeldon, 1989). We operationalize incremental production difficulty/rate in both modalities as WPM. We predicted a tradeoff between two planning strategies: individuals who waited longer to begin production should show faster WPM due to pre-onset planning, whereas individuals who began early should show slower WPM due to the need to plan on-line. We also investigate how participants arbitrate between these two strategies as a function of production modality, phase (verbatim repetition vs. correction), and item grammaticality. Results. We found a significant inverse relationship between onset latency and WPM in both modalities. Furthermore, onset latencies were significantly slower in ungrammatical vs. grammatical sentences. By contrast, we found the opposite effect for WPM: faster production rate in ungrammatical sentences. Intriguingly, our results revealed an asymmetric effect of phase on these two measures: while onset latencies were significantly shorter during verbatim than correction, no significant difference was observed in WPM. Finally, we observed slower onset latencies and WPM when correcting sentences in speech vs. typing. Discussion. Participants exhibited a trade-off between advance planning scope and incremental production rate in both speech and typing. Participants demonstrate a similar tradeoff with slower onsets but faster WPM for ungrammatical sentences than grammatical ones. Furthermore, planning scope varied depending on both phase and output modality, whereas production rate varied only as a function of modality. These results show that individuals flexibly adapt their planning strategies to meet sentence production demands.

E17 - Modulating Video Action Naming in Healthy Adults via Intermittent Theta Burst Stimulation

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Background. Most evidence about the neural basis of action naming comes from picture-based tasks. However, recent findings suggest that dynamic stimuli, such as action videos, better capture the complexity of real-life actions and may recruit different or additional brain networks. Previous work highlights the involvement of the left inferior frontal gyrus (IFG) and middle frontal gyrus (MFG) in action naming from pictures, but their role in video action naming remains underexplored. **Methods.** We applied intermittent theta-burst stimulation (iTBS) to modulate

neural activity in the left IFG, left MFG, and a control site—the left superior parietal lobule (SPL). Thirty-six healthy young adults were randomly assigned to receive either active iTBS (n = 18) or placebo stimulation (n = 18). Participants completed video action naming tasks before and after active or placebo iTBS. We analyzed changes in response latencies and naming accuracy. **Results.** Participants who received active iTBS showed shorter response latencies post-iTBS compared to the placebo group, regardless of the stimulation site. Both groups exhibited improved accuracy post-iTBS, with greater improvement in action naming accuracy in the iTBS group, particularly after left IFG stimulation compared to left MFG. **Conclusion.** These findings offer novel insights into the cortical substrates of video action naming, confirming the relevance of frontal regions such as the IFG and MFG. To our knowledge, this is among the first studies to examine the effects of iTBS on video action naming in healthy individuals.

E18 Sandbox Series - Priming Effects in Language Comprehension and Production

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This MEG study investigates the extent to which human language production and comprehension processes share neural procedures. While many researchers claim that production and comprehension involve tightly interwoven neural processes (Pickering & Garrod 2013), it must be noted that production and comprehension have fundamentally different goals. Language production is a communication problem in which a speaker aims for their listener to develop an intended mental representation. Language comprehension is a perceptual problem in which a comprehender uses a signal to make inferences about the world. Cognitive models like the dual stream model highlight the distinctions between production and comprehension, asserting that they involve diverging neural pathways, with production utilizing the bilateral dorsal stream and comprehension utilizing the left-lateralized ventral stream (Hickok & Poeppel 2007). To investigate the differences between these processes, the current study uses a repetition priming paradigm. It has been strongly established that repetition of a stimulus leads to a reduction in amplitude of neural responses (e.g. Misra & Holcomb 2003). A possible explanation of this reduction is predictive inference – the identical prime increases the perceived likelihood of the target compared to a novel percept, reducing the ‘prediction error’ and thus, the amplitude of neural responses (Grill-Spector, Henson, & Martin 2006; Summerfield et al. 2008). If language comprehension is an inferential process that involves different mechanisms than language production, we expect priming effects to be stronger in comprehension trials because the identical prime provides information to facilitate the perception of a target rather than the endogenous planning of an action. Additionally, if the processes involve distinct physical structures, we expect the locus of priming effects to be different across comprehension and production trials. In a 2020 study, Dirani and Pykkänen observed that evoked response amplitude differences between primed and unprimed word reading trials were larger than the differences between primed and unprimed object naming trials. However, in this study, prime and target

were presented in the same modality in word reading trials, but not in object naming trials, making it challenging to isolate the effects of task. The current study extends their work using a within-subjects experimental design involving two counterbalanced experimental blocks: a primed picture naming block for production and a primed word reading block for comprehension. Trials begin with a spoken word prime in both blocks, meaning that the prime is always presented in a different modality than the target. In the comprehension block, participants read a presented word silently. Some trials are followed by comprehension questions, probing participants on whether or not they read certain words. In the production block, participants name the presented image aloud. Each block contains 150 trials. In 50 of the trials, the spoken word matches the written word/image. In the remaining 100 trials, the spoken word is unrelated to the written word/image. Data collection is already underway and MEG responses for N=8 subjects point towards differences in both the magnitude and location of priming effects across comprehension and production.

E19 Sandbox Series - Verbs as privileged cues for sentence retrieval

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Intro: In a sentence recall task, how might cues of different roles affect the retrieval of a sentence bound in episodic memory? Following work on structural priming and theories of lexicalized syntactic knowledge (Joshi & Schabes 1992, Segaert et al. 2013), we propose a privileged connection between the verb and the clause it heads, and aim to test this theory by examining sentence retrieval signals in MEG. Predictions: Verbs will be more informative cues to structure and meaning, controlling the combinatorics of the clause, e.g. differences in transitivity, verbs like 'notice' canonically require a direct object, whereas verbs like 'sit' prohibit one. Noun cues will only serve to assist retrieval of their argument position, which do not limit combinatorial possibilities as much. The relative structural informativeness of verbs then should lead to more information recollected post-cue comprehension compared to noun cues, which can be measured by activity in left Angular Gyrus (Rugg & King 2018). Because retrieved verbs and their associated structure encompass more of the 'pre-compiled' sentence, we hypothesize they will facilitate subsequent production, possibly suppressing activity in left posterior inferior frontal gyrus and left posterior middle temporal gyrus, relieved from some of their typical production computations (Matchin & Hickok 2019, Giglio et al. 2022). Materials: 150 transitive sentences and 150 intransitive sentences will be created, intransitives will include prepositional phrases for length and balancing the number of nouns present across sentences. [Transitive - The strict teacher noticed the noisy student // Intransitive - The lonely professor sat near the old dean] There will be three cue types: null (XXXX), subject, verb. Sentence-Cue pairs will be controlled for Mutual Information derived from a dependency-parsed corpus, such that any difference between conditions cannot be attributed to the statistical informativeness of the cues. Methods: Data will be collected from 25 participants using MEG. In critical trials participants will hear a sentence, complete a spoken arithmetic task to suppress phonological loop effects, then be visually cued to recall the sentence. Spoken responses will be recorded to facilitate speech-onset analyses and recall accuracy scoring.

Evoked fields will be analyzed between cue display and speech onset. Previous work on memory retrieval electrophysiology points to a time window around 500-800ms post-cue presentation (Vilberg et al. 2006, Evans & Wilding 2012) in left AG that displays a parametric response to informativeness of a retrieved memory, which we expect to correlate with cue type. We then predict any suppressed activity in left MTG and IFG should follow the onset of this time window, ~600-800ms. Interpretations, Future work: Given a reliable effect of verb-cueing we would take this as evidence for a privileged connection between a verb and its clause, though the results would equivocate between a conceptual/event representational origin or a grammatical origin. Should this methodology prove successful in eliciting different neural markers, it can be extended to other constructions that may help to distinguish between these, such as passives, transitive sentences with cognate objects, etc.

E20 - Changes in EEG beta functional connectivity during narrative listening reflect linguistic-pragmatic impairment in schizophrenia

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INTRODUCTION. Disorganization in language is a hallmark feature of schizophrenia, which has received attention both at behavioral and neural levels, with studies reporting alterations within the language network[1,2]. However, little is known about functional connectivity (FC) mechanisms underlying language difficulties[3], including higher-level pragmatic abilities, which are especially vulnerable in schizophrenia[4]. Here, we aimed to investigate FC within the language network in a group of participants with schizophrenia undergoing an ecological linguistic task, i.e., narrative listening, linking it to participants' linguistic-pragmatic profile. METHODS. We recruited 49 participants with schizophrenia based on DSM-5 criteria (Age: 38.34±12.75, Education: 11.50±2.22, Illness Duration: 16.51±11.33, Chlorpromazine-equivalent dose: 492.91±500.32), clinically stabilized and treated with the same antipsychotic therapy for at least two months, assessed for pragmatic abilities using the APACS Test[5]. Participants were engaged in a passive-listening task of a 5-minute-long narrative during EEG recording. EEG signal was acquired using a 128-channel system and underwent an automated pre-processing pipeline, including a 0.1Hz high-pass filter, 50Hz notch filter, bad channels removal and interpolation, and artifacts correction with Independent-Component-Analysis and Artifact-Subspace-Reconstruction. From source-level oscillations (computed with eLORETA), we extracted static connectivity matrices with Phase Locking Value (PLV), measuring the consistent alignment in

time of oscillations between two ROIs. We computed PLV values in five frequency bands (alpha, lower-beta, higher-beta, lower-gamma, higher-gamma) across 39 ROIs from Destrieux's cortical atlas, reflecting the Extended Language Network of narrative comprehension[6]. A representation of the pipeline is available in Figure1 (<https://tinyurl.com/4k5vdxfc>). Statistical analysis focused on the comparison between participants above the APACS total score cut-off (Unimpaired, n=16) and participants below the cut-off and with different degrees of pragmatic impairment, defined via median split as Mildly-Impaired (n=16) and Severely-Impaired (n=17). Differences in PLV values were analyzed using permutation tests (50,000 permutations) across ROIs and frequency bands (FDR-corrected). RESULTS. The Severely-Impaired group, compared to Unimpaired participants, showed a significantly reduced FC in lower-beta oscillations between the left angular and the right middle frontal gyri ($p=.023$). They also exhibited a significantly increased FC, compared to Unimpaired participants, in lower-beta oscillations between the left transverse temporal sulcus and the right posterior superior temporal gyrus ($p=.023$). See Figure2 (<https://tinyurl.com/33hsy48z>). Between-group differences remained significant after controlling for Age, Illness Duration, and Chlorpromazine-equivalent dose via linear regression analysis. CONCLUSIONS. Here, we found differences in beta FC within the language network during narrative listening, reflecting different pragmatic profiles. Our results confirm the importance of fronto-temporo-parietal connections and beta oscillations in discourse comprehension[7]. A possible explanation for changes in beta FC might be related to altered predictive mechanisms involved in language[8]. Our data suggest a link between these changes in the extended language network and pragmatic impairment in schizophrenia, supporting the hypothesis that altered predictive mechanisms at the oscillatory level underlie language disorganization in this population[3]. Our findings have implications for the neurophysiological characterization of linguistic difficulties in schizophrenia, as well as for understanding the neural underpinnings of linguistic-pragmatic skills.

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E21 - A frontotemporal network processes conceptual relatedness during spoken narrative comprehension

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INTRODUCTION. The semantic landscape of a narrative necessarily evolves over time. Listeners must, then, integrate content across multiple timescales to iteratively construct meaning. As discourse unfolds, listeners integrate incoming words with preceding context; a process linked to activity in frontotemporal regions. Whereas there is a long history of functional imaging studies of spoken sentence processing, little work has examined how the brain responds to shifting semantic

relationships between local and more global elements of spoken discourse processing. Discourse offers the opportunity to use a naturally-evolving speech stream to identify brain networks that are sensitive to the evolution of a narrative across multiple timescales. Leveraging the richness of spoken narratives is not new. However, emerging work has largely focused on measuring word-level and concept-level neural activation, leaving the jump to larger timescales largely unexplored. A useful metric by which to examine how listeners contend with an unfolding discourse is semantic distance (Reilly et al., 2023), wherein the dissimilarity between two or more concepts can be quantified. The current fMRI study modeled semantic shifts across multiple timescales using a novel n-gram measurement index that yielded distance metrics between successively larger chunks of words. Our aim was to elucidate brain regions that are sensitive to fluctuation(s) in semantic distance in naturalistic discourse. We hypothesized that larger jumps in semantic space would require additional neural support—perhaps from frontotemporal regions—not needed for making small hops. METHODS. We examined data from Mechtenberg et al., (2024), wherein a total of 79 participants listened to a 10-minute segment of the podcast Fresh Air. We calculated semantic distance of content words from progressively larger units of preceding context using the 'SemanticDistance' R package (Reilly et al., 2025). Subject-level analyses used an amplitude-modulated regressor time-locked to the onset of the second word event. For example, in the word-to-word model, values were time-locked to the onset of the second word. We included lexical frequency and phonological neighborhood density as covariates. The output, at the group-level, allows us to examine neural activation scaled to the semantic distance between gram sizes. Results were corrected for whole-brain statistical significance at the cluster level using permutation testing. RESULTS and DISCUSSION. For the word-to-word model, activity in the bilateral posterior superior temporal gyrus, bilateral fusiform gyrus, right cuneus, and left superior occipital cortex showed a negative relationship with semantic distance, such that as semantic distance increased, activity in these regions decreased. Right angular gyrus, however, showed a positive relationship with semantic distance. We interpret these findings as reflecting semantic integration at a moment-to-moment timescale, which may rely less on regions that are implicated in selective attention (e.g., Yoncheva et al., 2010) and in directing more challenging processes—such as integrating semantic content over larger chunks. The results of the larger n-gram models of semantic distance show different patterns, lending credence to the hypothesis that narrative construction may require listeners to rely on additional brain regions to support long-scale content building.

E22 Sandbox Series - The Neural Signatures of Processing Counterfactual and Open Possibilities

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Introduction: A fundamental aspect of human language is our capacity to refer to situations that are open possibilities, like “maybe he grabbed the knife”, or counterfactual, e.g., “if only he had grabbed the knife”. Such non-actual statements are common in everyday language, yet we know little about how they are mentally represented. Factual information (e.g., “Mike

grabbed the knife”) updates the mental model of the described situation to associate the object ‘knife’ with the entity ‘Mike’, increasing the accessibility of the concept ‘knife’ in probe-recognition tasks (Glenberg et al., 1987; Morrow et al., 1989; Zwaan & Madden, 2004) and eliciting increased neural responses associated with model updating (Speer et al., 2007; Tulling et al., 2021; Whitney et al., 2009). However, for counterfactual statements, situation model updating seems to be blocked (de Vega et al., 2007; de Vega & Urrutia, 2012), and both counterfactuals and open possibilities have independently been shown to lack electrophysiological responses that reflect model updating (Tulling et al., 2021; Urrutia et al., 2012). Yet, it remains unclear whether counterfactuals and open possibilities are treated similarly by the brain. This ongoing project uses the behavioral and electroencephalography (EEG) correlates of situation model updating as the lens to explore how these two types of non-actuality are represented and maintained in memory. Methods: Forty participants complete a probe-recognition task while reading six murder mysteries in French. Their accuracy, reaction time (RT), and brain responses (ERPs) are recorded. The stories are split into 30 blocks that include 72 key sentences combining three utterance types: FACTUAL, COUNTERFACTUAL, and POSSIBLE, with two object statuses: ASSOCIATED (e.g., ‘took’) or DISLOCATED (e.g., ‘dropped’). There are also 72 filler sentences and 36 distractors. Each target sentence is shown in six short, timed chunks (e.g., translated: It was | a bottle | of wine | And Mr. Green | maybe grabbed it (EEG window 1) | from the counter), surrounded by a full context and continuation sentence. After each block, a probe word appears, e.g., BOUTEILLE ‘bottle’ (EEG window 2), and participants respond as fast as possible if it occurred before. Reaction time will be analyzed with linear mixed-effects model with overall reading time and age as random factors. ERP-responses will be analyzed with a cluster-based permutation test time locked to the presentation of factual or non-actual association/dislocation (window 1), and to the probed word (window 2). Predicted results: In the FACTUAL condition, we expect a model updating effect in Window 1, 100-300ms after object association (Tulling et al., 2021; Urrutia et al., 2012). We also expect that dislocated concepts are less available than associated concepts, reflected in longer RTs in the probe-recognition task and stronger N400 responses in Window 2. For the COUNTERFACTUAL condition, we expect the opposite. For the POSSIBLE CONDITIONS we expect no situation updating and therefore expect no difference between the ASSOCIATED and DISLOCATED conditions in Window 1. Regarding concept accessibility, the question is whether both ASSOCIATED and DISLOCATED scenarios are represented simultaneously (remaining accessible), or whether only the described possibility is represented.

E23 - Cortical reinstatement during learning supports later holistic retrieval of newly learned lexical memories

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Theoretical accounts of lexical representation suggest that newly learned words are stored as multi-element units that bind form and different aspects of meaning together in memory (e.g., Perfetti, 2017). We recently provided the first behavioural evidence for these elements being retrieved holistically, showing that recalling a newly learned word form automatically evokes

all discrete elements of its meaning, and recalling one element of the meaning automatically evokes the other elements and the word form (i.e., retrieval dependency; Crowley et al., preprint). A likely neural mechanism for such holistic retrieval is hippocampal pattern completion whereby all elements of a memory are reinstated in response to a partial cue (Marr, 1971). While this mechanism is widely researched in episodic memory, no evidence to date has linked it to the integration of lexical elements during word learning. Moreover, it remains unknown whether reinstatement requires active recall or can also emerge during passive restudy. To address these issues, we recorded EEG from 64 electrodes whilst 38 native English-speaking participants learned 20 novel written word forms (e.g., flimir) paired with a picture (e.g., balloon) and environmental sound (e.g., baby crying), representing the word's multi-element meaning. These word triplets were designed to reflect how naturalistic word learning integrates information across different modalities. Participants first learned each word triplet through repeated simultaneous exposure to all three elements, and then passively restudied pairwise associations from the word triplets (e.g., balloon-baby crying). One week later, we tested memory for the pairwise associations. EEG data were analysed using general linear models in SPM v12. First, we identified cluster- and peak-level activations specific to each modality. We then assessed whether modality-specific regions were reactivated during restudy trials that excluded the relevant modality (e.g., whether auditory areas activate when participants restudy a word form and its associated picture). Activity specific to word forms was primarily found in the left superior temporal gyrus ($z = 5.65$, puncorr < .001) with this region also being reactivated during picture-sound restudy. Similarly, activity specific to sounds emerged in the left superior frontal gyrus ($z = 9.20$, puncorr < .001) and reappeared during picture-word restudy trials. Hence, EEG revealed reliable evidence of cortical reinstatement whereby non-presented elements of a lexical memory were spontaneously reactivated during restudy. Critically, the degree of reinstatement for word forms during picture-sound restudy trials predicted participants' likelihood of holistic retrieval one week later, indicating that reinstatement during restudy supports long-term lexical binding. The implications of these findings are two-fold. First, they identify a neural mechanism for how word forms and multi-element meanings become integrated in long-term memory. Second, they challenge the view that reinstatement mechanisms are exclusive to intentional retrieval and suggest that educational approaches emphasising restudy may enhance vocabulary acquisition. This work extends theories of word learning and deepens our understanding of how hippocampal pattern completion contributes to lexical knowledge being formed over time.

E24 - A vectorial code for semantics in human hippocampus

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As we listen to speech, our brains actively compute the meaning of individual words. Inspired by the success of large language models (LLMs), we hypothesized that the brain employs

vectorial coding principles, such that meaning is reflected in distributed activity of single neurons. We recorded responses of hundreds of neurons in the human hippocampus, which has a well-established role in semantic coding, while participants listened to narrative speech. We find encoding of contextual word meaning in the simultaneous activity of neurons whose individual selectivities span multiple unrelated semantic categories. Like embedding vectors in semantic models, distance between neural population responses correlates with semantic distance; however, this effect was only observed in contextual embedding models (like BERT) and was reversed in non-contextual embedding models (like Word2Vec), suggesting that the semantic distance effect depends critically on contextualization. Moreover, for the subset of highly semantically similar words, even contextual embedders showed an inverse correlation between semantic and neural distances; we attribute this pattern to the noise-mitigating benefits of contrastive coding. Finally, in further support for the critical role of context, we find that range of neural responses covaries with lexical polysemy. Ultimately, these results support the hypothesis that semantic coding in the hippocampus follows vectorial principles.

E25 - Compositional encoding by single neurons in humans during speech comprehension

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Humans are capable of conveying exceptionally complex and diverse information through language. Understanding the basic cellular building blocks by which we derive information from language or by which neurons process natural speech, however, has remained a challenge. Here, we used a rare opportunity to record from single cells in the frontotemporal cortex over prolonged durations and employed interpretable deep neural networks in combination with modeling and decoding techniques to discover detailed and diverse linguistic representations by neurons during natural speech processing. We find that whereas certain neurons preferentially tracked basic sound- or word-level features that generalize broadly across contexts, others reflected concepts that varied in content and topic from real-world events and activities to abstract ideas such as organization or time. Rather than mirroring the linguistic signals, these cells provided 'gestalt' level representations of the information being conveyed and could coarsely predict the composition of the phrases and sentences heard during speech. These cellular representations could also be projected onto a common conceptual manifold that reflected their latent structure and provided broad coverage of possible concepts as derived from natural language. Together, these findings reveal a highly scalable cellular process that could support our ability to comprehend natural speech and that could enable linguistic inputs not only to be encoded at a granular level but to also be mapped onto a coarser conceptual space that reflects their composition.

E26 - Decoding and Characterizing the Intracranial Representation of Semantic Information

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An emerging treatment for speech loss resulting from a neurological condition is a language-based brain machine interface (BMI). Current state of the art systems target the sensory-motor cortex to decode attempted speech, however, such systems would have relative difficulty distinguishing phonetically similar words like 'fork' and 'fort'. Incorporating even crude semantic information, like the knowledge that an item is a kitchen utensil rather than a building, should improve these systems' performance. Here we investigate the feasibility of this while also better characterizing neural semantic representations across cognitive tasks. We performed intracranial (sEEG and ECoG) recordings from 18 epilepsy patients while they performed a battery of 5 semantic processing tasks comprised of 3 language production tasks (picture naming, semantic category naming, and a category-fluency/noun-generation task) and 2 comprehension tasks (word-to-picture matching and semantic category matching). The comprehension tasks used both audio and text presentation of each word stimulus in different trials. The stimulus in each trial was a noun from one of 15 concrete semantic categories (tools, animals, foods, etc.). We trained linear support vector machines to classify the semantic category as well as the animacy of the item each trial within a single task based on the time-windowed high gamma power (70-150 Hz) from all channels recorded in a given patient, with ample coverage of the left-hemisphere semantic language network in our dataset. The highest performing semantic category decoder had a 79.4% accuracy (10-fold cross-validation; chance = 6.7%), while the best animacy decoder had a 100% accuracy (chance = 50%). These results are a marked improvement over prior studies such as Rogers et al. 2021 which achieved a maximum accuracy of 75% for animacy decoding. We evaluated cross-task model generalization and found that models trained on a production task generalized best to other production tasks and generalized more weakly, but still significantly, to comprehension tasks. Models trained on comprehension tasks generalized more weakly, but still significantly, across all tasks, and did so to a comparable degree to production and comprehension tasks. Note that these models are trained to discriminate between categories within a task, thus these results do not reflect, for example, generic motor-preparatory activity unique to speech. Altogether these results suggest that there is significant similarity of semantic codes between production and comprehension, but with marked differences that merit further investigation. Based on rank consistency analysis of SVM weights across ROIs, the left Inferior Frontal Gyrus contributes the strongest to semantic category decoding in our data, with other major contributions coming from the left Temporal Pole (TP), the left hippocampus, and the left posterior Middle Temporal Gyrus. The TP appears to specifically contribute more strongly to finer category decodes while the hippocampus may contribute more to superordinate (animacy) decodes. These results demonstrate the feasibility of decoding semantic information from the distributed semantic network in a way that can benefit language BCIs and reveal that some components of the neural code for semantic information are shared between production and comprehension, while some are specific to each of those.

E27 - Competing Cues in Ambiguous Speech Comprehension: The Role of Visual Competition and Linguistic Context

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Successful spoken language comprehension requires listeners to quickly resolve ambiguity, often relying on contextual cues and word-meaning frequency information to correctly comprehend words with multiple meanings (homonyms; e.g., bat as an animal or baseball equipment). Several psycholinguistic models offer different accounts of how homonyms are processed. Some propose that all potential meanings of a homonym are always accessed, regardless of contextual information (Dopkins et al., 1992). Others suggest that strong contextual constraints can prevent activation of irrelevant meanings, especially when encountered prior to the homonym. The frequency of a particular meaning (derived from speech corpora) also appears to predict meaning activation (Gardner et al., 1987). Although more frequent (dominant) meanings are generally accessed more easily, it remains unclear how these two cues to the appropriate meaning – context and meaning frequency – interact, particularly when they are in tension (i.e., context supports less frequent meaning). We used a modified (online) visual-world paradigm (Huettig et al., 2011), in which 202 participants listened to sentences containing an ambiguous target word and were instructed to select the item representing the 'correct' meaning from an array of four images presented in four quadrants of the screen. Images were presented after participants heard the target word. We measured how quickly and how accurately listeners selected the image representing the correct meaning. We manipulated whether the correct meaning was dominant or subordinate, and whether sentential context disambiguating the homonym was available before, or after, it was heard. In this initial study, we also manipulated visual competition – whether items representing both the subordinate and dominant meanings were present in the array of four items. We asked whether the mere presence of the 'incorrect' meaning in the array slows selection times, or whether slowing is only evident when the subordinate meaning is correct, and whether reaction times depend on the timing of disambiguating context relative to the homonym in the sentence. This design allowed us to assess whether visual competition interferes with meaning selection, and whether these effects are further influenced by context and meaning frequency. Both context and word-meaning frequency strongly influenced target word interpretation. Prior context and dominant target word meanings resulted in faster and more accurate target item selection. Furthermore, the benefit to accuracy when the dominant meaning was correct was smaller in the prior context conditions, likely due to a ceiling effect. Accuracy was significantly reduced when the competitive distractor was present, particularly when the target word meaning was subordinate. Notably, although competitive distractor presence influenced accuracy, it did not significantly affect reaction time on correct trials. Accuracy at selecting the target meaning of a homonym was higher, and reaction time faster, when disambiguating context was heard before (vs after) the homonym, and when the dominant (vs subordinate) meaning was correct. Intriguingly, the presence of distractors compromised accuracy (particularly when the subordinate meaning was correct), but not reaction time on correct trials.

This “all or nothing” effect – distractor presence either drove interpretation entirely, or did not affect it – requires further investigation.

E28 - Neural Dynamics and Representational Content across Abstract and Concrete Concepts

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While concrete concepts have been argued to rely on both a linguistic and a perceptual format, abstract concept representation has been considered purely linguistic for a long time (Paivio, 1991). However, more recent embodied cognition accounts claim that even abstract concepts rely on experience, namely the emotional one (Vigliocco et al., 2014). Moreover, concrete concepts have been divided into clear-cut categories derived from taxonomic information. While the literature highlighted the existence of different abstract categories (Conca et al., 2021), the distinction of these categories is fuzzy and often relies on experiment-specific measurements (Persichetti et al., 2024; Villani et al., 2019). In our study, we used MEG to record neural responses during written word comprehension, and used Representational Similarity Analysis (RSA) to correlate distributional, experiential, and taxonomic models separately on concrete and abstract word-to-word sensor and source-localised MEG responses. We investigated: (i) which information (i.e., which model) is encoded during concept comprehension, (ii) when, and (iii) where the information is encoded; in other words, the spatial localisation and the temporal unfolding in the brain of concrete and abstract concepts processing. Concrete and abstract words in the visual modality were presented to participants during MEG recording. MEG data was pre-processed, segmented around word triggers, and analysed through RSA. First, the signal elicited by each word, on both the sensor level and the source space, was used to compute word-to-word neural dissimilarity matrices (RDMs), separately for concrete and abstract words. Then, RSA was computed between the neural RDMs and model-derived word-to-word RDMs. The applied models were based on linguistic (distributional model), experiential (sensorimotor and emotional models), and taxonomic (continuous and categorical models) information. RSA results were compared between concrete and abstract concepts. We collected data from 6 participants, and data collection is ongoing. We expect significant correlations between the MEG signal and the distributional model for abstract and concrete concepts in frontotemporal linguistic regions (Hultén et al., 2021; Kaiser et al., 2022). This correlation is expected to precede correlations with the experiential models temporally (Vignali et al., 2023). Concrete concepts signal is expected to correlate with the sensorimotor experiential model in occipital and sensorimotor areas, while abstract concepts are expected to correlate with the emotional model (Vigliocco et al., 2014). Taxonomic models are expected to correlate with concrete, but we do not have strong predictions for a correlation with abstract concepts (Fernandino et al., 2022). This study, thanks to the MEG high temporal resolution, will fill the gap in the literature about the temporal unfolding of the semantic representation of abstract and concrete concepts, which has been scarcely studied until now, while providing new insights into their spatial localisation. By comparing the results between concrete and abstract concepts across multiple semantic models, we will be able to assess the significance of the different

organisational principles for each of the two domains: we will observe whether sensorimotor, affective and taxonomic principles contribute to abstract concepts processing too, and how this contribution differs in time and space compared to concrete concepts.

E29 - N400 responses to proverbs: group findings versus single case effects

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Proverbs are commonly known statements that express an advice or perceived truth. Because they are so frequently encountered, it is easy for participants with intact semantic language processing to recognize them and to detect deviating endings. Hence, they could be well-suited to study semantic processing in clinical populations, e.g., with the N400 paradigm. Nevertheless, few studies have investigated electrophysiological correlates of proverb processing. Almost none have looked at the detectability of the proverb N400 at the single-subject level. Here, we recorded ERPs while 33 healthy participants listened to common German proverbs. These had either correct endings (1) or one of two types of incorrect endings: semantically possible (2) or semantically inadequate (nonsense) endings (3). In the group analysis, we found large N400 effects with expected centro-parietal topography when comparing correct with possible or nonsense endings, but no difference in brain responses between the possible and nonsense endings. In a further analysis, we assessed the presence of the N400 at the single-subject level using a t-test and a cluster-permutation method. Depending on the method used (t-test vs. cluster permutation) and the contrast chosen (nonsense – correct, possible – correct), only between 33.3 and 63.3% of participants were identified as having a significant N400 effect, despite almost all having a numerically negative condition difference. Our results show that proverb violations are indeed suited to elicit large N400 effects on the group level. Moreover, interestingly proverbs induce very strong and specific predictions that are not even partially met by other semantically plausible endings constraining theories on the functional significance of the N400. At the same time, current single-subject analysis methods are not statistically powerful enough to reveal an N400 in each awake and neurologically intact participants, limiting its potential as a reliable clinical indicator. We will discuss ways to improve power for these single-subject analyses.

E30 Sandbox Series - Semantic Processing in Anesthetized and Awake Patients

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It has been shown that the meanings of words are encoded during language comprehension via both vectorial coding and prediction. More recently, we discovered that despite reduced perceptual processing during anesthesia, semantic processing

persists though potentially different from semantic processing in awake patients. To address this gap in knowledge, we recorded hippocampal single neuron activity using Neuropixel and sEEG electrodes from anesthetized and awake patients, respectively, during naturalistic speech presentation. Here, we compared how dense (or sparse) the codes were in the two contexts, as it may be the case that reduced firing rates and less noise during anesthesia allow for a sparser code to encode word meanings compared to awake patients. We also examined whether semantic categories are decoded similarly as a function of word frequency between awake and anesthetized patients, despite overall lower firing rates in anesthetized patients. Additionally, we analyzed whether semantic encoding systematically varies along the length of the Neuropixel probe. We found that the ability of word embeddings to predict neural activity varies with anatomical location in the hippocampus. We expect that neurons physically closer to each other have more similar embedding predictor patterns. This research provides insights into how different states of consciousness affect linguistic processing in the human hippocampus, potentially highlighting aspects of semantic processing that are apparent in varying levels of awareness.

E31 - Vision Language Model Representations Predict EEG Response to Visual and Auditory Attributes in Property Verification

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A key debate in the semantic memory literature contrasts the grounded/embodied vs language-distributional sources of our semantic knowledge. In recent years, support for distributional semantics has increasingly come from studies showing that vector representations from large language models can, to a certain extent, explain human behavior and brain data in language tasks. However, the lack of computational models of embodied semantics has made it difficult to perform comparable tests of grounded accounts. An alternative is to use multimodal language models that combine text with other sensory information (e.g., vision, sound), as their embeddings are informed by the perceptual properties of real world objects that can afford quantitative predictions regarding semantic processing. Here we use CLIP, a vision and text model, and GPT2, a model similar in architecture to CLIP's text encoder, to ask whether distributional representations informed with vision (CLIP) can explain human neural responses while controlling for contributions by purely distributional information (GPT2). We model EEG data collected from 19 participants, in a property verification task with LMER models predicting differences in EEG to visual ("red") versus auditory ("loud") words. This analysis included all TRUE responses from the task (e.g., "APPLE-red", "DYNAMITE-booms") for visual (e.g., "red", n=1373) and auditory (e.g., "loud", n=1160) property words. We measured mean voltage at each electrode in successive 100ms windows, beginning with the onset of the property word until 700ms, and fit the following five LMER models for each of seven windows. The NULL model included no lexical or semantic predictors, but only interactions of scalp-dimensions and modality type (auditory/visual) as fixed effects, and item and

subject-level random effects. The rest of the models progressively include predictors of interest in interaction with the scalp dimensions and modality. The second model is the BASE model that includes word frequency and number of letters. The third model builds on by adding GPT2 cosine distance between the concept and the property vectors to operationalize contribution from language distributional information to the predictors in the BASE model. Similarly, to operationalize contributions from visual resources, the fourth model added cosine distances for CLIP to the BASE model. The final/full model adds all the predictors. We used Akaike Information Criterion (AIC) scores for statistical model comparison considering AIC differences of 10 as robust evidence for a more likely model. Model comparison results show that the Base model improves the fit above the null model from 200-700ms, GPT2 improves over Base 0-400 and 500-700ms, and CLIP improves over Base from 200-700ms. The full model improves over the GPT2 model and the CLIP model across all windows except the first one (i.e. 0-100 ms). This suggests that human semantic representations in this task are informed both by the statistical regularities of a word and by its associated visual properties. Superior performance of GPT2 in the first 100ms may support the proposal that early word processing is sensitive to pure distributional information.

E32 - The influence of task type on ERP effects in the PWI Paradigm

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Many studies have utilized the Picture-Word Interference (PWI) paradigm to study lexical selection and production. These studies often report typical N400 priming effects (reduced N400s) in identity conditions (e.g., the word "DOG" with a picture of a dog) and faster reaction times (RTs) for related versus unrelated pairs. However, semantic conditions (e.g., the word "CAT" with a picture of a dog) often report behavioral interference (slower picture naming RTs) for related versus unrelated pairs but still typically show priming on the N400 (i.e., larger N400s for unrelated than related word-picture pairs). A recent study by Holcomb et al. (2025) examined this incongruity between behavioral and event-related potential (ERP) data in the semantic condition using a RT based analysis. Each item in the semantic condition was grouped based on their average RT with items that showed faster RTs with related versus unrelated primes in the facilitation bin and RTs showing the reverse were placed in the interference bin. Using this novel scheme, we found a polarity reversal in the N400 for the interference RT trials, potentially indicating traditional ERP analysis may obscure effects reflective of interference behavior. However, it is still unclear why interference occurs. Some propose interference occurs during lexical selection, others during production. To better understand when and why this interference behavior occurs, this study explores how task intention modulates these effects. In both experiments, participants engaged in a typical PWI paradigm with 120 word-picture pairs shown twice, once with a related prime word and once with an unrelated prime. Sixty of the pairs were in the identity condition and 60 in the semantic condition. In Experiment one, participants pressed one button every time they saw a vegetable picture (about 16% of the stimuli) and

another for any non-vegetable picture. Experiment two used the same stimuli, but the task was to press one button every time they saw a related prime picture pair and another if the pair was unrelated. Experiment one revealed significant priming effects only in the identity condition, and not the semantic. When examining bins formed based on the interference RT items from Holcomb et al. (2025), ERPs did not reveal any priming effects, while the comparable facilitation RT bins revealed a strong positivity in the late N400 window with significantly more negativity for related versus unrelated pairs in the 700-1200ms window. In Experiment two, priming effects appeared for both the identity and semantic conditions, as well as in the facilitation and interference RT groups. Together, these results indicate that task affects early stimuli processing. Further, without the requirement of production, interference effects in the interference RT bins disappear, indicating that the intent to produce a word plays a key role in the resulting interference.

E33 Sandbox Series - ERP Investigation of Semantic Organization in Bilingual Mandarin-English Adults

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Research suggests that native language impacts semantic organization in the bilingual brain. For example, adult native English monolinguals tend to favor taxonomic relationships (e.g., "dog-cat") over thematic ones (e.g., "dog-bone") (Mirman et al., 2017). However, native Mandarin high schooler bilinguals learning English show a preference for thematic relationships in Mandarin and taxonomic relationships in English (Li et al., 2009). These findings suggest linguistic and cultural factors can influence semantic organization. However, the role of second-language proficiency and potential neural correlates remains unclear. This project explores the neural mechanisms underlying these effects in highly proficient Mandarin-English bilinguals. We recruited thirty native Mandarin-speaking college students from Beijing Normal University with high English proficiency. All participants complete a Language History Questionnaire to assess their language proficiency and experience prior to undergoing the EEG task. Participants completed a word association task in both Mandarin and English while EEG was recorded. The task required them to select, as quickly and accurately as possible, the "most semantically related" word-pair from triads that included a target word (e.g., dog), either a taxonomically (e.g., cat) or thematically (e.g., bone) related word, and an unrelated word (e.g., book). Behavioral measures included accuracy and reaction time (RT). Based on the literature, we predicted language-dependent effects on thematic vs. taxonomic processing (faster, more accurate, lower N400 (an index of semantic processing) for thematically related pairs in Mandarin, reversed in English). Our preliminary results show higher accuracy for thematic relationships in both languages, with no RT differences. This suggests thematic associations may be more salient for proficient Mandarin-English Bilinguals, even in English. Planned EEG analyses will determine if neural responses reflect this behavioral preference as we predict lower N400 amplitudes for thematic relationships, regardless of language, or whether language-specific modulations emerge. By combining behavioral metrics with neural indices this research enhances understanding of how language experience and cultural components shape semantic processing and will investigate

whether bilinguals' semantic categorizations are rooted in conceptual structures or in neurolinguistic processes. The findings of this research hold important implications for language instruction and clinical interventions, by suggesting that focusing on associations best suited to an individual could improve second language learning and therapeutic strategies for bilingual aphasia.

E34 - Bottom-up and top-down propagation of residual information across the left fronto-temporal cortex during sentence comprehension: Converging evidence from M/EEG and predictive coding simulations

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Introduction: Following the presentation of unexpected words, a bottom-up sweep of neural activity propagates from the left temporal to inferior frontal cortex between 300–500 ms, giving rise to the scalp-recorded N400. Within a predictive coding (PC) framework, this activity is posited to reflect a bottom-up residual error signal—lexical-semantic information within the bottom-up input that was not predicted by the prior context. In high-constraint sentences, the N400 to plausible unexpected words is often followed by a late frontal positivity (LFP) between 600–1000 ms. Recent MEG evidence has linked this later response to the reactivation of inferior frontal and temporal regions, but with a reversed dipole orientation, consistent with a reversal in information flow. Although the LFP is canonically evoked by plausible words that disconfirm top-down predictions, it can also be evoked by unexpected words in low-constraint contexts, provided they receive sufficiently prolonged processing. The present study asks (a) whether LFPs in low-constraint contexts similarly reflect late top-down reactivation of fronto-temporal regions, and (b) whether a single PC model can account for LFPs evoked by unexpected inputs in both high- and low-constraint contexts. **Methods and Results:** M/EEG. We recorded M/EEG from 31 native English speakers as they read 210 low-constraint sentences ending with unexpected words and 210 high-constraint sentences ending with expected words (600 ms SOA). ERPs revealed robust N400 and LFP effects to unexpected (vs. expected) sentence-final words. MEG source localization revealed an evoked response across left temporal and inferior frontal regions between 300–500 ms followed by a reactivation of the same regions from 600–1000 ms with the reversed dipole orientation. **Simulations.** To simulate these effects, we implemented a two-unit PC model of lexico-semantic processing, adapted from the visual system. The model received either top-down pre-activation or no pre-activation, followed by bottom-up inputs that corresponded to 1) expected words, 2) high-constraint unexpected words, or 3) low-constraint unexpected words. Relative to expected words, both types of unexpected words elicited larger bottom-up residual error whose rise-and-fall dynamics mirrored the timing of the N400. Additionally for the unexpected words, this was followed by top-down residual error whose dynamics mirrored the LFP. The larger top-down residual error to high-constraint unexpected vs. low-constraint unexpected words encoded mispredicted semantic information present within higher-level states that was absent from lower-level lexical states. In contrast, the larger top-down residual error to low-constraint unexpected vs. expected

words encoded newly-activated, higher-level semantic information that was not already encoded in the lower-level lexical states ("postdiction"). In both cases, however, this top-down residual error was propagated down from higher to lower levels of the hierarchy as the PC algorithm converged over time. **Conclusions:** These findings support a PC account of language comprehension, in which early bottom-up residual errors propagate up the cortical hierarchy, followed by later top-down feedback to reconcile mismatches between levels.

E35 - Late Frontal Positivities during self-paced reading are sensitive to lexical predictability, not misprediction: Evidence from EEG and Predictive Coding simulations

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INTRODUCTION: It is well established that predictable words evoke smaller N400s relative to unpredictable words. Within a predictive coding (PC) framework, the N400 can be simulated as bottom-up residual error, i.e., information within the input that has not been reconstructed (predicted) by higher levels. In studies with unexpected (but plausible) words that disconfirm strong predictions, the N400 is often followed by a late frontal positivity (LFP, 600–1000ms). In PC, this response may reflect top-down residual error, which contains "mispredicted" information at higher levels that does not appear in the input. A challenge, however, is that LFPs can also be observed in less constraining contexts, where mispredictions are unlikely to occur. While the conditions that produce LFPs remain unclear, they are often seen during self-paced reading—possibly because self-pacing encourages active engagement with each word. When present, these LFPs are sensitive to lexical predictability (smaller, less positive-going LFPs to more predictable words). Here, we ask (1) during self-paced reading of short stories, are LFPs routinely evoked by all content words, and (2) can we reconcile both LFP patterns within a single PC framework? **METHOD AND RESULTS:** (ERPs) We recorded EEG while participants (N=22) self-paced through short, engaging vignettes. We measured the N400 (300–500ms, centroparietal sites) and LFP (500–1000ms, frontal sites) evoked by each content word. Predictability was operationalized using an online cloze task (N=361). Linear mixed effects models revealed an effect of Predictability (target cloze probability) but not Misprediction (the probability of the most common "mispredicted" word) on the N400, replicating its sensitivity to cloze and insensitivity to contextual constraint. We found similar patterns on the LFP with smaller (less positive-going) responses to more predictable target words (regardless of the degree of mispredicting). **(Simulations)** We implemented a PC model of lexico-semantic processing. To simulate lexical predictability, top-down activation was fed into the highest conceptual level, while bottom-up input was presented to the lowest orthographic level. N400s and LFPs were operationalized as the magnitude of bottom-up and top-down residual error (RE), respectively, as the PC algorithm converged. In all simulations, the bottom-up RE (simulated N400) was sensitive to predictability and not

misprediction. In contrast, the effects of predictability and misprediction on top-down RE (simulated LFP) varied depending on the number of iterations over which top-down and bottom-up inputs were presented, as well as the extent of overlap between these phases. For longer durations of top-down pre-activation and bottom-up presentation, the pattern of top-down RE mirrored the LFP effects from our self-paced ERP experiment (larger LFPs to less predictable inputs). This top-down RE effect arose because newly activated, unpredicted higher-level semantic information was retroactively propagated to lower-level lexical states that had not yet encoded it. In contrast, when the model was given limited time to process the input, the pattern of top-down RE more closely resembled patterns of LFPs observed in previous experimental studies using faster RSVP, i.e., the simulated LFP was primarily sensitive to misprediction. In our model, this was due to continued propagation of mispredicted higher-level representations to the lower lexical level.

E36 Sandbox Series - Neurocognitive Signatures of Reinforcement Learning Proficiency: Behavioral and Electrophysiological Insights

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Individual differences in reinforcement learning (RL) proficiency may have important implications for second language (L2) acquisition, particularly in adults, where successful learning often depends on efficiently processing corrective feedback and adapting linguistic representations (Ellis, 2006). However, the neurocognitive mechanisms that underlie individual differences in RL proficiency—and their potential impact on feedback-driven language learning—remain poorly understood. Therefore, this study presents preliminary findings from an ongoing project using an RL task to examine behavioural and neural signatures of RL proficiency, focusing on how performance aligns with established neural markers of feedback processing from prior studies (Tobias et al., 2014; Eisma et al., 2021; Giustiniani et al., 2020; Cavanagh & Frank, 2014). More importantly, the established paradigm will lay the groundwork for future analyses linking RL mechanisms to L2 acquisition within the same cohort, whose language data are currently being collected. Forty young adults participated in the experiment. In the RL task, participants stopped a moving dot (90°/s) at a target location on a circle, with each point linked to a certain probability of reward (+1) or penalty (-1). Reward probabilities were linearly distributed, with the highest probability at the reward centre (80%) and the lowest (20%) at the opposite end. Each participant completed 120 trials, with feedback displayed on the monitor after a 1-second delay. Participants were divided into two RL proficiency groups based on learning trajectories, with positive curves indicating high proficiency and negative curves indicating low proficiency. We then examined whether RL proficiency modulated neural responses, focusing on event-related potentials (ERPs) and oscillatory activity time-locked to the feedback onset. A significant interaction between groups and outcomes (reward vs. penalty) was observed in feedback-related negativity (FRN) amplitude ($p = 0.0143$), with the low RL proficiency group showing greater FRN amplitude differences between the two outcomes. Time-frequency analysis of frontal theta power also revealed a significant interaction between groups and outcomes ($p = 0.045138$), with the low RL proficiency group again

exhibiting greater frontal theta power differences between the outcomes. Interestingly, both groups showed enhanced P300 amplitude in response to rewards compared to penalties ($p < 0.00001$) during feedback processing. FRN reflects early, transient feedback processing. The low proficiency RL group exhibited hyper-reactivity to penalties and overfocused on negative feedback. In contrast, the high proficiency RL group showed balanced feedback processing and faster feedback-based learning. Frontal theta power indicated increased cognitive control demand in the low RL proficiency group, while the high RL proficiency group showed more efficient feedback processing. The enhanced P300 amplitude to rewards suggests increased motivation and attentional focus on positive outcomes during feedback processing. These findings suggest that RL proficiency is reflected in distinct neurocognitive profiles. By establishing an RL paradigm sensitive to individual neural differences, this work lays a foundation for future investigations linking feedback-based learning mechanisms to second language acquisition. While analyses directly connecting RL proficiency to L2 outcomes are pending, the current findings highlight the importance of efficient feedback processing and adaptive learning strategies—mechanisms likely to be crucial in language learning contexts.

E37 Sandbox Series - Mapping idiographic affective interpretations to brain activity using semantic embeddings

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Emotions are critical to our everyday information processing, yet capturing moment-to-moment fluctuations in these multi-system responses poses a unique challenge. When processing complex stimuli like narratives, emotional responses integrate both exogenous information from the environment and endogenous representations shaped by individual differences in internal homeostatic states, past experiences, and future goals (Ashar et al., 2017). This integration results in highly idiosyncratic interpretations across individuals (Chang et al., 2021). Unlike sensory experiences which can be directly linked to external stimuli, emotional experiences cannot be locked to specific elements in the external world, creating a fundamental methodological challenge: asking participants to report on their internal states disrupts the ongoing experience of their internal states, yet such probing remains our only window into understanding them. As a potential solution, we propose a novel computational framework that captures individuals' idiosyncratic affective interpretations during naturalistic movie viewing by combining collaborative filtering with advances in natural language processing. Participants (N=122) watched 8 emotionally engaging audiovisual stories in the form of autobiographical narratives while undergoing fMRI. Following fMRI scanning, participants were presented with transcripts of each story and asked to indicate which moments in the story affected them the most and were asked to make comments on their internal states and thoughts in these moments. We extracted semantic embeddings of each response using a BERT Sentence Transformer (384 dimensions; Reimers and Gurevych, 2019). Next, for each embedding dimension, we performed data imputation using collaborative filtering to create a dense participant-by-time-by-embedding dimension tensor

using the Neighbors toolbox (Jolly et al., 2022). For each participant, we computed distance correlations (Székely et al., 2007) between time-by-time representational dissimilarity matrices (RDMs) derived from the semantic embeddings and from brain activity in each region of interest (ROI) from a k=50 whole brain parcellation (de la Vega et al., 2016). This approach relates patterns of semantic similarity in participants' affective interpretations to patterns of neural activity similarity across time points. Ultimately, by mapping these time-varying semantic representations to multivariate brain activity, we can identify which brain regions encode state transitions in emotional processing as approximated by the language model embeddings of participants' subjective responses. Across all stories, we find preliminary evidence for associations between participants' idiosyncratic interpretations to the narratives and dynamic fluctuations in several brain regions, including the vmPFC, the lateral occipital/temporal occipital cortex, and the temporal occipital fusiform area. These results support prior work that has demonstrated that the vmPFC is involved in affective appraisals (Chang et al., 2021). Additionally, we observe story-specific regional activations that vary based on narrative content. This approach provides a proof of concept of how sparsely sampled subjective interpretations can be used to reconstruct a more complete picture of dynamic emotional experiences while minimizing disruption to the ongoing experience. While additional validation is needed, these preliminary findings have potential implications for understanding the neural basis of idiosyncratic emotional processing and the links between participants' interpretations and the semantic content of the narratives themselves.

E38 - Language Entropy and White Matter Connectivity: dimensional approach to bilingual experience

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Introduction: Bilingualism has been linked to cognitive effects that extend beyond the language domain (Bialystok et al., 2012), with evidence also pointing to structural brain changes associated with the use of more than one language (Tao et al., 2021). For instance, Pliatsikas et al. (2014) reported effects in white matter (WM) integrity among late bilinguals compared to monolinguals, with higher fractional anisotropy values in the corpus callosum, in the inferior fronto-occipital fasciculus (IFOF), superior longitudinal fasciculus and uncinate fasciculus. However, most previous research has approached these neurocognitive adaptations within a categorical framework (bilingual vs monolingual), potentially oversimplifying the complex bilingual experience. Adopting a dimensional perspective may provide an enhanced comprehension of its impact on the brain. Therefore, we aim to explore the relationship among WM and language entropy, a measure based on Information Theory that quantifies the uncertainty and diversity in bilinguals' use language across different communicative contexts (Gullifer & Titone, 2021). **Method:** Data from 164 healthy right-handed participants (mean age = 22.16 ± 2.69) who had completed a language use questionnaire and underwent an MRI diffusion Tensor Imaging (DTI) were analysed. The number of streamlines was extracted following the automatic tractography procedure outlined by Radwan et al.

(2019). As measures of multilingual use, we calculated an average of self-rated proficiency across all languages known and a global language entropy for each participant as the average of entropy estimates from family and social contexts items regarding most recent years. **Results:** Bivariate correlations were conducted to examine the relationship between language entropy and potential covariates. A significant positive correlation was found between education level and language entropy (Spearman's $r = 0.185$, $p < 0.05$). Generalized linear models were then constructed, controlling for sex, gender, and fluid intelligence (measured with matrix reasoning test), with a focus on brain regions previously identified in Pliatsikas's study. Among these regions, only the left IFOF showed a significant improvement in model fit when measures of multilingual use were included. Furthermore, the inclusion of language entropy alongside multilingual proficiency further improved model fit, suggesting that greater structural connectivity in the left IFOF, as indicated by the number of streamlines, may be associated with both higher multilingual proficiency ($z = 2.024$; $p = .044$) and increased diversity in multilingual context ($z = 2.089$; $p = 0.038$). Given the IFOF's role in semantic processing (Nogueira et al., 2025), these results may reflect a neural adaptation to optimize semantic processing, which could be linked to the need to enhance cognitive flexibility and semantic control in response to linguistic unpredictability in multilingual context. *Valeria Mosqueda Cáceres and Tatiana Davydova contributed equally to this work.

E39 Sandbox Series - Neural signatures of non-native video learning: proficiency-specific strategies revealed by neural coupling and encoding

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Higher education has seen exponential growth in international students learning in a non-native language. However, current neurocognitive research on bilingual processing has overwhelmingly focused on isolated words or sentences, leaving the mechanisms supporting non-native comprehension of complex, real-world content largely unexplored. In this study, we examine how learners with varying English proficiency levels process and comprehend naturalistic, college-level educational video. Participants included native English speakers ($n = 16$), high-proficiency ($n = 17$), and medium-proficiency non-native speakers ($n = 19$). All participants viewed a ~12-minute English video lecture during fMRI acquisition. The instructor was also scanned while delivering the lecture, serving as a neural model of content delivery. Intersubject correlation (ISC) analyses were performed (a) within the three learner groups and (b) between learners and the instructor, focusing on three networks implicated in video learning: the language network, the multiple demand (MD) network, and the default mode network (DMN). Support vector machines (SVMs) classified learners by proficiency based on ISC patterns. We also employed neural encoding models using GPT-2 embeddings as a proxy for idealized linguistic representations to examine how well learners' brain responses aligned with the lecture content. Behaviorally, native and high-proficiency groups showed comparable performance and outperformed the medium group,

who also reported more unknown words, which further negatively predicted learning. fMRI results revealed that ISC in semantic areas of the language network was highest in native learners and lowest in the medium group, with ISC negatively associated with unknown word count. The MD network showed higher ISC in non-native groups, with neural synchrony in the high-proficiency group associated with learning outcomes. In the DMN, ISC was highest in the native group and also predicted learning. Classification based on ISC features achieved 81% accuracy for both the language and MD networks, and 62% for the DMN, indicating robust group-specific neural signatures of engagement. Teacher-student ISC analyses revealed that delayed coupling in the right IFG and angular gyrus predicted learning in the native group. In contrast, for medium-proficiency learners, delayed coupling in the left IFG and posterior temporal lobe correlated negatively with unknown words and positively with learning. Neural encoding analysis indicated that, in native learners, prediction accuracy in the left IFG and MFG positively predicted learning, whereas in both non-native groups, accuracy in the left ATL predicted learning. Together, these findings reveal distinct neural strategies for video learning across proficiency levels. Native speakers exhibited more homogeneous semantic processing, with learning supported by teacher-student coupling in the right hemisphere and by neural tracking of linguistic structure in left frontal regions, suggesting a balanced reliance on syntactic, semantic, and integrative cues. Medium-proficiency learners showed reduced synchrony in semantic areas but relied more on left-lateralized semantic processing, particularly with limited lexical knowledge. High-proficiency non-native learners exhibited stronger MD engagement, suggesting greater cognitive effort and flexible resource allocation. These results underscore differentiated neural mechanisms that support non-native video learning and highlight the need to tailor multimedia educational strategies to individual learners' linguistic and cognitive profiles.

E40 Sandbox Series - Cortical Tracking of Code-Switching in Naturalistic Speech Perception: Insights from Spanish-English Bilinguals

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Code switching is a critical tool for successful communication between bilingual speakers with overlapping linguistic backgrounds, aiding speakers in contextual adaptation and enhancing listener understanding (Beatty-Martinez et al., 2020; Rayo et al., 2024). In this ongoing study, we have investigated the impact of code-switching on neural correlates of speech perception for a cohort of simultaneous Spanish-English bilinguals from the US-Mexico border region. Specifically, we evaluated how code-switching impacts cortical tracking of speech, an electrophysiological readout of acoustic and linguistic encoding during comprehension (Meyer et al., 2020; Obleser & Kayser, 2019). We recorded 64-channel EEG while healthy adult participants (current n = 23) listened to three naturalistic passages (~3 minutes each) that were constructed so as to contain approximately 50% Spanish content & 50% English. Intra-sentential switching and inter-sentential switching were embedded in each passage with equal frequencies of occurrence. Using a forward modeling approach (Crosse et al., 2016), we quantified cortical tracking of the broadband (1-25Hz) and narrowband envelopes in the delta (1-3Hz), theta (3-5Hz)

frequency ranges, which correspond to the rate of phrases and words in the continuous speech stream (Lakatos et al., 2008). Preliminary findings indicate significant word tracking in the theta band, which predicted characteristics of participants' language usage history. Specifically, increased bilingual speaking experiences improved speech tracking, while increased hearing exposure to participants' second language decreased speech tracking. These findings suggest that speaking experiences may provide a more flexible neural architecture that may be better suited for unpredictable linguistic dynamics of bilingual communication. However, listening exposure may lead to a more rigid auditory model that may be monolingual-centric, resulting in less efficient speech encoding when codeswitching occurs. Planned additional analyses will evaluate the impact of code-switching type and the direction of the switch (Spanish to English vs. English to Spanish) on cortical tracking, as well as how such factors impact encoding latencies as evidenced by multivariate temporal response functions. These findings inform understandings of neural function for bilinguals when listening to naturalistic speech that contains code-switching. Future work may build upon these findings by evaluating the relationship between code-switching and cortical tracking of self-produced speech.

E41 Sandbox Series - Wait, who said that?: Talker accent modulates neural processing of Mandarin-English code-switched speech

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Code-switching, the act of using multiple languages in a single speech utterance, typically results in behavioural (Thomas & Allport, 2000; Costa & Santesteban, 2004; Fricke et al., 2016; Olson, 2017) and neurophysiological costs (e.g., N400, LPC; Fernandez et al., 2019; Yacovone et al., 2021). That said, anticipatory phonetic cues reduce behavioral switch costs (Shen et al., 2020). Additionally, foreign accented speech, which contains language-specific phonetic cues, modulates neurophysiological responses to otherwise unexpected speech patterns (Hanulíková et al., 2011). Here, we ask whether bilingual listeners process code-switched sentences differently when speaker accent varies. Using EEG, we observe a sustained negativity to English-to-Mandarin code-switches in North American accented speech compared to Mandarin accented speech. More specifically, there was a contrast in the response to code-switched and unilingual speech to the North American talker, but no difference to the Mandarin talker. Participants (n = 15) listened to English sentences with and without Mandarin code-switches produced by a North American- or Mandarin-accented talker, while their neural activity was recorded using a 32-channel whole-head EEG. In half of all audio stimuli, the entire sentence was spoken in English, while in the other half, a sentence-medial noun was spoken in Mandarin, while the rest of the sentence was in English; for example, e.g., He did his homework on the school bus or He did his zuòyè (homework) on the school bus. We predicted an N400 and possibly a LPC for code-switched stimuli, but not for unilingual stimuli, consistent with switch costs seen in prior research (Fernandez et al., 2019; Yacovone et al., 2021). We expected Mandarin-accented sentences to induce relatively smaller N400 effects compared to Canadian English-accented ones, as listeners use cues available in the accent to anticipate the switch. Preliminary results show no clear N400s or LPCs.

However, a sustained negativity (similar to Gosselin et. al, 2022) was observed in the Canadian English accented code-switched condition as compared to the Canadian English accented unilingual condition, possibly indexing a switch processing cost. In contrast, there was no ERP difference present between the Mandarin accented code-switched and unilingual conditions. We infer that the talker accent does influence switch processing, and that the Mandarin accent may ease English-to-Mandarin switch processing. Hence, talker accent modulates the neural processing of code-switched speech, indicating that accent helps bilingual listeners anticipate switches and ease processing demands. This supports a lack of associated switch cost in naturalistic settings, consistent with some recent code-switching research (Blanco-Elorrieta and Pykkänen 2017). This research provides insight into the neurophysiological mechanisms underlying code-switching, deepening our understanding of phonetic variation and cross-linguistic interactions in the multilingual brain.

E42 - The Neural Bases of Theory of Mind: The Role of Language Profile

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Theory of Mind (ToM), or the ability to felicitously assign mental states to others, has previously exhibited sensitivity to individual differences in verbal memory, working memory, executive control, and bilingual status. Though there is a robust literature on bilingual children exhibiting enhanced performance on tasks engaging ToM (Schroeder, 2018), recent studies reveal that these trends extend into adulthood; bilingual adults reliably outperform monolinguals on belief reasoning and director task trials in which an egocentric bias must be overcome (Rubio-Fernández & Glucksberg, 2012; Navarro & Conway, 2021), a signature of ToM proficiency. However, it is yet unclear whether this is owing to domain-general cognitive efficiency that has variably been reported for bilinguals or increased perspective taking abilities as a result of sustained contact with multiple languages and, by extension, multiple cultures. Using EEG, the present study seeks to characterize the neural processes that underlie adult ToM performance and to discern how individual differences in language background and cognitive control contribute to the modulation of these processes. Early Spanish-English bilingual (current n=23) and English monolingual (current n=16) young adults completed a belief reasoning task (Guan et al., 2018) during EEG recording. Short vignettes in which visual scenes were accompanied by auditory narrations were presented. Critical trials depicted object-transfer scenarios; in false-belief (FB) trials, a transfer causing incongruence between the participant's perspective and that of the vignette protagonist takes place, while true-belief (TB) trials feature a transfer that permits participant and protagonist perspectives to remain congruent. To explore individual differences in linguistic profile, all participants completed the Language History Questionnaire 2.0, allowing for the later extraction of language entropy measures (Gullifer & Titone, 2020). An adaptive flanker task during EEG recording was administered to explore individual differences in inhibitory control. In line with previous findings (Meinhardt et al., 2012), preliminary data reveal a sustained late (400–1350ms) centro-

posterior positivity or Late Positive Complex (LPC) for the perspective disambiguation point of FB relative to TB trials, indexing a reorientation of resources from external observation to internal knowledge about another's mental state. Though the LPC is attested for all participants, the component's differential sensitivity to FB vs TB trials differs by language group. The difference in LPC amplitude between FB and TB conditions is largest for bilinguals, reflecting increased sensitivity to the FB trials. Additionally, the point at which the two conditions diverge in the ERP signal is also earlier for bilinguals, suggestive of efficiency in resource reallocation. These findings provide preliminary evidence that bilingual experience modulates the neural mechanisms underlying ToM, particularly during the processing of belief-incongruent scenarios. The enhanced, earlier LPC observed in bilinguals suggests not only greater sensitivity to others' mental states but also increased efficiency in redistributing cognitive resources to disambiguate perspective conflicts. Future analyses will explore the roles of individual differences in language entropy and cognitive control in FB resolution to discern by which means language experience is modulatory of social-cognitive processing.

E43 - Grammatical Gender and Number Agreement in Spanish Heritage Speakers: An ERP study

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Heritage speakers (HS) are bilingual users who typically acquire a minority language at home as their first language along with a societal language as the second language in formal school settings. Despite being the most representative group of bilinguals in the US (AAAS, 2017), they are the least studied group. HS may vary in proficiency in the heritage language due to limited opportunities to develop literacy skills in it. In Spanish, the heritage language under study, HS vary in their ability to establish grammatical gender agreement when compared to "native" homeland controls (Keating, 2022). What is often overlooked is how Spanish HS' grammatical gender processing might compare to highly proficient L2 learners of Spanish. The comparison is of interest because both groups are English dominant, yet differ in how they acquired Spanish. While HS acquire Spanish early in life in a naturalistic environment, L2 speakers acquire Spanish beyond early childhood via formal education. We hypothesize that differences in Spanish acquisition will result in different neurophysiological patterns. Previous research on L2 Spanish learners suggests that highly proficient learners exhibit more native-like P600 responses to gender violations (Rossi et al., 2014). While studies that examine Spanish HS' processing of grammatical gender agreement using online methods are currently emerging, electrophysiological studies on the topic are scarce. This study seeks to fill in that gap by examining Spanish HS' sensitivity to grammatical gender and number agreement in clitic pronouns. A secondary goal of the study is to examine the role of individual differences in language proficiency in moderating the neural responses of different violations. Methods: 26 Spanish HS from Southern California read sentences in four conditions via RSVP as their EEG was recorded (Rossi et al., 2014). The conditions

were: correct gender and number agreement (e.g., “Después de lavar los cuchillos, Andrea los colocó en la mesa del comedor” (After washing the knives, Andrea placed them on the dinner table), gender violation (e.g., ... Andrea las...), number violation (e.g., ... Andrea lo...), and a double violation (e.g., ... Andrea la...). Each sentence was followed by a grammaticality judgment and a comprehension question. Preliminary results suggest that relative to the baseline condition, gender violations elicited a lexico-semantic N400 as well as a left-anterior negativity (LAN), while number and double violations elicited P600 responses. The LAN effect from the preliminary data suggests HS’ exhibit an automatic grammatical gender sensitivity but no later P600 reanalysis. In contrast, number violations and double violations elicited only later reanalysis, suggesting less reliance on faster automated processing. These findings evince the importance of using highly sensitive methods that capture the nuances that come with the heritage language experience. Future Directions: Data collection is ongoing to assess the effects of individual differences. We predict that individuals with higher Spanish proficiency will elicit more P600 effects, while individuals with lower Spanish proficiency will elicit more N400 effects.

E44 - The role of speech reading during visual word processing in hearing children: an fMRI study

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Speech reading, or the ability to identify speech components from visual cues of the face, contributes to the development of phonological awareness which in turn supports reading acquisition. The left superior temporal sulcus (STS) is a key region known to be involved in multisensory integration of speech stimuli. Previous studies have shown a behavioral relation between speech reading and reading skill, and separately, engagement of the STS in audiovisual integration for speech reading and word reading. No prior study has directly demonstrated that speech reading mechanisms in the STS are related to word reading skill. This study’s research questions, hypotheses, and analytical plan were pre-registered on OSF prior to data analysis. Using functional magnetic resonance imaging (fMRI) we evaluate the role of the left STS in 10- to 16-year-old hearing children (N=39) during a speech reading localizer task to measure visual-to-phonological mapping which requires converting mouth movements into likely phonemes. To identify the voxels most sensitive to phonological processing, we computed a voxel-wise regression of the activation in the left STS during the speech reading task with a standardized measure of phonological awareness collected outside of the scanner. The top 1000 voxels from this analysis formed our functional STS mask of interest. We then examined 1) how these identified voxels were engaged in a visual word-rhyming task in the scanner that requires grapheme-to-phoneme mapping, 2) whether these voxels were related to individual differences in a standardized measure of reading skill. We further investigated 3) whether the activation in the left STS and its association with reading skill is selective to phonological processing in comparison to semantic processing and 4) in a set of behavioral analyses, the relations between performance on

the in-scanner tasks and measures of phonological awareness and word reading skill. Across a series of pre-registered and exploratory analyses, we report three main findings. First, the left STS, functionally localized using an independent speech reading task, was significantly engaged during a visual word-rhyming task. Second, there was weak evidence that the activation of the left STS during word-rhyming was related to word reading skills. Third, there was strong evidence that reading skill was more strongly related to phonological processing than to semantic processing in the STS. Overall, our study adds to the growing body of evidence that better reading skill in children is supported by more robust engagement of specific phonological mechanisms, including those conveyed by visual speech gestures. Moreover, our results show that this relation is facilitated by the left STS – a key region for multisensory integration of various linguistic stimuli. These findings contribute to the current knowledge of the development of reading abilities and how neurobiological mechanisms of speech reading moderate the improvement of these skills.

E45 - Semantic representations in the prefrontal cortex: insights from single-cell recordings in humans and monkeys

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Semantic information is essential for navigating and interacting with the environment, not only in humans but also across many animal species. It is thought that key components of semantic processing systems are evolutionarily conserved, given the shared need to extract similar types of information from a certain stimulus. While prior studies have explored neuroanatomical similarities across species, semantic representation at the level of single neurons remains poorly understood. To address this gap, we conducted single-unit recordings from homologous regions of the prefrontal cortex—areas involved in semantic processing and categorization—in macaque monkeys (n = 2) and human participants (n = 3) undergoing awake neurosurgery. During the recordings, participants were shown images spanning a wide range of semantic categories, valences, and themes. To facilitate cross-species comparison, matched sets of images were used. Human participants also heard spoken sentences reflecting similar semantic content. We derived vectorial representations of each stimulus using two approaches: (1) BERT-based sentence embeddings of descriptive labels and (2) a set of 14 behaviorally relevant attributes, encompassing sensory, motor, spatial, temporal, affective, social, and cognitive dimensions, rated by participants via Amazon Mechanical Turk. These vectors were employed for clustering stimuli and modeling neuronal responses. Neurons selective to specific semantic domains were identified in both species. Decoding analyses revealed that both human and macaque neuronal populations encoded semantic information in strikingly similar ways. However, we also observed species-specific variability in how semantic domains were organized and mapped within population-level response patterns. These differences suggest evolutionary divergence layered upon a conserved hierarchical framework for semantic representation. Together, these findings offer novel insights into the single-

neuron and population-level coding of semantic information, illuminating both conserved mechanisms and species-specific adaptations in the neural basis of meaning.

E46 Sandbox Series - Neural substrates of orthographic coding in skilled deaf readers.

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Deaf individuals lack access to auditory phonology and may rely more on visual-orthographic processing to develop proficient reading ability. However, the details of orthographic coding, specifically how they represent letter position versus identity, remain unresolved. Furthermore, it is unclear whether enhanced visual processing in deaf readers is domain-specific (limited to language) or extends to other symbolic systems like digits. This study addresses three questions: (1) Can auditory deprivation be compensated by hyper-precise orthographic coding? (2) Does this precision mechanism prioritize position-based or identity-based letter encoding? (3) Is enhanced visual processing common to both linguistic and non-linguistic domains? By comparing skilled deaf and hearing readers, we investigate whether deaf individuals recruit similar or different neural mechanisms for orthographic processing. Participants (25 prelingually deaf and 25 hearing adults matched for reading ability) completed a fMRI same-different perceptual task (adapted from Carreiras et al., 2015). Participants judged whether two sequentially presented four-character strings (containing either letters or digits) were identical or different. By manipulating the internal characters of the four-character strings we created three experimental conditions: Identical (e.g., KGBT→KGBT), Transposed (e.g., KGBT→KBGT) or Replaced (e.g., KGBT→KPRT). We will use linear mixed-effects models to investigate the transposition cost, operationalized as the difference in reaction time (RT) and accuracy between Transposed and Replaced conditions, across groups and character types (letters/digits). Similarly, we will analyze the fMRI data to inspect neural differences in the transposition cost effects between groups and character types. ROI-level functional connectivity analysis will be conducted to examine network-level differences. Behaviorally, hearing readers should show greater transposition costs (slower RTs, lower accuracy) for letters than for digits, in line with Carreiras et al. (2015). Based on preliminary data, deaf readers seem to display a similar pattern as hearing readers suggesting that any between-group difference in transposition cost effects is small or non-significant. However, if deaf readers employ a more rigid orthographic coding strategy, particularly with regard to position, they may exhibit faster RT and/or higher accuracy in Transposition condition than hearing readers. At the neural level, we anticipate that deaf readers will show greater involvement of the right hemisphere during general character processing compared to hearing readers, likely driven by the reorganization of the language network due to sign language knowledge. If deaf readers exhibit hyper-precise orthographic coding we expect to see distinct activation associated with letter and digit processing within the ventral occipitotemporal cortex (vOTC) for deaf compared to hearing readers. Additionally, if deafness induces neural reorganization due to greater reliance

on visual information, we predict a unique profile in the vOTC, along with altered connectivity with other regions, such as the superior parietal cortex, which plays a role in letter position coding. Preliminary results will be presented at the SNL conference. This study offers insights into reading development in sensory-deprived populations and how neuroplasticity accommodates diversity of linguistic experience.

E47 - Compensatory Reading Networks in Dyslexia: Revisiting the Dorsal-to-Ventral Shift Hypothesis

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Dyslexia is a common neurodevelopmental disorder affecting reading speed and fluency. Some individuals with dyslexia exhibit increased fluency reading inverted text, though the reason for this advantage remains unknown. We hypothesize this advantage may reflect altered reading network development in dyslexia, preserving reliance on parietal regions involved in mental rotation. Typically, as reading skill increases, activation shifts from dorsal regions, such as inferior parietal lobule (IPL), to ventral regions such as the visual word form area (VWFA) on the fusiform gyrus. Given that VWFA is hypoactive in dyslexia, continued reliance on dorsal structures in young adults with dyslexia may support an inverted text advantage. This study examined connectivity between dorsal and ventral structures during upright and inverted text reading using high-density electroencephalography (EEG) and behavioral measures in young adults with and without dyslexia. Young adults (18-35 years) with (DYS, N = 22), and without (TD, N = 24) dyslexia completed a modified version of the Gray Oral Reading Test (GORT-5), reading aloud with half the stories presented normally and half upside down. Average text deviations, self-corrections, time, and percentage of comprehension questions correct were recorded. High-density EEG recordings consisted of objects, words, and sentences presented at 0°, 90°, and 180° rotation. Connectivity analyses between bilateral fusiform gyrus, IPL, and inferior frontal gyrus (IFG) were conducted using Granger causality. GORT-5 performance was used to calculate inverted text advantage by calculating the absolute difference between average errors on inverted and upright stories ("inversion effect"). Participants with an inversion effect less than one standard deviation from the mean (0.38) were classified as "good inverters" (N = 5 in DHS). Correlations between Granger causality values and task performance revealed a trend toward a negative association between right IPL and right fusiform connectivity during inverted sentence reading and magnitude of the inversion effect ($r = -0.46$, $p = 0.062$) in the DHS group. During inverted word reading, a significant negative correlation was found in DHS good inverters between right IPL and right fusiform connectivity and magnitude of the inversion effect ($r = -0.97$, $p = 0.006$). Paired t-tests revealed that during word reading, the DHS group exhibited greater connectivity between left IPL to left fusiform for upright words ($p = 0.012$), but greater left IPL to right fusiform connectivity for inverted words ($p = 0.010$). In DHS good inverters, both left IPL to left IFG and right IPL to right fusiform were more active during upright word reading ($ps \leq 0.040$). As

opposed to continued dorsal pathway reliance, individuals in the DYS group may recruit a right hemisphere ventral pathway for inverted text reading and differ in reading efficiency and reliance on this pathway. The DYS good inverters appear to utilize a more efficient right hemisphere ventral pathway, which may explain their reduced inversion effect. In contrast, the DYS group exhibits a shift from a canonical left ventral pathway for upright words to a bilateral ventral pathway for inverted words. These results provide support for the development of compensatory right hemisphere reading networks in dyslexia.

E48 - Neural Specialization for Word Recognition in Monolingual and Bilingual Children

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Children's literacy development is closely tied to the fine-tuning of neural systems for language. As children develop, these systems become increasingly specialized for processing language meaning and structure. Cross-linguistically, this neurodevelopmental process may be influenced by learning to read in different types of orthographies. For instance, as compared to English, Chinese emphasizes character meanings at the level of lexical morphology, whereas Spanish relies more heavily on phonology and sound-to-letter mappings. Neurodevelopmental theories, such as Interactive Specialization, suggest that interactions between the competing neural systems and their interactions with the environment and the learning experiences shape the developing neurocircuitry (Johnson, 2011). Bilingualism is a common variation in learning experiences. Cross-linguistic transfer theories posit that experiences with structurally distinct languages and orthographies can influence children's emerging neural and cognitive architecture for learning to read (Chung et al., 2019). Guided by these frameworks, we asked two questions. First, how is children's reading fluency related to neural specialization for meaning and structure (i.e., the ventral and dorsal pathways) in bilingual and monolingual children? Second, how does bilingual experience with structurally distinct home languages interact with young bilingual children's emerging neural specialization for learning to read in their primary academic language? We predicted that children with stronger reading skills would show greater specialization along the dorsal and ventral neural pathways for learning to read. We further hypothesized that Chinese-English bilinguals would exhibit stronger specialization along the ventral system, whereas Spanish-English bilinguals would show stronger specialization along the dorsal system. To test these predictions, we examined young English monolinguals, Chinese-English bilinguals, and Spanish-English bilinguals (N=286, n ≈ 100 per group, average age = 7), attending English-only U.S. schools, with heritage language exposure maintained through family and community programs. During Functional Near-Infrared Spectroscopy (fNIRS) neuroimaging, children completed English-language phonological onset-rime detection and lexical root-compound morphology tasks, designed to engage the dorsal and ventral pathways, respectively. Our findings regarding specificity partially supported our predictions. More fluent readers demonstrated stronger activation in the left dorsal IFG during phonology and stronger activation in the left posterior STG and angular gyrus during morphology. Notably, across all groups,

the morphology task elicited greater engagement of language networks than the phonology task. This is likely because morphological processing draws on both phonological segmentation and lexico-semantic retrieval. These results suggest that while morphology engages broader language systems, better readers show more targeted neural specialization for the subprocesses of language. In terms of bilingualism, Chinese-English bilinguals showed the strongest specificity effects, with enhanced left pSTG activation during morphology and stronger left supramarginal gyrus activation during phonology. These findings advance theoretical perspectives on language and literacy by revealing how distinct language subprocesses recruit specialized neural pathways and how this specialization is linked to reading proficiency. The findings further advance bilingualism perspectives by illustrating how language-specific structures influence the development of neural pathways through cross-linguistic transfer. The findings thus help inform cognitive and neurodevelopmental perspectives that aim at explaining literacy development across languages and learners.

E49 - Associations between Self-Reported Reading Experiences and Reading Accuracy after Stroke

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Introduction: Approximately 68% of people with aphasia present with reading deficits after stroke (Brookshire et al., 2014), which may lead to a lower quality of life (Hilari, 2011). Patient-reported outcome measures for aphasia are limited in their assessment of reading (Swinburn et al., 2019). To our knowledge, no studies have examined whether self-reported reading ability and activity relates to reading scores after stroke. Before-stroke reading ability and activity might provide resilience to stroke-related reading deficits, but this has also not previously been tested. To address these gaps, we examine relationships of self-reported reading experience and ability before and after stroke to oral and silent reading tasks in adults with chronic left-hemisphere stroke. Methods: Participants were 52 individuals with left-hemisphere stroke, primarily in the chronic phase. Participants completed an oral word reading task and two silent reading tasks (lexical decision and word-to-picture matching) along with matched auditory versions. Participants also completed a novel functional reading task that assessed reading comprehension in simulated real-world scenarios, e.g., finding key information on a pill bottle. In addition, a reading questionnaire was administered to evaluate participants' ease, frequency, and enjoyment of reading before and after stroke, both at home and at work. For this study, we focused on at-home scores since many stroke survivors did not return to work. Non-parametric correlations examined relationships of self-reported reading with age, education, and lesion volume. Partial correlations examined relationships between the reading tasks and reading questionnaire scores, controlling for age, education, and lesion volume. Results: Self-reported ease of reading after stroke was inversely related to lesion size. Self-reported enjoyment of reading both before and after stroke was related to education level. Controlling for age, education, and lesion size, self-reported before-stroke reading ability and activity was not

significantly correlated with accuracy on the reading tasks. In contrast, self-reported ease of reading after stroke was positively correlated with the oral and silent reading tasks, and, at an uncorrected threshold, also with auditory word-to-picture matching. Ease was not correlated with the functional reading task. Accuracy on the functional reading task was significantly correlated with all of the silent and oral reading tasks as well as their auditory versions. Conclusions: A short patient-reported outcome measure about at-home reading appears valid, in that it relates to silent and oral reading accuracy after stroke. This questionnaire has potential applications in clinical practice to assess at-home reading ability and activity. We expected self-reported before-stroke reading to relate to reading ability after stroke, but did not find this effect above and beyond the role of education level in reading after stroke. We also introduced a new functional reading measure. This measure was unrelated to self-reported reading outcomes, perhaps because the outcomes reflected reading of text such as emails and books and not the goal-directed reading required for the functional tasks. Future work will need to examine the validity of this measure.

E50 - Letters from home: Parent-child correspondence in reading achievement

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Background/Goals: The intergenerational transmission (IGT) of linguistic and cognitive skills is influenced by diverse genetic and environmental factors and their interactions. Neurobiological and cognitive research has identified sex-dependent and sex-independent patterns of parent-child transmission. Drawing on data from the NIH-supported Intergenerational Neuroimaging of Language and Reading Networks project, we sought to examine whether parent-child associations in reading vary by component skill; whether associations differ by parent and child sex; and whether shared reading (SR) mediates or moderates these relationships. **Methods:** Our sample comprised 76 parent-child triads (mother, father, child[ren] aged 8-12). Phonetic Decoding Efficiency (PDE; pseudoword reading) and Sight Word Efficiency (SWE; word reading) were assessed using the Test of Word Reading Efficiency, Second Edition (TOWRE-2). SR was indexed by frequency of shared reading. We used path analysis, linear mixed models (LMMs), and permutation testing to provide converging evidence for parent-child resemblance and the role of SR. **Results:** Path analyses revealed robust direct effects, particularly for PDE. Fathers' scores predicted children's PDE in the both-parents ($\beta = 0.40$, $pFDR < .001$) and father-daughter models ($\beta = 0.63$, $pFDR < .001$); mothers' scores showed moderate effects in the both-parents ($\beta = 0.21$, $pFDR = .004$) and mother-son models ($\beta = 0.37$, $pFDR = .001$). SWE showed weaker effects, with only the father-daughter model achieving bootstrap significance ($\beta = 0.42$, 95% CI [0.06, 0.78]), though p-value significance did not survive FDR correction ($pFDR = .12$). A significant SR-to-child path emerged in the mother-son PDE model ($\beta = -.494$, $pFDR = .02$); other mediation paths were non-significant. Given the near absence of mediation effects in our path models, we used LMMs to test SR as a potential moderator. For PDE, parent-child resemblance was strongest in cross-sex dyads, particularly father-daughter ($\beta = 0.76$, $pFDR < .001$) and mother-son ($\beta = 0.69$, $pFDR = .01$) pairs, with non-significant effects in same-sex dyads (father-son:

$pFDR = .36$; mother-daughter: $pFDR = .40$). SR did not moderate PDE transmission in any model. For SWE, parent-child effects were weaker, with only the father-daughter association achieving significance ($\beta = 0.40$, $pFDR = .05$). SR significantly moderated paternal transmission, with SR $\times$ father interactions in the both-parents model ($\beta = 0.43$, $pFDR = .04$) and father-only model ($\beta = 0.56$, $pFDR = .04$), indicating stronger resemblance in families with higher SR. Permutation tests corroborated key findings. For PDE, correlations were significantly larger in related than unrelated pairs, and the strongest correlations were observed in cross-sex dyads (father-daughter: $r = 0.58$, $p < .001$; mother-son: $r = 0.38$, $p = .01$); same-sex dyads yielded non-significant correlations. For SWE, only the father-daughter correlation approached significance ($r = 0.32$, $p = .05$). **Discussion:** Our findings provide preliminary support for potential domain- and sex-specific transmission pathways in reading achievement, with PDE exhibiting stronger familial resemblance, particularly in cross-sex pairings. SR moderated but did not mediate parent-child similarity, suggesting a limited role as an intergenerational transmission pathway in our sample. Results are presented as observational, rather than mechanistic, and require replication in larger, more diverse samples.

E51 - Neural associations between fingerspelling, print, and signs: An ERP priming study with deaf readers

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Fingerspelling is a leading predictor of reading ability for deaf people who use a signed language, but few neuroimaging studies have examined how it supports reading. We used event-related potentials (ERPs) to investigate how fingerspelled words prime printed words. Twenty-four skilled deaf adult readers who were native or early signers of American Sign Language (ASL) participated in this study. Participants completed a Go/No-Go semantic categorization task (i.e., detect an occasional animal name) while viewing printed English word targets following related and unrelated primes in one of three conditions: printed English words, ASL signs, and fingerspelled words. N400 priming effects were strong across all three conditions. Because it would be difficult to compare target words with primes from different modalities, we calculated difference waves by subtracting the related condition from the unrelated condition within each prime type. This approach allowed us to remove any modality-specific effects from the ERPs prior to analysis in order to compare priming of printed target words by each prime type. Difference waves showed that early N400 effects were similar for printed word primes and fingerspelled word primes but weaker for sign primes, suggesting shared orthographic representations for printed and fingerspelled words. Late N400 effects were strongest for printed word primes, reflecting less effortful processing when primes and targets were in the same language and the same printed modality. Overall, the differences in the magnitude, latency, and distribution of the N400 priming effects observed in this study suggest a stronger relationship between fingerspelling and print than between signs and print. These findings provide evidence for cross-language and cross-modal priming between fingerspelled and printed words and underscore the importance of fingerspelling in developing word representations for skilled reading.

E52 Sandbox Series - Reading in a noisy environment: An ERP study of the effects of cross-modal divided attention on prediction and repair

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Our brains efficiently process rapid and complex streams of input that we experience during language comprehension. We rely on sustained attention to update semantic memory as sentence context builds, allowing us to revise our expectations about upcoming linguistic information. Previous research has shown that this efficient use of sentence context during reading is reduced with divided attention, specifically when imposing a sustained secondary visual³ task or attentional load through a secondary auditory² task. The current study aims to understand the effect of sustained auditory background noise (unintelligible babble) on the use of sentence context during reading. We measure event-related potentials reflecting access to semantic memory¹: the N400, which is modulated by degree of facilitation for a specific word. We also examine the late frontal positivity (LFP), which is typically elicited during prediction violations (when a word is provided in a sentence where the context favored a different word^{4,5,6}). Previous research using dual-task paradigms had participants respond to tones² prior to target words or track visual distractors³ (respond to the direction of moving dots) while reading. Both paradigms revealed reduced N400s to words in sentence context when attentional resources were taxed compared to when no secondary task was imposed. The current study uses a novel cross-modal design with passive background noise while reading to investigate if prediction (N400) and revision (LFP) are modulated by sustained, cross-modal divided attention. By eliminating the secondary task we can better isolate the effects of sustained attention on reading comprehension; the cross-modal design measures attentional effects without competing for the same sensory resources. Participants read sentences from Hubbard and Federmeier (2021)^{4,3} that are either strongly (SC) or weakly (WC) constraining, and end with an expected (E) or unexpected (U) plausible word. The sentences are presented one word at a time either in silence or with continuous babble playing through headphones. Participants read the sentences for comprehension and reply to occasional memory probes about the sentence content to ensure engagement. No secondary task is imposed with the noise, however tones embedded in the babble can be used as individual measures of attention to the noise based on N1/P2 amplitude. This study is in the data collection phase; no statistical analyses have been conducted. Visual inspection of preliminary data (n=20) suggests a replication of Hubbard and Federmeier (2021) with graded N400 amplitude based on constraint and expectancy for reading in silence (smallest for SCE then WCE, WCU, and largest for SCU) and an LFP effect of expectancy with U targets eliciting a more positive amplitude. For trials with imposed noise, an apparent attenuated N400 effect is visible with no visible difference between WCE and WCU. Additionally in noise, we see an LFP with the strong constraint unexpected endings elicit a more positive amplitude compared to the weak constraint expected and unexpected amplitudes. These findings will inform how sustained attention affects reading comprehension in a noisy environment, like coffee shops, as well as individual differences in this ability.

E53 - When signs slip the mind: A corpus-based study of the Tip-of-the-fingers phenomenon in German Sign Language (DGS)

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Signers who experience a Tip-of-the-fingers (TOF) are not able to fully produce a sign while insisting that they actually know it. As a consequence of this phenomenon, which is known as Tip-of-the-tongue (TOT) in spoken languages, a sign or a word is not fully retrieved from the mental lexicon, and while semantic information can be accessed, the phonological forms cannot. The TOT phenomenon in spoken languages has been studied extensively since the 1960s (e.g., Brown & McNeill, 1966); however, to date, TOF research on sign languages is still scarce. In an experimental study on American Sign Language (ASL), Thompson, Emmorey, & Gollan (2005) identified fingerspelled words and lexical signs as two possible categories of TOFs. Their findings support a two-tiered lexical approach for sign languages, where semantic and phonological representations are processed separately in the mental lexicon (e.g., Liddell & Johnson 1989; Brentari 1998). In the present study, we address two main questions: First, whether the TOF phenomenon can be observed in DGS, and second, to what extent identified categories might overlap with those that were established for ASL by Thompson et al. (2005). To this end, we apply a corpus-based approach, analyzing natural data from the DGS corpus, which includes data from 330 deaf participants from 12 different locations in Germany (Blanck et al. 2016). To be identified as a TOF, a case had to meet at least one of the two following objective markers: 1) the signer can describe a target word (assign attributes), but not directly or only partially (cognitive network), and/or 2) the signer shows linguistic expressions of deliberation (e.g., I don't remember, what was the name again?). All identified occurrences were examined in collaboration with a deaf signer and categorized according to the specifics of the TOF. All cases were then annotated and evaluated in ELAN. In total, 88 initial cases of possible TOFs were found in the data, of which 54 occurrences were excluded in the analysis because they did not meet the criteria of a TOF or were not clear enough. A total of 34 examples were included in the analyses. These 34 cases were derived from 31 participants (21 female, 10 male), who differed in age at data collection (mean age: 46.7 years; range: 24-78 years; sd: 14.5 years) and in age of sign language acquisition (mean age: 3.3 years; range: 0-8 years; sd: 2.3 years). TOFs in DGS were found for fingerspelled words (n=12), lexical signs (n=16), and a combination of fingerspelling and sign (n=1). In addition, a novel category was identified, which includes the interaction of mouthing and sign (n=5). Overall, the findings of the present study reveal that the TOF phenomenon can be found in different sign languages, indicating a language-independent structure of the mental lexicon. However, the results also point to some language-specific differences between TOFs in DGS and ASL, possibly altering lexical access. These differences might be based on, for example, the role of mouthing as a nonmanual component, the use of fingerspelling, and initialization of signs.

E54 Sandbox Series - How do iconicity and embodied cognition interact during sign processing?

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Most deaf/hard-of-hearing (DHH) children are born to hearing parents who do not know sign language, though their caregivers may wish to learn to provide their child with accessible communication. In fact, DHH children who receive accessible sign language input are protected from harmful academic and health effects of linguistic deprivation. However, caregivers who wish to learn sign language require support to effectively and quickly acquire a new language (in a new modality). One difference between signed and spoken language is the use of the visual-motor modality, which facilitates a mapping between the form of the sign and its meaning. Called iconicity, this mapping allows visual elements of the world to be represented in a way that isn't possible in spoken language and some research has suggested a facilitatory effect of iconicity in both first and second-language vocabulary acquisition. One potential avenue for this facilitation is embodied cognition, as research shows that both child and adult language processing involves accessing stored knowledge from past sensory-motoric experiences. Motorically-iconic signs have an iconic mapping that depict the signer manipulating the referent (e.g., the ASL sign HAMMER depicts the signer holding and swinging a hammer). This visual-motor mapping could facilitate signers accessing their embodied cognition. Though caregivers of DHH children may not know how to sign, they already have these stored sensory-motoric experiences that they could tap into during language learning and as they explore the visual-motor modality. In this study, we will explore whether signers engage their stored motor experiences when producing and comprehending motorically-iconic signs in a production (picture-naming) and comprehension (sign-identifying) task. Behavioral and EEG results will be compared between a set of motorically-iconic and non-iconic signs. EEG will be used for Event-Related Potential (N400 component) and time-frequency analysis of the mu rhythm. The N400 is an ERP component that indexes semantic processing, and if motoric iconicity facilitates sign retrieval we expect to see smaller N400s for motorically-iconic signs, indicating reduced effort during sign retrieval. Mu rhythm desynchronization occurs during embodied engagement of the sensorimotor cortex. If signers access their past experiences during sign processing, we expect to see greater desynchronization for motorically-iconic signs. We don't expect to see effects for non-signers doing the same tasks in English, as there is no difference in iconicity between the English translations. Ultimately we will conduct the same experiments in caregivers of DHH children. These caregivers will be taught the same ASL signs (but will otherwise have no knowledge of ASL). If we find similar results to those for the native signers, these findings would suggest that the caregivers integrated iconicity and embodied cognition to support their learning, and that motorically-iconic signs may be a starting place when caregivers are first acquiring language in the visual-motor modality. As sign acquisition is the best protection from linguistic deprivation for DHH children, interventions that support caregiver learning ultimately improve communication with the DHH child, providing a foundation for language development and protection against the lifelong effects of linguistic deprivation.

E55 Sandbox Series - The core language network at rest: Differences in resting-state functional connectivity between deaf signers and hearing non-signers

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Introduction: The major networks implicated in language processing can also be discerned using resting-state MRI and several studies have used data-driven approaches to study whole-brain resting state functional connectivity (rsFC) in deaf signers. In contrast, hypothesis-driven analyses of rsFC based on findings from task-based studies of sign language processing are currently still missing. Here, we investigated rsFC of the so-called "core" language network, consisting of left posterior inferior frontal gyrus (pIFG) and posterior middle temporal gyrus and superior temporal sulcus (pMTG/STS), to five sets of regions relevant for (sign) language processing in bilateral frontal, parietal, temporal, and occipital cortex. **Methods:** This analysis includes resting state magnetic resonance imaging and structural data from 24 deaf signers (11 male; mean age = 32.25, SD = 8.69) who acquired a sign language already early in life (mean age of acquisition = 1.29, SD = 2.22) and primarily from their deaf parents (N = 19), as well as 24 hearing non-signers (11 male; mean age = 32.75, SD = 8.25). All data was pre-processed using the standardised workflow implemented in fMRIprep (Esteban et al., 2019) which integrates advanced quality control measures and enhances reproducibility. Further processing steps were carried out using the "nilearn" package (version 0.11.1; Nilearn Contributors, 2024): We first applied a bandpass filter, denoised the data using the 24-parameters approach by Satterthwaite et al. (2013), and applied a smoothing kernel of 4mm FWHM. We then computed rsFC between left pIFG and pMTG/STS as a sanity check. Next, whole-brain seed to voxel correlation maps were computed using either left pIFG and left pMTG/STS as seed region. From the resulting whole-brain maps, we then extracted five sets of pre-registered (<https://doi.org/10.17605/OSF.IO/8DS93>) ROIs from the Brainnetome atlas (Fan et al., 2016): Bilateral (1) parietal cortex, (2) rolandic cortex, (3) premotor cortex including supplementary motor area, (4), fusiform gyrus and posterior inferior temporal gyrus, and (5) occipital cortex. Lastly, we fit Bayesian hierarchical regression models for each seed region and set of target ROIs using Stan via the "brms" package (version 2.22.0; Bürkner et al., 2021) in R (version 4.4.3; R Core Team). **Preliminary Results:** Both seed regions of the core language network show high rsFC to each other as is predicted by the direct anatomical connectivity via the arcuate fasciculus. At the time of submission, computing of Bayesian models was still ongoing. Preliminary results obtained during determining the appropriate model structure indicate several differences in rsFC to the sets of target regions between both groups. **Outlook:** Our analyses will shed light on whether the modality-independent core language network in the brain's left hemisphere exhibits differential resting-state connectivity in the groups of deaf signers and hearing non-signers in regions that have previously been associated with different aspects of sign and spoken language processing in task-based studies.

E56 - Multivariate fMRI Uncovers Form-Invariant and Language-Specific ASL Verb Representations in Deaf Signers

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Verbs are a linguistic universal and partially neurobiologically dissociate from other word types (e.g., nouns) and visual representations of actions (Bedny et al., 2012; Papeo et al., 2019; Elli et al., 2019; Wurm et al., 2019). Previous studies in spoken languages implicate the left middle temporal gyrus (LMTG) in the representation of verb lexical-semantics (e.g., Hauptman et al., 2025). Sign languages have rich verb lexicons and morphology, the neurobiological underpinnings of which remain underexplored. American Sign Language (ASL) verbs provide an important test-case because in ASL, depicting verbs take handling classifiers. For example, the non-classifier verb form of 'give' is modified with a handling classifier to convey how the object is handled. Depicting classifier forms are iconic and resemble the actions they refer to (e.g., open, give, pick up), raising questions about their linguistic versus gestural nature. We used multivariate pattern analysis (MVPA) fMRI to look for abstract ASL verb representations invariant across classifier (i.e., form) variation and across sentence contexts. We scanned congenitally profoundly deaf participants (N = 15; ASL acquisition ranging from native to late) as they viewed ASL sentences featuring six action verbs (give, take, open, close, pick-up, put-down) in three grammatical structures: Subject-Verb-Object with Non-Classifier form, Object-Subject-Verb with Non-Classifier form, and Object-Subject-Verb with Classifier form (e.g. in ASL GLOSS: "MAN OPEN BOTTLE", "BOTTLE MAN OPEN".) Sentences varied in signers' identity (man, woman), the grammatical subject (man, woman), and object (bottle, book, laptop, teapot). In a matched non-linguistic condition, participants watched meaning-matched action videos (e.g., a video of a man opening a bottle). As a low-level control, participants viewed perceptually matched but meaningless videos created by superimposing backward-played ASL and action videos that preserved motion, human bodies, and faces. Individually defined functional ROI-based MVPA (cross validated) and whole-brain searchlight analyses were conducted to decode verbs and actions. MVPA revealed largely non-overlapping decoding of verbs and actions. A language-responsive left MTG region showed above-chance decoding for ASL verbs ($p < 0.01$) but did not decode actions depicted in videos ($p > 0.1$). Whole-brain searchlight analyses identified different spatial distributions for ASL verbs (left MTG) and visual actions (right-lateralized posterior temporal and occipitotemporal cortex). Cross-domain decoding, i.e., training on ASL verbs and testing on actions and vice-versa, failed to identify common representations across sentences and videos. Thus, we find a neural dissociation of ASL action verbs (linguistic) and visual actions (non-linguistic). ASL verbs were successfully decoded across perceptual and grammatical variation in ASL sentences, including signer identity, grammatical subject and object, and word-order (all p 's < 0.01). Most importantly, decoding was also invariant of classifier surface form, i.e., training on classifier constructions and testing on non-classifier constructions and vice-versa showed above chance decoding ($p < 0.001$). In conclusion, classifier and non-classifier verbs in ASL are represented in language-specific

regions previously associated with verb processing for spoken languages, i.e., the LMTG. ASL verb representations are invariant to surface classifier forms. Despite sharing modality and perceived iconicity with action representations, ASL verb representations are neurally language-specific.

E57 Sandbox Series - The influence of American Sign Language on neural dynamics and spatial cognition

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Through repeated practice, visual-spatial language, such as American Sign Language (ASL), may reshape non-linguistic spatial cognition and its neural substrates. Prior research points to fluent signers outperforming non-signers on spatial tasks such as mental rotation, perspective-taking, and spatial attention, suggesting experience-dependent neuroplasticity. Previous EEG studies have reported preliminary evidence linking ASL fluency to increased mu-rhythm (8-13 Hz) suppression over the sensorimotor area. Such findings point to differences in motor processes across fluency gradients, possibly due to the embodied motor processing inherent in sign language. However, the precise behavioral and neural mechanisms that drive these changes remain underexplored, particularly in those with diverse linguistic experiences. We propose a 2.5-hour behavioral and EEG study to more clearly examine the role of ASL fluency, measured via the ASL Comprehension Test (ASLCT), on spatial cognition and the underlying neural mechanisms. Specifically, we hypothesize that: (1) greater ASL fluency will predict faster and more efficient performance on a 2D mental rotation task, reflecting stronger ability to envision and navigate their environment; (2) increased ASL proficiency will correlate with greater mu suppression as a result of practice effects; (3) fluent signers will show fewer perspective-taking errors during spatial navigation EEG paradigm when compared to non-fluent and non-signers due to automaticity in switching during daily communications; and (4) greater ASL proficiency will be associated with increased frontal-parietal phase locking in theta and alpha bands, suggesting a stronger spatial network integration. Sixty-five adults stratified by hearing status and ASL fluency (Deaf fluent, Deaf non-fluent, Hearing fluent, Hearing non-fluent, Hearing non-signers) will complete a computerized 2D mental-rotation task (140 trials), the Virtual SILCton navigation task, and a 2x2 (Perspective x Difficulty) EEG navigation paradigm (135 trials across nine blocks). Planned analyses include mixed-effects ANOVAs, hierarchical regressions controlling for age and English proficiency, moderation by hearing status, and bootstrap mediation of ASL proficiency's effects on network-behavior relationships. Data collection will begin in Summer 2025, with preliminary results to be presented at the SNL conference. Findings will clarify how ASL's spatial grammar may scaffold mental transformations and reorganize cortical networks, informing linguistic relativity and neuroplasticity theories.

E58 - The Influence of Modality and Early Language Experience on the Neural Network for Language

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This study investigates the neural correlates of language comprehension in a sample of deaf adults who are bilingual in American Sign Language (ASL) and written English, and who experienced variable language access in early childhood. We obtained functional MRI data from 20 deaf signers with ages of ASL exposure (AoE) ranging from birth to 20 years (mean AoE = 8.3; SD = 7.1 years). Our sample is characterized by relatively high proficiency in both ASL and English, despite delayed early language access. Participants viewed sentences and pseudo-sentences in written English and in ASL, along with a visual baseline condition for ASL. Pseudo-sentences in each language were sentences made up of phonologically legal but non-existing words or signs. We designed pseudo-sentences to elicit equivalent phonological processing but less syntactic/semantic processing when compared to sentences. We derived effect sizes for all conditions by estimating responses within subject-specific functional regions of interest (fROIs), which were defined using a contrast between ASL sentences and the visual baseline. Our fROIs were constrained to homologous regions known to be involved in ASL comprehension: frontal regions (IFG and MFG), temporal regions (posterior and anterior temporal cortex), and occipitotemporal regions (including fusiform cortex). We evaluated the effects of language (ASL vs. English) and stimulus type (sentences vs. pseudo-sentences) on neural effect sizes using a linear mixed-effects model. Broadly, ASL elicited stronger activation as compared to English, particularly within occipitotemporal and posterior temporal regions. Neural activation was bilateral with a slight bias to the right hemisphere for both ASL and English; ASL elicited stronger right-lateralization compared to English. The comparison between sentences and pseudo-sentences did not differ across languages, with sentences eliciting greater activation than pseudo-sentences in bilateral frontal and temporal regions, but not in occipitotemporal or fusiform regions. To investigate the effect of early language experience on neural activation, we included ASL AoE as a covariate in the model. There were two interaction effects: Participants exposed to ASL later had more right-lateralized activation for English, and they also had stronger activation in occipitotemporal regions for ASL. There was a small effect of AoE in the MFG, in which delayed ASL exposure led to attenuated activation for ASL, but AoE did not modulate activation in the IFG. AoE did not interact with the type of input (pseudo-sentences or sentences), suggesting that effects of delayed early language occur at the phonological level in this population. Our results suggest that the right hemisphere is recruited for both ASL and written English comprehension in deaf bilinguals. Additionally, delayed language exposure predicts a rightward shift in activation for written English. Bilateral activation for both written English and ASL comprehension has been observed in previous studies (Neville et al., 1998), and strong right-hemisphere activation has been documented in late signers (Ferjan Ramirez et al., 2014; 2016; Mayberry et al., 2018). Our findings replicate prior research showing that a delayed AoE increases occipitotemporal activation, but we do not find attenuated frontotemporal activation with later language exposure (Twomey et al., 2020; Mayberry et al., 2011).

E59 - Characterizing the effects of delayed auditory feedback and associations with related measures: A multiple case study

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Delayed auditory feedback (DAF) disrupts speech. However, the effects of DAF remain relatively poorly understood and vary across speakers. Here, we describe a multiple case study addressing DAF along with other related measures to characterize the sensorimotor control of speech in individual subjects. We present a detailed analysis of five native English speakers who completed several speech tasks. Speakers completed 248 trials of syllable sequence and 200 trials of sentence production tasks with 0-250 ms delays. Two phonetically balanced reading passages were used to extract habitual speaking rate (HSR). Speakers also completed an F1 perceptual acuity task, the Spontaneous Speech Synchronization (SSS) task (Assaneo et al., 2019), a reflexive formant perturbation task, and a demographic survey, providing detailed profiles of each participant. The speakers presented here were selected from a 56-participant dataset based on preliminary analyses. The selected participants exhibited HSRs within the lower, median, and upper quartiles of the full dataset and exhibited contrasting responses to DAF. The difference between the average speaking rates of 0 and 250 ms delay trials was used as a proxy for the extent of DAF's effect on speech. Syllable sequence production was analyzed based on alignment to stimulus transcripts using Montreal Forced Aligner, with manual listening used to confirm automated measures. Log likelihood (LL) alignment scores were compared to a null model, with improvement in LL serving as the measure of interest. There is a strong positive correlation between HSR and improvement of LL at 250 ms delay ($r = 0.956$). This suggests slower speakers may depend more on auditory feedback during speech, therefore experiencing more induced errors under DAF. Of the five speakers, two strongly synchronized the rhythm of their whispered speech to an external syllable stream during the SSS task. These participants showed minimal change in rate across DAF conditions compared to the three non-synchronizers. There was a strong negative correlation between the participants' SSS task phase-locking values and their reductions of speech rate with 250 ms delay. This correlation was found in both syllable sequences ($r = -0.901$) and sentences ($r = -0.965$). This relationship suggests that the non-synchronizers (who may have reduced overall sensorimotor integration), increase their dependence on feedback control in response to their auditory errors under DAF, resulting in an inverse relationship between rate and delay. However, the synchronizers (naturally stronger sensorimotor integration) may engage their feedback control system under normal speaking conditions and thus do not exhibit the same slowing. Only the two synchronizers of the five cases analyzed reported "moderate" to "extreme" proficiency in any musical instrument on the demographic survey. They also performed the best of the five participants in the F1 perceptual acuity task, both ranking within the 87th percentile of acuity scores across the larger dataset. The overall results suggest individual performance on speech production tasks is modulated by learned factors of auditory processing and sensory-motor integration. Having multiple related measures from each participant allows for a detailed analysis of individual speech patterns and how they are impacted under DAF.

E60 - Effects of auditory feedback structure on adaptive and corrective responses in speech motor control

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Objectives: Speech motor adaptation enables speakers to maintain accurate production despite sensory disruptions, yet the relationship between immediate (corrective) and sustained (adaptive) responses remains under-characterized. This study examined how structured auditory perturbations influence the magnitude of adaptive and corrective responses in speech motor control. **Methods:** Thirty right-handed native English-speaking adults (19 female, 11 male; ages 18+) with no reported neurological, hearing, or language impairments completed two experimental sessions. Participants were prompted to produce monosyllabic words containing the vowel /ε/ while receiving real-time auditory feedback through insert earphones. Across sessions, each participant experienced all four perturbation conditions, which varied by onset pattern (gradual vs. sudden) and feedback contingency (clamped vs. shifted). Perturbations were applied to the first (F1) and second (F2) formant frequencies to acoustically shift the vowel /ε/ (as in “head”) toward /æ/ (as in “had”). In clamped conditions, the altered feedback was fixed and unrelated to the speaker’s production. In shift conditions, feedback was modified relative to the speaker’s articulatory output within the trial. Gradual perturbations increased incrementally over trials; sudden perturbations were introduced in stepwise increments across trial blocks. Adaptive and corrective responses were extracted via acoustic analysis of F1 and F2 trajectories. Adaptive responses—reflecting feedforward control—were measured in the initial 25% of the vowel duration, prior to the availability of auditory feedback from the current trial. Corrective responses—reflecting feedback-based, online adjustments—were measured in the final 25% of the vowel duration. **Results:** Adaptive responses were larger in magnitude than corrective responses across all conditions. Both response types were slightly attenuated in the clamped feedback conditions compared to shifted feedback. There were no significant differences between gradual and sudden onset conditions for either response type. These results suggest that the relevance of auditory feedback, rather than the timing of perturbation onset, more strongly influences both adaptive and corrective control in speech. **Conclusion:** The structure of altered auditory feedback plays a critical role in shaping speech motor responses. Adaptive responses—reflecting feedforward control—were more robust than corrective responses, particularly under feedback conditions that maintained a meaningful relationship to the speaker’s output. These findings support models of speech motor control that differentiate between adaptive and corrective mechanisms and highlight the importance of feedback relevance in driving motor learning.

E61 - Evaluating a causal role for right temporal cortex in accessing talker-specific phonetic signatures

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Individual talkers may exhibit substantial variation in how they produce their speech sounds, and listeners are exquisitely sensitive to the idiosyncratic phonetic signatures of different talkers. For example, listeners can explicitly indicate whether the voice-onset time (VOT) of a voiceless stop consonant is typical or atypical of a given talker (e.g., whether a talker tends to produce sounds like /k/ with a relatively short or long VOT; Allen & Miller, 2004). Such sensitivity to talker-specific phonetic variation may be advantageous for conditioning speech perception on talker information. A growing body of neuroimaging data suggests that the integration of talker information during speech perception recruits the brain’s right hemisphere, especially the right temporal cortex. For example, one study found that during a phonetic categorization task, the right middle temporal gyrus (MTG) was differentially activated for VOT variants that were typical or atypical of a given talker (Myers & Theodore, 2017). However, an open question is whether recruitment of the right hemisphere is strictly necessary for integrating talker information and phonetic detail or simply incidental to this integration process. Recently, our team conducted a transcranial magnetic stimulation (TMS) study (Luthra et al., 2023) to test for a causal role of the right posterior temporal cortex in learning what phonetic variation is typical of a talker. During an initial exposure phase, participants heard two talkers, one of whom produced voiceless stop consonants with a relatively short VOT and one with a relatively long VOT. During exposure, TMS was applied to the right MTG, left MTG, or a control site (scalp vertex). In a subsequent test phase, participants judged whether VOT variants were typical or atypical of a learned talker. Listeners exhibited near-ceiling performance in this talker typicality task regardless of stimulation site; disruption to the right MTG did not have consequences for learning which phonetic variants were typical of a talker. This finding leaves the specific contributions of the right MTG to talker-specific phonetic processing unclear. In the current study (planned N=36, data collection ongoing), we follow up on our previous work to further characterize the role of the right temporal cortex in talker-specific processing. Specifically, we test the hypothesis that the right MTG may play a causal role not in learning what phonetic variation is typical of a talker but rather in accessing a listener’s beliefs about a talker’s phonetic signature. The design of our study closely resembles our previous work, but with the important difference that we now apply TMS during the test phase (talker typicality judgment) rather than during the exposure phase. Preliminary results (N=17) indicate that listeners may be best able to determine what phonetic variation is typical of a talker following right MTG stimulation and worst following left MTG stimulation. If this pattern holds, such a finding would suggest that the right and left MTG may play distinct causal roles in accessing talker-specific phonetic beliefs. Ultimately, results will provide insight into the differential contributions of the brain’s two hemispheres for conditioning speech perception on talker information.

E62 Sandbox Series - Effect of Language-specific Syllables on Heritage Speakers' Speech Perception: An ERP Study

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The current study investigates whether heritage speakers can use language-specific syllables to identify the surrounding language environment. Previous studies show that

metalinguistic cues, such as social interactions, can help bilinguals categorize speech by signaling language contexts. However, the role of more implicit phonological information, such as language-specific speech sounds, remains less understood. Although heritage speakers use their heritage language less frequently, they often retain sensitivity to its phonological contrasts due to early exposure. Previous studies further suggest that proficiency in the heritage language may affect the perception of certain phonemic distinctions. Building on these insights, we ask whether bilinguals with varying proficiency levels in their heritage language can draw on language-specific syllables to distinguish language environments during speech perception. We recruited Mandarin-dominant heritage speakers of Taiwanese in Taiwan, and divided them into two groups, Proficient (N=17) and Inexperienced (N=18), based on their proficiency levels in Taiwanese. The EEG experiment employed a 2x2 design, crossing Language section (Mandarin, Taiwanese) with Participant group (Proficient, Inexperienced). An oddball paradigm was used to elicit the Mismatch Negativity (MMN), a neural marker of early auditory processing that reflects the integration of acoustic and phonological information. In the Mandarin section, the standard was [təja] 'to clip' (a Mandarin-specific syllable); in the Taiwanese section, it was [kʰja] 'to ride' (a Taiwanese-specific syllable). In both sections, the deviant was [jã] 'to win,' a nasal-vowel syllable present in Taiwanese but absent in Mandarin, forming a cross-language phonemic contrast in the Mandarin section and a within-language contrast in the Taiwanese section. This design allowed us to test whether participants could implicitly track language environments based on language-specific syllables. If successful, we expect larger or earlier MMN responses in the Mandarin section, where the deviant violates the phonological structure of the dominant language. In contrast, the Taiwanese section, where both syllables were phonologically legal, may elicit a weaker or later MMN. Additionally, if proficiency affects access to heritage phonology, the Inexperienced group may exhibit delayed MMN responses in the Taiwanese section. Each section included 1,032 trials, with 80% Standard and 20% Deviant tokens. To maintain task engagement, participants responded to filler click trials via button press. Preliminary results show earlier MMN responses in the Mandarin section for both groups, suggesting that heritage speakers may use language-specific syllables to identify language contexts. This supports the view that acoustic-phonological integration is more efficient in the dominant language, even without explicit context language cues. Notably, the Inexperienced group showed a delayed MMN response in the Taiwanese section, suggesting that lower proficiency may result in less automatic phonemic processing in the heritage language. Together, these findings highlight a potential role for implicit phonological cues in shaping language-mode sensitivity, and suggest that early exposure alone may not ensure efficient processing; instead, proficiency appears to affect the ability to use phonological cues in real-time.

E63 - When words hit harder: Neural speech tracking is stronger for angry than for neutral speech at the word rate

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Emotional speech plays a crucial role in navigating the social world. As a result, emotional words attract more attention than neutral words and more cognitive resources are allocated towards their processing (Fields & Kuperberg, 2012, *NeuroImage*; Kissler et al., 2009, *Biological Psychology*; Sander et al., 2005, *Nature Neuroscience*). In social settings, we encounter emotional language in the form of a continuous auditory stream rather than individual words. However, little is known about the neural processing of continuous emotional speech and the role of neural oscillations in the underlying mechanisms. The present study investigated the differences in the neural processing of ongoing emotional and non-emotional speech. — Twenty-six participants listened to recordings of angry and neutral conversation segments, as well as to speech-shaped noise, while their EEG was recorded. An example of an angry segment (in Czech, native language of the participants) was "Přestaň na mě takhle čumět. Ten tvůj debilní ksicht mě irituje" [Stop staring at me like that. This dumb face of yours is annoying me.]. Respective frequency bands were calculated based on the structure of the stimuli, corresponding to the rate of phrases, words, and syllables in the angry and neutral recordings. Neural speech tracking, quantified as oscillatory power and inter-trial phase coherence (ITPC) in the defined frequency bands, was analyzed. — The results revealed larger oscillatory power across the phrase, word and syllable band during exposure to angry speech in comparison to neutral speech (mean slope = 0.599, $t = 3.775$, $p < .001$). This effect was most pronounced in anterior regions. There was a main effect of valence on intertrial phase coherence, indicating that phase coherence was lower in the angry condition (mean slope = -0.017, $t = -5.042$, $p < .001$). For ITPC, there was also an interaction effect of valence and rate (mean slope = 0.025, $t = 5.251$, $p < .001$). Comparisons of estimated means and 95% confidence intervals revealed that the effect of valence was in opposite directions for phrases and syllables (stronger ITPC for neutral speech) than for words (stronger ITPC for angry speech) and this was most pronounced at the anterior sites. — The stronger intertrial phase coherence for neutral speech in the syllable and phrase range reveals more accurate neural speech tracking for commonly encountered speech patterns. Interestingly, a reverse pattern seen for the word rate – i.e. stronger phase coherence in angry speech might be driven by better predictability of lexical content in emotional speech, potentially reflecting stronger top-down modulations in how the brain tracks speech. The present findings extend prior literature that mostly addressed event-related processing of emotional content in isolated words or phrases (Chen et al., 2013, *Neuroscience Letters*; Fields & Kuperberg, 2012, *NeuroImage*; Kissler & Herbert, 2013, *Biological Psychology*). Our study provides novel insights into the oscillatory dynamics underlying the processing of naturalistic, continuous emotional speech.

E64 - Feedback-Related Negativity Predicts Flexible Generalization in Non-Native Speech Category Learning

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Acquiring non-native speech categories can be particularly challenging for adults. To succeed, they must identify the acoustic features that are linguistically more relevant. This can be particularly difficult when non-native speech is produced by

multiple speakers across varying word contexts., as these additional sources of variability can hinder the perception of linguistically relevant features. Previous fMRI work [1] has shown that trial-by-trial feedback can significantly improve the acquisition of non-native speech categories, rewarding correct behavior through engagement of cortico-striatal pathways. In the present study, we used the Feedback-Related Negativity (FRN)—an EEG marker of reward prediction error in response to feedback—to model the neural mismatch between expected and actual outcomes and its impact on non-native speech category learning. Greater FRN amplitudes are thought to reflect larger discrepancies between expected and actual errors, offering a neural index of expectation-outcome dynamics during learning. Native English speakers (N = 36) were trained to categorize 36 exemplars of three French nasal vowels that are not contrastive in English. Stimuli were produced by two native speakers across six word contexts, and presented in random order across five training blocks, with each token repeated once per block. On each trial, participants received immediate visual feedback indicating whether their categorization was correct or incorrect. Following the training phase, participants completed a brief generalization block in which they categorized 36 novel tokens produced by unfamiliar speakers, without receiving feedback. Individual accuracy during the training and generalization phases was calculated as the percentage of correct categorization responses. FRN magnitude was measured following established procedures [2], by computing the difference wave between ERP responses to incorrect and correct feedback. The mean amplitude of the difference wave was then averaged within a 325-425 ms time window across midline electrodes (Fz, Cz, and Pz). Participants successfully learned the vowel categories above chance level (mean training accuracy = 52.9% correct; logistic mixed-effects model: $z = 3.72$, $p < 0.001$), indicating that the training paradigm was effective. During the training phase, we found no significant difference in FRN magnitude between learners performing above and below the 50th percentile in categorization accuracy. However, in the generalization phase, learners in the top half conveyed significantly less negative FRN magnitudes in response to unexpected errors compared to those in the bottom half. This indicates that learners with more realistic expectations, operationalized as smaller neural discrepancies between expected and actual outcomes, are more likely to form flexible and generalizable speech representations. In contrast, consistent with the Dunning-Kruger effect [3], learners who overestimate their performance develop poorer generalization skills. References: [1] Yi, H. G., ... & Chandrasekaran, B. (2016). The role of corticostriatal systems in speech category learning. *Cerebral Cortex*, 26(4), 1409-1420. [2] Opitz, B., Ferdinand, N. K., & Mecklinger, A. (2011). Timing matters: The impact of immediate and delayed feedback on artificial language learning. *Frontiers in Human Neuroscience*, volume 5-2011. [3] Dunning, D. (2011). The Dunning-Kruger effect: On being ignorant of one's own ignorance. In *Advances in experimental social psychology* (Vol. 44, pp. 247-296). Academic Press.

E65 - Interpreting Neural Signatures of Word and Nonword Processing Across Speakers and Dialects using SVMs and RSA

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Background Decades of behavioural research have shown that word recognition is an incremental process involving competition among multiple lexical candidates. Recent work by McMurray et al. (2022) demonstrated that SVM-based machine learning can decode the neural spatiotemporal encoding of phonetically similar words and non-words from EEG signals, and that decoding response patterns closely mirror prototypical lexical competition effects. Here we describe two studies that replicate and extend McMurray et al. (2022). In Study 1, we decode EEG signals associated with word and nonword recognition within a lexical competition framework. In Study 2, we extend this paradigm to decode across different speakers, dialects, and genders. In both, we further assess the decoder's sensitivity to individual differences by correlating decoding performance with behavioral task data, and explore spatio-temporal differences in word-form representations using representational similarity analysis (RSA). Methods: Study 1 20 participants were exposed to 4 word and 4 non-word pairs. Pairs were constructed such that the onsets were identical (e.g. "badger" and "baggage"), thus prompting lexical competition. Participants heard words and nonwords in pseudo-random order for a grand total of 960 trials. Data were acquired with a 32-channel Brain Vision Actichamp Plus. Study 2 20 participants were exposed to a new set of 4 word and 4 non-word pairs selected from the Auditory English Lexicon Project corpus hosted by the National University of Singapore. Word and non-word tokens are produced by 6 speakers, which are further characterized as falling into three dialects; each dialect is produced by 1 male and 1 female speaker. Data were acquired with a 128-channel, MagStim EGI. An SVM was trained to predict word-form pairs from one another, as well as speaker identity and dialect identity. The time-course of target vs cohort vs unrelated identification is compared across word and non-words in both studies. In addition, across both studies within-participant Representational Dissimilarity Matrices (RDMs) were constructed for each decoding task (e.g., word identity, speaker identity) using pairwise Euclidean distances between activation patterns across electrodes and timepoints. These participant-specific neural RDMs were compared with one another to assess the similar structure of neural representations underlying word and non-word processing across time between participants. Results: Study 1 replicates McMurray et al (2022). Target word-forms were identified significantly above chance (chance = 0.12), and the time-course of auditory integration mirrors findings from the eye-tracking psycholinguistic literature. Study 2 demonstrates the same pattern of word-form identification and competition dynamics across speakers and dialects, and rapid successful identification of speaker identity, dialect, and gender with very little evidence of confusability. Individual difference analyses are ongoing. Conclusion: Our findings confirm the robustness of McMurray et al. (2022)'s results, validating their reproducibility and highlighting machine learning's efficacy in neural decoding for spoken word recognition. Further implementation of RSA will help clarify the structure of neural representations over time, enhance interpretability of decoding models, and provide a framework for comparing individual and group-level representational dynamics. References: McMurray et al. (2022). Decoding the temporal dynamics of spoken word and nonword processing from EEG. *NeuroImage*, 260, 119457.

E66 Sandbox Series - The Role of Contextual Information in Auditory Perception: Investigating N400 Effects Under Speech Degradation

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This study investigates how contextual information influences auditory perception when acoustic signals are degraded. In daily communication, listeners often encounter noisy environments that challenge speech comprehension. Using magnetoencephalography (MEG), we examine how the brain leverages top-down contextual information to compensate for degraded bottom-up acoustic input, focusing on the N400 component as an index of semantic integration difficulty. In Experiment 1, we establish a baseline for auditory perception in noisy environments using a repetition suppression paradigm. For one experiment trial, participants hear a prime word, and subsequently a target word, followed by an intelligibility rating question on the target. Two variables are manipulated on the target: priming (repeated vs. novel) and degradation (clear vs. degraded). The experiment includes 400 trials with 100 repeated targets and 300 novel distractors, balanced between degraded and undegraded conditions. The stimuli consist of 700 words extracted from the MRC Psycholinguistic Database (Coltheart, 1987), each with two syllables and moderate familiarity ratings. All primes are presented clearly, while targets vary in the degradation condition (clear vs 8-band vocoding). Participants rate target word intelligibility on a 1-4 scale (4 being most intelligible) during their MEG recordings. We hypothesize that auditory degradation will increase the number of words that potentially match the acoustic signal. This will render the number of options in the matching and non-matching conditions similar, resulting in similar N400 amplitudes between matching and non-matching words under degradation. In Experiment 2, we continue to examine the interaction between contextual information and auditory processing by introducing additional semantic content via wordlist primes. In a 2x2 design, we manipulate semantic relatedness (related vs. unrelated word lists) and speech quality (clear vs. degraded) in a priming paradigm. The experiment includes 200 trials in four conditions distributed within-subject. For each trial, participants hear a word list followed by a target word and a subsequent intelligibility question on the target. The wordlists have two context types: semantically related (e.g., "horse-dog-sheep" preceding "cat") or unrelated (e.g., "house-doctor-sun" preceding "cat"). Targets appear in either clear or degraded forms. We predict that (a) semantically related contexts will reduce N400 amplitudes, and (b) this facilitation effect is stronger in degraded speech processing, indicating greater reliance on contextual support when acoustic information is compromised. Building on previous findings by Aydelott et al. (2006) and Strauß et al. (2013), who demonstrated that semantic contexts with acoustic degradation affect the amplitude and latency of N400 responses of a target word, this project instead manipulates acoustic input while maintaining the clarity for contexts. This allows us to investigate the role contexts play in the processing of reduced bottom-up information. While Aydelott et al. and Strauß et al. recorded N400 using electroencephalogram (EEG), the MEG data will allow us to compare activation regions between experiments. Our research aims to contribute towards understanding the

neural mechanisms of speech perception under adverse conditions and how the brain dynamically balances bottom-up acoustic information with top-down contextual knowledge during language comprehension.

E67 - Interplay Between Sound Perception and Lexical Prediction in Speech Accent Processing: An ERP Study

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Research on the perception of accented speech offers a valuable opportunity to explore the inter-relationship between acoustic and more semantically driven aspects of speech processing. The extent that contextual factors influence the perception of accented speech is currently unclear, and some controversy surrounds how less familiar speech sound variations from a foreign accent can influence the generation of lexical semantic predictions. To explore these issues, we recorded EEG from 40 native English speakers as they listened to sentences spoken with either a local or foreign accent. Each sentence frame had both a predictable (high cloze) or a less predictable (low cloze) ending, and all target words occurred in both the predictable and less predictable conditions. The use of multiple stimulus lists ensured that each participant heard only a single variant of each stimulus. Mixed effects models were used to analyze the latency and amplitude of the N1, P2, and N400 components elicited by the first word in each sentence and the sentence final (target) words. Contextual expectations are minimal at the first word, thus these analyses addressed whether foreign accents pose challenges for native listeners via a fixed effect of Accent and a random intercept for subjects. Analysis indicates the N1 and P2 components peaked later for the foreign accent (N1: $p < .05$; P2: $p < .001$); the P2 amplitude was larger for the local accent ($p < .001$); and the N400 was similar in both latency ($p = .405$) and amplitude ($p = .373$) for both accents. These results suggest that perceptual processing of foreign accented speech is less efficient, but its impact on lexical processing is negligible. To examine how semantic predictions modulate accent effects, we conducted similar analyses of ERPs elicited by sentence final words using models with fixed effects of Accent and Predictability and a random intercept for subjects. Results revealed larger P2 amplitudes for high cloze than low cloze words ($p < .05$), suggesting acoustic processing is more successful when supported by sentential context. Sentence final P2 peaked earlier for local accents ($p < .05$), indicating more efficient processing occurred irrespective of contextual support. Interestingly, sentence-final words elicited larger amplitude P2 in foreign than local accented speech ($p < .05$), suggesting listeners may rely more on predictive processing for the perception of foreign accents. Accent effects were observed on the latency of the N400 (earlier for local; $p < .001$) and Predictability effects were observed on N400 amplitude (larger for low cloze; $p < .001$). Planned comparisons revealed Predictability effects for words in both local ($p < .001$) and foreign ($p < .001$) accented speech, indicating participants were able to use contextual information to make lexical predictions regardless of accent. Lexical predictions from sentence context thus impacted the amplitude of the P2 component, but not the timing. Conversely, the familiarity of local accents impacted the timing of the N400, with negligible impact on either its overall amplitude, or the size of N400 predictability effects. Though accent and predictability effects were largely

independent, results suggest listeners use context to facilitate acoustic feature extraction from foreign accented speech.

E68 - Pupil dilation during effortful listening reflects individual differences in context sensitivity

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Introduction: Successful speech comprehension requires the appropriate allocation of cognitive resources, reflecting the amount of “listening effort” an individual employs to reach their listening goal. The amount of effort needed to perform well on a given listening task varies depending on a number of factors including the listening environment, the listening task at hand, and the differences in the listener themselves. One factor that may influence listening effort is contextual support from the semantic predictability of the spoken materials. Sentence-based semantic predictability has been shown to modulate neural responses, increases processing speed and accuracy after speech perception, and even improves comprehension of degraded speech signals. These studies tend to find that when the number of words likely to complete a sentence is restricted by the sentence context (i.e., there is high sentential constraint), and when the word completing the sentence is one of those options with high likelihood, neural responses are smaller. Moreover, newer work suggests that the processing benefit from predictive contexts might vary across individuals. Yet, how semantic predictability leads to these patterns of improvement is still uncertain, and semantic predictability’s impact on listening effort is still understudied, especially at the individual level. This study used pupillometry to examine how semantic predictability affected the allocation of listening effort, and how this effort modulation systematically varied across participants. Pupillometry is a well-supported measure of listening effort and has been associated with the phasic norepinephrine activity in the locus coeruleus. **Methods:** Pupil dilation was recorded while young adult participants ($n = 64$) with normal hearing listened to sentences varying in semantic predictability. Sentence stimuli were mixed with background noise at a challenging signal-to-noise ratio, and participants completed a probe-word verification task after hearing each sentence. Pupil results were modeled using growth curve analysis to assess the dynamics of semantic predictability during online speech perception. Predictors of individual variation in predictive context sensitivity were derived from sentence predictability’s influence on probe-word response and from deviation from a separate, secondary cloze task. **Results:** Participants were indeed more accurate at identifying probe words embedded in highly predictable than less predictable sentences; importantly, this accuracy benefit for semantic predictability varied across participants. While sentence predictability did not significantly influence group-level pupil dilation directly, a post-hoc analysis showed that the magnitude of pupil dilation correlated with the individual degree of benefit from predictive semantic contexts. **Conclusion:** These data suggest that listeners differentially use contextual information to guide effortful processing during speech perception, leading to new insights into individual-level engagement with the speech signal. Future work is needed to explore the contributors to these observed differences, such as how prior language experience affects type and strength of input predictions, variation in working memory capacity and attentional control, and if there is a neurobiologically-based

limiting capacity of cognitive resources like firing rate of the locus coeruleus or differences in sensitivity to norepinephrine in the arousal system.

E69 - Preserved neural distinctiveness of speech in middle age despite cochlear neural degeneration: evidence from a gerbil model

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Speech processing declines in middle age despite normal audiometric thresholds. Using electroencephalography (EEG) to continuous naturalistic speech, Guo et al. (2025) demonstrated that middle-aged adults exhibit less distinct neural representations of phonemes compared to younger adults, consistent with cortical neural dedifferentiation. This dedifferentiation were not fully explained by age-related cochlear neural degeneration (CND) as peripheral measures – including markers of putative CND – accounted for less than 30% of the variance. However, CND cannot be directly verified *in vivo* in humans, and hence the mechanisms underlying neural dedifferentiation with age remain unclear. Here, we establish the Mongolian gerbil – an rodent with hearing sensitivities similar to humans in the speech frequencies – as an animal model to study the mechanisms underlying neural dedifferentiation with age. We examine whether middle-aged Mongolian gerbils exhibit reduced neural representations of phonemes when exposed to naturalistic speech, and independently model peripheral changes and central plasticity to understand the causes behind neural dedifferentiation with age. Thirteen younger gerbils aged 18–40 weeks and sixteen middle-aged gerbils aged 75 weeks were used. Neural responses were recorded with subdermal electrodes placed on the animals’ scalp. Animals were presented with speech stimuli from the Alice’s Adventures in Wonderland audiobook at suprathreshold sound levels. To assess cochlear synaptopathy, immunohistological analysis of organ of Corti whole mounts was conducted to quantify average afferent synapse counts in the 1 kHz and 3 kHz cochlear regions. Neural data were analyzed following the phoneme-related potential (PRP) approach (Khalighinejad et al., 2017; Guo et al., 2025), whereby we epoched responses at the vertex electrode from 0.0–0.5 s to instances of each phoneme and averaged across instances to derive the PRP. We quantified neural distinctiveness of major speech categories (vowels, nasals/approximants, fricatives, and stops) by computing the F-statistic over time, which measures the variation in PRPs between categories relative to that within each category. Histological analysis revealed a ~20% reduction in afferent synapse counts in middle-aged gerbils compared with younger ones, consistent with age-related CND. Yet, the two age-groups did not differ significantly in the time-averaged F-statistic ($t(24.43) = 0.30$, $p = 0.77$) and the peak F value ($t(26.87) = -0.48$, $p = 0.63$). Across all animals, there was also no significant correlation between synapse count and time-averaged F-statistics ($r = 0.25$, $p = 0.25$). These findings from the animal model indicated that, unlike the middle-aged adults in Guo et al. (2025), middle-aged gerbils show no decline in neural distinctiveness of phoneme representations despite verified CND. This dissociation implies that cortical dedifferentiation of speech may not arise completely from

reduced CND cascading downstream to the central auditory system. Ongoing analysis is aimed at modeling more extreme peripheral degradations using noise exposure, and independent maladaptive central plasticity using earplugs, to isolate the causes underlying neural dedifferentiation with age.

E70 - Speech-in-noise representations in the developing human brain

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Understanding speech in noisy environments relies on the successful integration of canonical speech perception processes along with active processes that enhance the signal and reduce the noise (Davis & Johnsrude, 2003; Eckert et al., 2016). In adults, beyond the speech processing regions in posterior superior temporal cortex and inferior frontal gyrus, speech-in-noise processing is supported by the speech motor system (Du et al., 2014) as well as an extra-auditory network including anterior insula, anterior cingulate, and middle frontal gyrus (Vaden et al., 2013) that especially kicks in under more challenging conditions. In children, speech processing networks have been shown to emerge slowly and shift gradually over the course of typical development. Children often demonstrate behavioral challenges in speech-in-noise processing, which has been correlated stimulus encoding fidelity with EEG (White-Schwoch et al., 2015). However, it is not clear how the specific neural processes underlying speech perception and speech-in-noise processing are instantiated during development. To understand the brain networks involved in processing speech in challenging listening environments in the developing human brain, we conducted a functional MRI speech-in-noise experiment with 7-to-13-year-olds. Participants performed a syllable identification task ("ba", "da", "ga", or "ma") in a Siemens 3 Tesla MRI during functional MRI acquisition. Syllables were spoken by one of four talkers (2 male, 2 female) and presented in one of five speech-shaped noise contexts (quiet and SNR = +8, 0, -2, and -6 dB). Participants completed three runs consisting of 160 trials each (two presentations per syllable, per talker, and per noise context) over 6.5 minutes per run (20 minutes total). Functional MRI data were preprocessed with FMRIPREP, which performs best-practice motion correction, image coregistration, template normalization, unwarping, noise component extraction, segmentation, and skull-stripping. We first investigated univariate fMRI contrast in quiet vs. in the highest noise conditions, where we found stronger fMRI responses to speech in quiet vs. speech in noise in bilateral superior temporal gyrus (STG). Conversely, responses in the head of the caudate were higher in noise compared to quiet, but these differences were not statistically significant. Next, to examine the representation of noise within the developing brain, we conducted representational similarity analysis (RSA), which allows us to directly compare stimulus characteristics (here, background noise level) with patterns of neural responses to the stimuli. We conducted searchlight RSA across the whole brain and found significant correlations between neural response and noise level dissimilarity matrices in left STG, right caudate head, and bilateral inferior frontal gyrus (IFG). Combining our two findings, while children more strongly activate broad canonical auditory and language regions in clear speech compared to noisy stimuli, background speech level itself is represented in

specific regions that may come online to facilitate speech processing in challenging listening conditions. Future work will investigate the emergence over development of noise level representations for speech-in-noise facilitation, their relationship to behavior, and how these representations are modulated by developmental communication disorders.

E71 - Low-Rank Tensor Encoding Models Disentangle Natural Speech Comprehension Processes

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Introduction: The recent emergence of LLM encoding models promises a new avenue to discover and characterize rich semantic information in the brain, yet interpretable methods for linking information in LLMs to language processing over time are limited. The non-interpretability of these methods — and the fact that most experiments using them employ uncontrolled stimuli — have led to criticism of this approach as potentially reflecting low-level processing instead of high-level semantic or syntactic computations. In this work, we develop a low-rank tensor regression method to decompose LLM encoding models into interpretable components of semantic features, time course, and brain region activation, and use this method to uncover important components related to speech comprehension from a Magnetoencephalography (MEG) dataset, where subjects listened to narrative stories. We use this approach to disentangle low-level and high-level language features and estimate their respective contributions to the recorded brain activity. **Methods:** To investigate the effects of language over time, we use a time delay encoding model with word embeddings from a large language model as inputs (Llama2-7b, 20 word context window), as well as low-level control variables such as the word onset times and the audio spectrogram. This input structure, combined with an output prediction over channels, yields a natural 3-D regression weight tensor over time, language features, and MEG sensors. In our method, we decompose this tensor using a low-rank CP approximation where the weight tensor is a sum of rank-1 tensor components. To fit, we use stochastic gradient descent with an MSE reconstruction loss and a ridge penalty. In order to interpret the language drivers of each factor, we compute the maximal driving natural language inputs for each embedding tensor component. Instead of using a generic beam search, which generates sequences with high linguistic probability, we introduce a new procedure in which we sample a sequence in the reverse order, starting with the most recent word which contributes most to the MEG activity. **Results:** Using our method, we show improved performance compared to a standard ridge regression encoding model when utilizing only a few factors, demonstrating that our low-dimensional constraint leads to more accurate characterization of MEG brain responses. Our model accounts for low level aspects of the speech input which are known to affect MEG activity (word onset, phrase boundaries, and audio signals), and is able to disentangle them from factors that are smaller in magnitude, but more complex (semantic attributes related to concepts such as pronouns, motion, emotions, etc). Our model also reveals the time-course and spatial locations of

these factors. Conclusions: In this work, we propose a novel low-rank tensor encoding model to extract and interpret complex semantic processing of language during naturalistic speech. This method demonstrates greater performance over ridge-regression encoding models while capturing more interpretable language computation, making it a powerful tool for exploratory language neuroscience. Crucially, our work addresses one of the main criticisms of naturalistic language experimentation — the correlation of different variables — and separates confounding components from the high-level components of interest.

E72 - Processing of Russian multiple wh-questions challenges the presumed syntactic nature of established ERP effects

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Long-distance dependencies are known to elicit sustained anterior negativity (SAN) and P600 effects, but the exact interpretation of these effects is still up for debate. We used Russian to conduct the first EEG study of multiple long-distance dependencies in order to disambiguate the functional interpretation of the following: (1) SAN: SAN between a displaced constituent and its gap is often interpreted as an index of syntactic working memory load. Recent studies have questioned this functional interpretation, either failing to replicate the same effect or reporting a decrease in amplitude of the effect due to contextual support. (2) P600: Positive-going voltage deflection at the gap site has been interpreted as an index of syntactic integration difficulty reflecting the number of syntactic operations involved in closing the dependency. (3) Phasic LAN: Several studies have reported transient LAN effects at the post-gap position indexing a retrieval process, rendering the syntactic integration interpretation of the P600 at the preceding position problematic. Previous ERP studies compare the presence of one long-distance dependency to its absence, making it hard to distinguish between different possible interpretations of known ERP effects. However, Russian allows multiple wh-elements to be displaced to the left periphery of the sentence, creating the possibility of a three-way distinction: no dependency vs. a single dependency vs. multiple dependencies of the same kind. As the complementizer 'that' (čto) is syncretic with 'what' in Russian, we used why-questions — arguably forming no dependency — as controls. 120 stimulus and 120 filler sentences were presented via RSVP to native Russian speakers (n=27). We ran repeated-measures by-subjects ANOVAs to test how the number of dependencies affected the amplitude of (1-3): (1') Multiple long-distance dependencies elicited a left-lateralized SAN effect ($p < 0.05$) compared to single and no-dependency conditions, which did not differ from each other. (2') At the verb, multiple and single dependencies did not differ from each other, but each elicited a P600 effect relative to the no-dependency condition ($p < 0.05$). (3') At the post-gap position, multiple and single dependencies again did not differ from each other, but each elicited a phasic LAN effect compared to the no-dependency condition ($p < 0.05$). (1') suggests that SAN is not simply a response to the formation of a syntactic dependency, and is thus not purely syntactic in nature. In contrast, the lack of a P600 difference between multiple and single wh-dependencies in (2') at the end of the dependency casts doubt on interpreting the P600 as indexing syntactic integration difficulty: there is more syntactic material to

integrate in a multiple wh-dependency. We suggest the P600 may instead reflect an all-or-nothing gap identification mechanism insensitive to the amount of associated syntactic information. This is also more consistent with a subsequent LAN effect in (3') indexing retrieval at the post-gap position in multiple and single dependencies. The lack of a difference between multiple and single dependencies here suggests that, if LAN indeed indexes retrieval, the nature of the retrieved information must be independent of the number of completed dependencies.

E73 - Active Use of Latent Tree-structured Sentence Representation in Humans and Large Language Models

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Understanding how sentences are internally represented in the human brain, as well as in large language models (LLMs) such as ChatGPT, is a major challenge for cognitive science. Classic linguistic theories propose that the brain encodes a sentence using a tree-structured representation, e.g., based on hierarchically organized constituents. In contrast, LLMs do not explicitly parse linguistic constituents while their latent sentence representations remain poorly explained. Here, we develop a method to reveal that humans and LLMs construct similar tree-structured latent representations of sentences by analyzing their rule inferencing behavior. The method is based on a novel one-shot learning task, in which the participants learn to delete a word string from a sentence based on a single demonstration. In the task, we always delete a constituent in the demonstration but, with just one demonstration, the underlying deletion rule is highly ambiguous — The participants may infer the rule based on, e.g., the ordinal position, semantic, or syntactic properties of individual words. Alternatively, if the participants internally encoded the sentence using a tree-structured representation, they may rely on such representations to make inference, e.g., whether the deleted word string is a constituent. We apply the method to 372 human participants and 5 recently developed LLMs, and find both humans and LLMs tend to delete a constituent, instead of a nonconstituent word string, and the inferred constituent deletion rule differs between languages, i.e., Chinese and English. These phenomena are not explained by models that only have access to word properties and word positions. Based on the word deletion behavior, we can reconstruct the latent tree structure of a sentence for both humans and LLMs, and the reconstructed constituency tree is partly consistent with the constituency tree informed by linguistic analyses. Altogether, these results strongly support that both human participants and LLMs can develop a tree-structured latent representation for sentences and actively use it in a language inference task. The data-driven methods proposed here can also be applied to characterize the internal representation of sentence for individuals or special populations in the future.

E74 - Composition by prepositional phrases comparing semantic relations in Brazilian Portuguese: an EEG-ERP study

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Introduction: In this EEG/ERP study, we investigate combinations of noun phrases with prepositional phrase (PP) modifiers in Brazilian Portuguese, contrasting two types of semantic relation: (i) PPs specifying material (ex. “fruteira de bambu”, i.e. a bowl [made of] bamboo) and (ii) PPs specifying the function (ex. “serrote de bambu”, i.e. a (little) saw [made for cutting] bamboo). These semantic relations may be distinguished by being feature vs. thematic based, respectively. Specifically in the second category, there seems to be the need to compute some hidden meaning in order to understand that ‘bamboo’ is the object for the purpose of cutting. Thus, seemingly identical structures convey distinct meanings, perhaps engaging different processes. In a MEG study, Flick et al. (2021) compared similar semantic distinctions in compounds (such as ‘metal cabinet’ and ‘trophy cabinet’) with thematic relations showing greater activation in the left posterior temporal lobe, 100–200 ms after phrasal head onset. We hypothesized that the processing of function meaning may involve coercion; that is, an action or implicit verbal event (i.e. for [cutting] in the case of “serrote de bambu”) is computed, leading to processing costs. A study by Neufeld et al. (2016) suggests that in the same time window, combinatory processing can be captured with EEG/ERP. We also expected these different semantic relations to affect the N400 component. **Methods:** We contrasted 2 relation types and a non-combinatory control condition with non-word items (e.g., “livro de nsplk”, “book of nsplk”), we varied the preposition in distractor items (ex. “caixa com bonbons”, box with chocolates). We applied a norming experiment (298 participants) in order to control familiarity and semantic interpretation. We selected 84 pairs (the same target word in two semantic contexts) that fit the semantic interpretation of either material (“is made of”) or function (“is made for x-ing”), with over 90% agreement and which were comparable for familiarity judgements on a 5 point Likert scale. Ratings of 3 (+/- 1) were preferred for not being too idiomatic nor too unfamiliar. We collected EEG data with 32 electrodes from 26 university students (M=12) in a phrase picture matching task. As a follow-up, we collected reaction times from self-paced reading and accuracy from a similar task, but no EEG, with 57 participants. **Results and discussion:** We found that combinatory items, in contrast to combinations with non-words, yielded greater negativity after the third word onset around 200ms (fronto-central channels) and around 400ms (strongest at parietal channels). However, there was no effect for semantic relation (material vs. function). This might be due to methodological issues (e.g. spatial dissociation is possible for MEG, but not EEG), or perhaps coercion and semantic integration are equally costly. An alternative explanation is that there is no difference in online computation, but rather specific task demands may engage pragmatic inference posterior to phrasal processing. Results from the behavioral picture matching study seem to suggest this, as reading times for the PP head were significantly longer for the function interpretation, as we had predicted.

E75 - Serial and Parallel Combinatorics: An MEG investigation into lexical and compositional processing during parallel presentation

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Language comprehension is often thought of as a serial, word-by-word process, as assumed in many theories of sentence processing. However, in reading, multiple words are visible at once, allowing us to ask to what degree processing becomes parallel when the stimulus itself has no temporal structure that unfolds serially over time. It has already been demonstrated that an N400 effect for a full sentence presented at once is timed similarly to classic N400s elicited for single words (Wen et al., 2019), showing no cost of reading multiple words. Further, neural reflexes of phrasal structure when glancing at short, written sentences are elicited as early as 130 ms (Fallon & Pykkänen, 2024), which also is hard to account for under a serial model. In this MEG study (n = 24), we used rapid parallel visual presentation (RPVP) and directly focused on the serial vs parallel question. We first identified composition related neural activity by contrasting combinatory and non-combinatory expressions at three levels of length. Then, for each effect of length that was only observed for combinatory stimuli, we asked whether processing within it showed sequential or simultaneous effects of the lexical and bigram frequencies within the expression. The stimuli were full sentences (e.g., the cats are nice), shorter phrases (the cats) and bare determiners (the), as well as lists of one, two, or three plural nouns. Composition related signals were first identified in a broadly defined language mask. Then a two-stage GLM assessed sensitivity to lexical frequency (proxy for lexical access) and bigram frequency (proxy for compositional processing) within these regions. Effects of composition were observed in the left anterior temporal lobe (LATL) at 237–349 ms (p = 0.005) and at 355–418 ms (p = 0.043). GLM analysis revealed the first cluster was sensitive to the frequency of the first bigram of both four-word sentences and two-word phrases (p = 0.016), and the second to the second bigram of four-word sentences (p = 0.009)—suggesting serial composition in the LATL. A composition effect was also observed in the middle temporal gyrus at 303–339ms (p = 0.049). GLM results on this activity showed simultaneous lexical frequency effects for the first two words, but only in grammatical sentences. In sum, our results reveal serial composition in the LATL, and later lexical and combinatory processing occurring in parallel in the MTG. This pattern departs from the predictions of fully serial models, and instead indicates that the brain appears to recruit both serial and parallel mechanisms.

E76 - Propagation of the N400 to subsequent words after lexical anomalies depends on the syntactic attachment point

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The N400 component is widely interpreted as an index of local semantic processing (individual word level), but its role in sentence-level meaning integration remains a subject of major debate (Brouwer & Crocker, 2017; Hagoort, 2019). Moreover, there is growing evidence that Late Positive Component (LPC) is also elicited by the effort to integrate local meaning within the sentence structure (Shen et al., 2016). Here, we present an EEG study designed to test the sensitivity of both components to the syntactic attachment points. The main question we address is whether the N400 or LPC generated by a lexical anomaly propagate to upcoming words in the sentence, and whether

such a cascading effect is modulated by constituent structure. We hypothesize that words that follow an anomalous lexical item that remains in the same constituent would elicit either an N400 or an LPC, while equidistant words outside the constituent would not. To this end, we created 200 Italian sentences following a consistent SVO+Modifier structure: [Determiner, Noun, Verb, Determiner, Noun, Preposition, Noun]. Sentences were rendered semantically correct or anomalous by manipulating the semantic congruency between the verb and the object noun. Additionally, half of the prepositional phrases (PPs) were attached to the object noun (Extended-DP condition), the other half to the verb (VP-modifier condition), resulting in four experimental conditions: Correct VP-modifier ("A customer books this table for tomorrow"), Correct Extended-DP ("A rabbit eats various herbs from the garden"), Incoherent VP-modifier ("A customer books this enemy for tomorrow"), and Incoherent Extended-DP ("A rabbit eats various levers of the garden"). We controlled for the semantic distance between the object and the noun within the PP, using cosine similarity on word2vec vectors, and the DP-VP conditions did not show a statistical significant difference ($t = 1.012$, $p = 0.312$). Sentences were presented auditorily to 29 native Italian speakers. Cluster-based tests with Monte Carlo permutations revealed a significant ($p < 0.05$) centroparietal N400 at the object noun and a parietal-occipital LPC when comparing correct to incoherent sentences. LPC extended to all the subsequent words in the anomalous sentences in both Extended-DP and VP-modifier conditions — indicating a propagation independent of the PP attachment point. In contrast, N400 effects at the noun within the PP were observed only in the incoherent Extended-DP condition ("The postman collects many cultures of congratulations"). These findings suggest that, once a lexical anomaly is introduced, semantic integration difficulties cascade across the sentence; however, the N400 appears more sensitive than the LPC to constituent structure and syntactic dependency. References Brouwer, H., & Crocker, M. W. (2017). On the proper treatment of the N400 and P600 in language comprehension. *Frontiers in Psychology*, 8(AUG), 1–5. Hagoort, P. (2019). The neurobiology of language beyond single-word processing. *Science*, 366(6461), 55–58. Shen, W., Fiori-Duharcourt, N., & Isel, F. (2016). Functional significance of the semantic P600: Evidence from the event-related brain potential source localization. *NeuroReport*, 27(7), 548–558.

E77 - The Salience of function words in implicit statistical linguistic learning: An ERP investigation

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Research has indicated that children and adults can implicitly learn language patterns; however, questions still remain regarding the role and nature of implicit learning, particularly of sequential patterns. Implicit statistical learning is a type of unconscious learning of sequential patterns, which may be especially relevant to phrase structure learning. Prior studies have highlighted the differential processing of function words (FWs) like determiners relative to content and nonsense words and have also pointed to particular neural response patterns (specifically, Anterior Negativity, or AN) to early syntactic violations. To date, there is relatively little work directly investigating the role of FWs in implicit statistical learning of linguistic patterns. The present study used electrophysiological

measures to test adults' ability to implicitly learn grammatical patterns. We hypothesized that: 1) adults would demonstrate implicit learning of the linguistic patterns; 2) grammatical violations would elicit an Anterior Negativity (AN) response, and 3) the inclusion of real FWs would elicit a more robust neural response, particularly for native English listeners. Method: Participants included eight native English-dominant (ED) and eight native Turkish adults, all between the ages of 18 and 35 years. In two experiments, Event-Related Potentials (ERPs) were recorded from 17 electrode sites while participants watched a muted movie while listening to auditory stimuli. The stimuli were designed to be analogous to elements of English Noun Phrases (NPs). Both experiments included nonsense word forms (e.g., /ua/, /ia/ /lea/). In Experiment 1 (Exp1), two of these nonsense forms were placed in the initial noun phrase position. In Experiment 2 (Exp2), two of the six stimuli were real English FWs, "the" and "an". Experiments were separated into two blocks; during the first block (B1) of each experiment, the six stimuli were presented in a pattern mimicking the phrase structure Determiner (Adjective)(Adjective)Noun for 16 possible combinations ("sentences"), each presented 13 times in a block. During the second block (B2) 20% of these sentences were reversed, violating the learned pattern. Results: Increased left-hemisphere AN responses were observed following grammatical violations in both experiments, which interacted with time and hemisphere. However, the two language groups showed different patterns. In Exp 1, for both groups, the early AN (100-200 ms) to the violation was bilateral, but left lateralized in a later time window 300 and 500 ms. In addition, the later response was larger for the Turkish listeners. For Exp2, the native English group showing an early AN to the violation, whereas the native Turkish listeners only showed the later left AN (300-500 ms). Discussion: We interpret these patterns to index implicit learning of the statistical patterns, and that the English FWs facilitated implicit learning for the native English listeners. The larger response in the late time interval for the Turkish learners may be due to second language (L2) experience with English. Future plans are to double the sample size (as intended), and to examine listeners from other languages backgrounds who have varying amount or L2 experience.

E78 - Isolating Syntax with Frequency-Tagged Verbs: An Intracranial Study

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Syntax, the abstract structure of language, enables humans to convey an unlimited number or complex thoughts. Despite its centrality, its neural instantiation remains poorly understood. In particular, there is ongoing debate regarding its localization, with some studies pointing to a hub in inferior frontal gyrus (IFG; e.g., Menenti et al. 2012; Zaccarella & Friederici 2015), others to posterior temporal regions (Matchin et al. 2020; Flick et al. 2020), and still others to a broadly distributed, non-localizable code (Ding et al. 2016; Blank et al. 2015). Progress has been hindered by two major obstacles: First, the trade-off between spatial and temporal resolution in non-invasive measures like fMRI and EEG. Second, is the difficulty of experimentally isolating syntax (see, e.g., Sprouse & Lau 2013; Murphy 2024). While concrete representations like phonemes or words can be

directly activated via simple exposure, syntax is abstract — a property of multiple words — making direct exposure impossible. Studies must therefore manipulate syntax indirectly, using multiple words, as in a common paradigm that contrasts syntactically-structured strings of words (e.g., “red boat”) and unstructured word lists (“red, boat”). However, such manipulations typically introduce confounding processes that must be accounted for, such as word processing and combinatorial semantics. This project addresses these limitations by combining (1) intracranial sEEG recordings, which offer both high spatial and temporal resolution, and (2) an innovative paradigm that uses single words to target particular syntactic frames. Verbs are especially well-suited for this, as they are linked to specific argument structures (e.g., “dine (*bread)” vs. “devour *(bread)”). These abstract syntactic frames can be activated by presenting just the verb, a process which is apparently automatic as it has been documented even when verbs are presented subliminally (Trueswell & Kim 1998; Berkovitch & Dehaene 2019). Here, we exploit this property to elicit activation of three syntactic frames — intransitive, transitive, and clausal complement — by visually presenting neurosurgical patients with verbs selected for strong bias toward each frame. Verbs were shown at 1Hz in six 4-minute blocks. In odd-numbered blocks, every 3rd verb was intransitive (i.e., 1/3Hz), every 5th verb transitive (1/5Hz), and every 7th verb clausal (1/7Hz), whereas in odd blocks, these frequency tags were rotated (intransitives at 1/5Hz, transitives at 1/7Hz, and clauses at 1/3Hz). Thus, an electrode in a location that represents the transitive frame should show spike in spectral power at 1/3Hz in odd blocks but 1/5Hz in even blocks. At the time of submission, data from one patient have been collected (and we anticipate running at least three additional patients by SNL 2025). Preliminary analysis reveals the expected pattern of significant peaks in power (calculated from local field potentials) in one electrode in the left supramarginal gyrus — adjacent to posterior temporal areas implicated in hierarchical syntax by recent models (Matchin & Hickok, 2020). These results provide early evidence for frequency-tagged activation of abstract syntactic representations using single-word stimuli and high-resolution neural data.

E79 - Intracranial mapping of the core spelling and reading networks

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Together, spelling and reading are fundamental aspects of literacy. Both of these are rapid behaviors that engage multiple distributed neural substrates, with core nodes commonly localized to mid-fusiform cortex (mFus), inferior parietal sulcus (IPS), and inferior frontal gyrus (IFG). Functional imaging studies demonstrate a population-level overlap of activation during spelling and reading, however, lesion studies demonstrate behavioral dissociations between spelling and reading, with selective deficits possible in only one of these functions. This implies that, while spelling and reading are closely related behaviors, having been learned together, they are still dissociable within individuals. Here, we use high spatiotemporal recordings to map the neural dynamics that allow us to rapidly spell both known and novel words, and map dissociations between the neural substrates of reading and

spelling. We probed this with direct intracranial recordings in 23 epilepsy patients, with extensive electrode coverage across left, language dominant cortex. Participants were auditorily presented with triphonemic CVC real words and novel pseudowords and were asked to spell them aloud, or repeat them aloud after a cued delay. They also read aloud visually presented words and pseudowords. We used this to create a spatiotemporal map of broadband gamma activity (70-150Hz), combined with multivariate models to show how this varied with multiple behaviorally relevant word attributes including lexicality, word frequency, and phoneme-to-grapheme surprisal. We found spelling broadly engaged frontal and parietal cortices, as well as mFus, before activation spread back to early visual cortex. Sensitivity to both word frequency and surprisal while spelling was seen across IFG, IPS and precentral sulcus. Greater activation was seen in these regions, as well as mFus, when spelling known words, while anterior IFG showed greatest activation when spelling pseudowords. Analysis of directed information flow within the core regions of the spelling network indicated that mFus, IPS, and IFG, the primary regions implicated in lesion studies of spelling, act as the most prominent information sources while spelling. We find a partial dissociation between reading and spelling, with temporal and parietal electrodes mostly showing overlap between the two tasks, while frontal electrodes were more likely to show distinct sites selectively engaged by either spelling or reading. We thus isolate the neural spatiotemporal correlates of the core, distributed spelling network involving mFus, IPS, IFG, and precentral sulcus. We provide direct evidence for a dynamic, distributed network underlying this complex behavior, that is modulated by factors that behaviorally influence spelling difficulty. We also demonstrate that reading and spelling do share some cortical resources and are only partially dissociable within individuals.

E80 - The Neural bases of orthographic word learning in older adults

Robert W. Wiley¹, Yuan Tao², Sartaj Singh¹, Brenda Rapp²; ¹University of North Carolina Greensboro, ²Johns Hopkins University

Introduction: Tao et al. (2024) examined the neural bases of the initial stages of orthographic learning in neurotypical young adults learning spellings for novel pseudowords during fMRI scanning. There, we reported a distinctive bilateral hippocampal increase in BOLD response with the increasing memory strength of learning trials. In contrast, in ventral occipital temporal cortical (VOTC/VWFA) we observed the reverse pattern of decreasing BOLD response with increasing memory strength. These findings are consistent with Complementary Learning System theory (McClelland et al., 1995) that predicts complementary roles for subcortical and cortical learning mechanisms. Subsequently, Rapp et al. (2024) reported that older adults had significantly more difficulty than younger adults in learning new words spellings. Here, we follow-up on these studies to examine the neural bases of orthographic learning in older versus younger adults using the in-scanner orthographic learning paradigm from Tao et al. (2024). Methods: Participants were N = 18 younger (YA; ages 18-35) and N = 23 older (OA; ages 55-80) neurotypical adults. As in Tao et al. (2024),

participants were tasked with learning the correct spelling of 10 novel pseudowords while undergoing two runs of fMRI scanning. There were eight trials for each target, and average accuracy across all trials was 74% for YA and 60% for OA. Trials were subsequently binned into “memory strengths” (MS; weak, medium, strong) as in Law et al. (2005). For each participant, mean BOLD response was extracted for each MS level bilaterally in the hippocampus and VWFA. Bayesian multilevel models were used to regress BOLD on MS, Group (OA vs YA), and their interaction, separately for the hippocampus and VWFA. Results: Behavior: In terms of in-scanner performance, the YA were significantly more accurate, $M = 0.74$, 95% CI [0.66, 0.82], compared to the OA, $M = 0.60$, 95% CI [0.54, .67]. The difference between groups was significant, $t(39) = 2.65$, $p \approx 0.01$. Hippocampus: Across MS levels, the YA showed a significant rising BOLD response bilaterally (left: $p < 0.01$; right: $p \approx 0.02$). The OA showed similar non-significant effects bilaterally (p 's > 0.21), although the pattern was not significantly different from the YA ($p \approx 0.21$). VWFA: The YA showed a significant falling pattern across MS levels in both hemispheres (left: $p < 0.01$; right: $p < 0.001$). The OA showed non-significant effects in bilaterally (p 's > 0.34), and this pattern was significantly different from the YA ($p \approx 0.02$). Conclusions We replicated the Tao et al (2024) findings that younger adults show distinct and complementary patterns of BOLD response in the hippocampus and VOTC during early orthographic learning. Furthermore, we show that older adults, who struggle to learn novel orthographic word forms, do not show these patterns. Instead, they exhibit an attenuated subcortical response in the hippocampus and a significantly different cortical response in the VOTC. These findings suggest that hippocampal weakness may trigger compensatory cortical responses.

E81 Sandbox Series - Neural bases of differences between older and younger adults in the learning of novel word forms and meanings

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Introduction While research shows a wide range of cognitive changes associated with aging, there is limited research on the impact of aging on novel word learning. Word learning involves learning multiple components—spelling, pronunciation, and meaning. Previously, in Rapp et al. (2024), we reported that older adults exhibited significant difficulties in learning the spoken and written forms of novel words, while, in contrast, word meanings were learned comparably to younger adults. Here, we report the behavioral results from the complete set of participants and, building on these robust behavioral effects, we focus on understanding the neural bases of the strengths and weaknesses exhibited by older adults. Specifically, we seek to answer the following: Question 1: Do cortical (language network) and subcortical (hippocampal) mechanisms contribute similarly to learning word forms and meanings in older and younger adults? Question 2: Do older and younger adults differ in the extent of neural differentiation/de-differentiation as indexed by BOLD peak magnitude and spread (Gordon et al., 2018)? If so, do these account for the observed learning differences? **Methods Behavioral:** Twenty-three older adults (OAs; mean age = 67.4 years, SD = 5.4) and twenty younger adults (YAs; mean age = 24.0 years, SD = 10.6), all native

English speakers. Participants attempted learning the spellings, pronunciations, and meanings of 36 novel words within a fantasy story, over several weeks. Results: For word spellings, YAs exhibited significantly higher accuracy than OAs ($p = 0.024$), with no significant differences in semantic learning between groups ($p = 0.14$). Analysis of phonological word-form learning is underway. **Neuroimaging:** fMRI scanning administered prior to learning allows for identification of predictors of learning effects; data collection is complete. **Language Localizer:** Language network responsivity indexed by the contrast of STORY>BACKWARD SPEECH. **Learning Localizer:** Learning responsivity indexed by the contrast LEARN>VISUAL BASELINE, in bilateral hippocampi. **Planned Analyses:** Analysis 1: Identify brain areas where responsiveness predicts subsequent word learning Step 1: Compute language and learning responsiveness measures per voxel, per participant. Step 2: For specific ROIs, use LME modelling to evaluate the relationship between the out-of-scanner word learning scores (one model for each of the three learning dimensions) and both language and learning neural responsiveness, across OA and YA groups. The ROIs will include: bilateral hippocampi, key nodes of the language network (ATL, IFG, STG, MTG). Analysis 2: Evaluate if neural differentiation/de-differentiation predicts later word learning Step 1: For each ROI and participant, extract locations corresponding to activation peaks for STORY>BACKWARD SPEECH in the language network ROIs, and the LEARN>VISUAL BASELINE for the bilateral hippocampi. Step 2: For each peak, extract unsmoothed percent-signal-change within spherical kernels, starting from a radius of 3mm and up to 10mm. Compute the incremental signal per unit volume added, then fit a $1/\text{radius}^2$ decay function across radii. Step 3: For each ROI, use LME modelling to evaluate the relationship between out-of-scanner learning (one model per learning dimension), and both BOLD peak magnitudes and spreads, across OA and YA groups.

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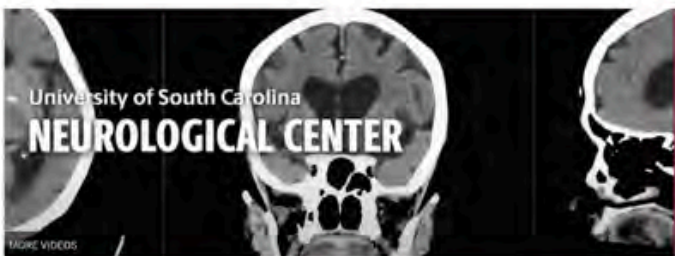
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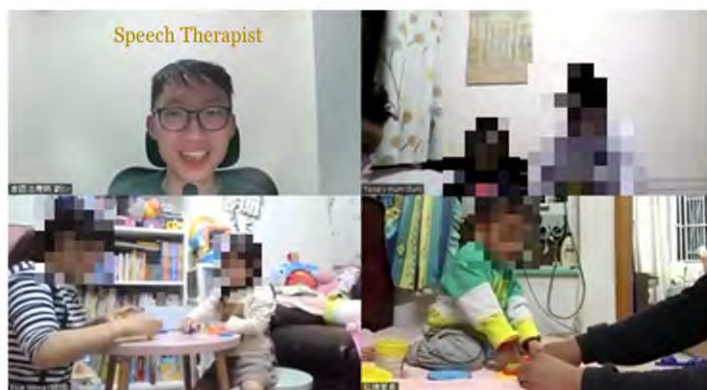
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