SNL 2015

OCTOBER 15-17, 2015
CHICAGO, ILLINOIS

www.neurolang.org

ABSTRACTS

Welcome to SNL 2015, Chicago, Illinois

Welcome to the 7th Annual Meeting of the Society for the Neurobiology of Language.

As you can see, we have a full program arranged for this year's meeting, including four distinguished keynote speakers from different areas of language and neurobiology. They will speak to us about gesture, language networks, motor learning, and the intrinsic activity of the human brain: a rich combination of topics that will surely stimulate ideas to enrich our own research. In addition, three platform sessions will again highlight some of the exciting work being carried out by our colleagues.

As our Society continues to grow, we have been experimenting with different formats for our special presentations, based on responses from post-conference surveys. This year, we have put the debates on hold in order to include an invited symposium that tackles the question of how aging affects the brain and language. This symposium includes an invited talk on the basic neuroscience of aging with additional presentations from three of our own members, and will address how this phase of the human life span might influence the way we communicate.

This year, SNL experienced a record number of abstract submissions, with a total of 468 from over 25 countries. Due to this increase, we expanded the number of poster sessions to allow more time to peruse and discuss the presented work. Also, in addition to the SNL reception, we have arranged for two additional "no-host" social hours for those who would like to stay and mingle over drinks.

Once again, we have been fortunate to have the expertise of Shauney Wilson and Shawna Lampkin who have been essential to the planning of this meeting and in running our Society over the past year. We are extremely grateful for the outstanding work they have done. Many thanks as well to our Meeting Liaison, Sonja Kotz, and Greig de Zubicaray for serving on the Program Committee, and Jeff Binder and Leora Cherney for assisting with local arrangements. Our sponsors also deserve many words of gratitude for their contributions, as do all of the reviewers who evaluated abstracts to assure an excellent slate of presentations.

The Board of Directors of the Society for the Neurobiology of Language hope you enjoy this year's meeting in the vibrant city of Chicago. We look forward to hearing your feedback about this year's format and what you might like to see in future meetings.

Nina Dronkers
Chair of the Board of Directors
Society for the Neurobiology of Language

TABLE OF CONTENTS

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Pascale Tremblay, Université Laval, Quebec, Canada

Schedule of Events

All events are held at the Drake Hotel.

Wednesday, October 14

4:00 – 8:00 pm **Pre-Registration Check-in and Onsite Registration** *Drake Room and French Foyer*

7:00 – 9:00 pm **Social Hour** (no host bar) *Venetian Room*

Thursday, October 15

7:30 am - 6:00 pm **Pre-Registration Check-in and Onsite Registration** *Drake Room and French Foyer*

8:00 - 8:45 am **Continental Breakfast** *French Room*

8:45 - 9:00 am **Opening Remarks** -Nina Dronkers, SNL Chair *Grand Ballroom*

9:00 - 10:00 am **Keynote Lecture - Susan Goldin-Meadow -** Gesture as a Mechanism of Change *Grand Ballroom*

10:00 - 10:30 am **Coffee Break** *French Room*

10:00 am - 12:00 pm **Poster Session A** *French and Walton Rooms*

12:00 - 1:00 pm **Lunch** (on your own)

1:00 - 2:20 pm **Slide Session A - Network Development and Reorganization** *Grand Ballroom*

2:20 - 2:50 pm **Coffee Break** *French Room*

3:00 - 4:00 pm **Keynote Lecture - Peter Strick** -A Tale of Two Primary Motor Areas: "Old" and "New" M1 *Grand Ballroom*

4:00 - 4:30 pm **SNL Business Meeting** *Grand Ballroom*

4:30 - 6:30 pm **Poster Session B** *French and Walton Rooms*

6:30 - 8:00 pm **SNL Reception** *Grand Ballroom*

Friday, October 16

8:00 am - 7:30 pm **Pre-Registration Check-In and Onsite Registration** *French Foyer*

8:00 - 8:45 am **Continental Breakfast** *French Room*

8:45 - 9:00 am **Announcements** *Grand Ballroom*

9:00 - 10:00 am **Keynote Lecture - Marsel Mesulam** - Revisiting Wernicke's Area *Grand Ballroom*

10:00 - 10:30 am **Coffee Break** *French Room*

10:00 am - 12:00 pm **Poster Session C** *French and Walton Rooms*

12:00 - 1:00 pm **Lunch** (on your own)

1:00 - 3:00 pm **Poster Session D** *French and Walton Rooms*

2:30 - 3:00 pm **Coffee Break** *French Room*

3:00 - 4:20 pm **Slide Session B - Perspectives on Language Processing** *Grand Ballroom*

4:30 - 5:30 pm **Keynote Lecture - Marcus Raichle** The restless brain: how intrinsic activity organizes brain function *Grand Ballroom*

5:30 - 7:30 pm **Poster Session E** *French and Walton Rooms*

5:30 - 7:30 pm **Refreshments and No Host Bar** *French and Walton Rooms*

7:30 – 9:00 pm **Social Hour** (no host bar) *Venetian Room*

Saturday, October 17

8:00 am - 2:00 pm **Pre-Registration Check-In and Onsite Registration** *French Foyer*

8:00 - 8:30 am **Continental Breakfast** *French Room*

8:30 - 9:50 am **Slide Session C - Outside the Left Peri-Sylvian Cortex** *Grand Ballroom*

9:50 - 10:30 am **Coffee Break** *French Room*

10:00 am - 12:00 pm **Poster Session F** *French and Walton Rooms*

12:00 - 1:45 pm **Invited Symposium -** Language and the Aging Brain *Grand Ballroom*

1:45 - 2:00 pm **Closing Remarks - Nina Dronkers** and **Greig de Zubicaray** *Grand Ballroom*

Keynote Lectures

GESTURE AS A MECHANISM OF CHANGE

Thursday, October 15, 9:00 - 10:00 am, Grand Ballroom

Chair: Nina Dronkers, VA Northern California Health Care System and University of California, Davis

Susan Goldin-Meadow, Ph.D.

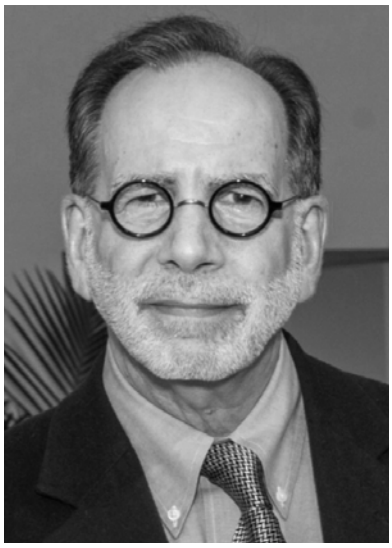
University of Chicago

The spontaneous gestures that people produce when they talk have been shown to reflect a speaker's thoughts––they can index moments of cognitive instability and reflect thoughts not yet found in speech. Gesture can go beyond reflecting thought to play a role in changing that thought––the gestures we see others produce can change our thoughts, and the gestures we ourselves produce can change our thoughts. In this talk, I consider whether gesture effects these changes because it itself is an action and can thus bring action into our mental representations. But gesture is a special kind of action––it spatializes ideas, even ideas that are inherently non-spatial, and it is representational and thus more abstract than direct action on objects. Gesture's representational properties may thus allow it to play a role in learning by facilitating the transition from action to abstraction.

A TALE OF TWO PRIMARY MOTOR AREAS: "OLD" AND "NEW" M1

Thursday, October 15, 3:00 - 4:00 pm, Grand Ballroom

Chair: Sonja Kotz, University of Manchester, UK and Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany



Peter L. Strick, Ph.D.

Scientific Director of the University of Pittsburgh Brain Institute, Thomas Detre Professor and Chair of the Department of Neurobiology at the University of Pittsburgh, and a Senior Research Career Scientist at the Pittsburgh VA Medical Center

This presentation will lay out the evidence to develop the following thesis:

1) The central control of movement is faced with an evolutionary constraint: Our skeletomotor system is built on the framework of a relatively ancient spinal cord.

2) Most descending systems, including the corticospinal system, use the pattern generators and motor primitives that are built into the spinal cord to generate motor output.

3) Cortico motoneuronal (CM) cells (i.e., cortical neurons with axons that make monosynaptic connections with motoneurons) are a relatively new phylogenetic and ontogenetic development. Furthermore, CM cells are located in a separate part of the primary motor cortex.

4) Thus, area 4 is split into 2 regions: a rostral region we have termed "Old M1" which has disynaptic input to motoneurons; and a caudal region we have termed "New M1" which has monosynaptic input to motoneurons.

In essence, Old M1 makes use of the circuits built into the spinal cord to generate motor output. This region of the motor cortex enables the motor system to avoid the "curse of dimensionality" and to solve the "degrees of freedom problem." In contrast, New M1 uses CM cells to bypass the constraints of spinal cord mechanisms. This region of the motor cortex enables the motor system to use all of the available degrees of freedom to sculpt novel patterns of motor output.

These arguments lead us to predict that the two regions of the motor cortex are differentially involved in motor learning. We speculate that Old M1 is especially important during the initial stages of learning a new skill by enabling the motor cortex to use existing spinal circuits to rapidly construct new movement patterns. In contrast, New M1 may be especially important during the later stages of learning a new skill by enabling the motor cortex to refine and precisely specify patterns of motor output.

REVISITING WERNICKE'S AREA

Friday, October 16, 9:00 - 10:00 am, Grand Ballroom

Chair: Jeffrey Binder, Medical College of Wisconsin

Marsel Mesulam, M.D.

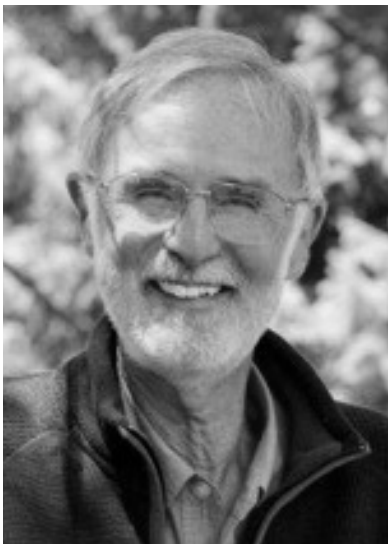
Director, Cognitive Neurology and Alzheimer's Disease Center
Ruth Dunbar Davee Professor in Neuroscience and Professor in Neurology
Ken and Ruth Davee Department of Neurology, Northwestern University

Wernicke's aphasia is characterized by severe word and sentence comprehension impairments. The location of the underlying lesion site, known as Wernicke's area, remains controversial. Questions related to this controversy were addressed in patients with primary progressive aphasia. Clinicoanatomical correlations were explored at the individual and group levels. These analyses showed that neuronal loss in temporoparietal areas traditionally included within Wernicke's area leave single word comprehension intact and cause inconsistent impairments of sentence comprehension. The most severe sentence comprehension impairments were associated with a heterogeneous set of cortical atrophy sites variably encompassing temporoparietal components of Wernicke's area, Broca's area, and dorsal premotor cortex. Severe comprehension impairments for single words, on the other hand, were invariably associated with peak atrophy sites in the left temporal pole and adjacent anterior temporal cortex, a pattern of atrophy that left sentence comprehension intact. These results show that the neural substrates of word and sentence comprehension are dissociable and that a circumscribed cortical area equally critical for word and sentence comprehension is unlikely to exist anywhere in the cerebral cortex. Reports of combined word and sentence comprehension impairments in Wernicke's aphasia come almost exclusively from patients with cerebrovascular accidents where brain damage extends into subcortical white matter. The syndrome of Wernicke's aphasia is thus likely to reflect damage not only to the cerebral cortex but also to underlying axonal pathways, leading to strategic cortico-cortical disconnections within the language network. The results of this investigation further reinforce the conclusion that the left anterior temporal lobe, a region ignored by classic aphasiology, needs to be inserted into the language network with a critical role in the multisynaptic hierarchy underlying word comprehension and object naming.

THE RESTLESS BRAIN: HOW INTRINSIC ACTIVITY ORGANIZES BRAIN FUNCTION

Friday, October 16, 4:30 - 5:30 pm, Grand Ballroom

Chair: Nina Dronkers, VA Northern California Health Care System and University of California, Davis



Marcus Raichle, M.D.

Neurologist and Professor in the Departments of Radiology, Neurology, Neurobiology and Biomedical Engineering at Washington University in St. Louis

Traditionally studies of brain function have focused on task-evoked responses. By their very nature such experiments tacitly encourage a reflexive view of brain function. While such an approach has been remarkably productive at all levels of neuroscience it ignores the alternative possibility that brain functions are mainly intrinsic and ongoing, involving information processing for interpreting, responding to and predicting environmental demands. I suggest that the latter view best captures the essence of brain function, a position that accords well with the allocation of the brain's energy resources, its limited access to sensory information and a dynamic, intrinsic functional organization. The nature of this intrinsic activity, which exhibits a surprising level of organization with dimensions of both space and time, is revealed in the ongoing activity of the brain and its metabolism.

Mark Your Calendar

August 17-20, 2016

Invited Symposium

LANGUAGE AND THE AGING BRAIN

Saturday, October 17, 12:00 - 1:45 pm, Grand Ballroom

This special symposium will discuss how aging affects the neurobiology of language. We have invited Prof. Naftali Raz to begin the session by reviewing the progress being made in understanding the mechanisms and factors of neural change in aging. His talk will be followed with presentations by three SNL members, Lorraine Tyler, Jonathan Peelle, and Pascale Tremblay. They will discuss whether or not aging affects some of the different levels of language processing -- speech perception, speech production, or syntactic comprehension -- and the neurobiological underpinnings of their findings. A final discussion period will allow meeting attendees to ask questions or discuss different issues raised by these presentations.

Naftali Raz, Ph.D.

Professor of Psychology and an Associate Director for Life-Span Cognitive Neuroscience at the Institute of Gerontology, Wayne State University, Detroit, MI

Aging of the Brain: Its Modifiers and Cognitive Correlates

Brain and cognition change with age but the rates of change differ among individuals and across brain regions and cognitive domains. The mechanisms of these differential changes remain unclear. Multiple factors associated with vascular and metabolic risk, inflammation, stress, accumulation of reactive oxygen species and beta-amyloid modify the course of aging. Genetic variants that alter availability and metabolism of hormones, enzymes and neurotransmitters also contribute to individual variation in age-related rates of change. Interventions that ameliorate the negative modifiers, e.g., exercise and active life-style inspire cautious optimism as they promise mitigating age-related declines. I will review the progress in understanding brain aging and its impact on cognition with a specific emphasis on long-term longitudinal studies.

Lorraine Tyler

University of Cambridge and the Cambridge Centre for Ageing and Neuroscience

The adaptive brain: brain and cognition in ageing

Language comprehension is a complex system that involves the rapid transformation of the speech input into various different types of representation. In spite of the multiple rapid computations involved, there is little evidence that aging significantly impairs normal language comprehension. Focusing on syntactic processing during natural listening, we find no evidence for functional compensation of the left hemisphere specialized syntax network. While age-related decreases in grey matter are associated with weakened connectivity within the syntax network and increased inter-hemispheric connectivity elsewhere, these changes are related to poorer performance and therefore are not evidence for successful compensation. Where we do see functional compensation is during experimental paradigms that place additional cognitive demands on the listener. Under these conditions, older listeners show increased activation of domain-general (but not domain specific) networks that are associated with improved performance. Overall, this research suggests that in the context of widespread age-related grey matter changes, preserved syntactic comprehension depends on the residue of the domain-specific language system and that this system does not functionally reorganize. I will discuss these findings in relation to current neurocognitive models of aging.

Jonathan Peelle, Ph.D.

Assistant Professor in the Department of Otolaryngology at Washington University in Saint Louis

Individual differences in auditory and cognitive factors during spoken language comprehension

Understanding spoken language relies on joint contributions from incoming acoustic information and cognitive systems that allow us to extract meaning from these signals. I will review evidence that individual differences in hearing sensitivity and cognitive ability jointly contribute to the processing of spoken language, affecting the cognitive and neural systems listeners engage during speech comprehension. Although frequently studied in the context of adult aging, these principles have broader implications for our understanding of how auditory and cognitive factors interact during spoken language comprehension.

Pascale Tremblay, Ph.D.

Assistant Professor at Université Laval in Québec City and Director of the Speech and Hearing Neurosciences Lab

Speech production in aging: from behaviour to brain imaging

Despite the importance of verbal communication on quality of life, the manner and extent to which speech production mechanisms, from respiration to articulation, change throughout adulthood, as well as the nature and extent of the physiological and neurobiological mechanisms that underlie these changes, remain poorly understood. In this talk I will discuss recent experiments from my lab that explored the behavioural changes in speech production that occur with age as well as the physiological, neurostructural and neurofunctional mechanisms that underlie these changes. The results of all these experiments reveal that the decline in speech production that occurs with age has a complex, multifactorial aetiology. Future research directions will be discussed.

Abstract Merit Awards

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

Graduate Student Merit Award Winners

Fatemeh Geranmayeh, Imperial College, London, UK
Judy Kim, Johns Hopkins University, USA

Post Doctoral Merit Award Winners

Frank Eisner, Radboud University, the Netherlands
Sergey Kornilov, Yale University, USA

Travel Awards

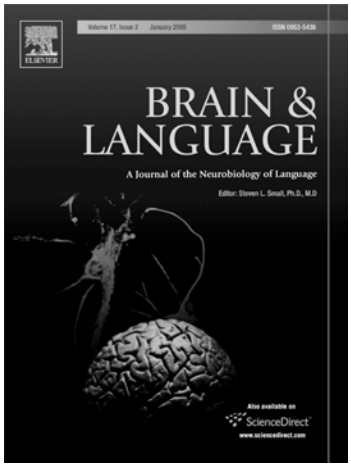
This year, the Society for the Neurobiology of Language granted four Travel Awards. The awards help to cover travel and registration costs for the 2015 Society for the Neurobiology of Language Meeting in Chicago, Illinois.

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

The 2015 Travel Awards were given to:

Josefine Andin, Linköping University, Sweden
Esti Blanco-Elorrieta, New York University, USA
Lukasz Bola, Jagiellonian University, Poland
Dorian Pustina, University of Pennsylvania, USA

Thank You to Our 2015 Sponsors



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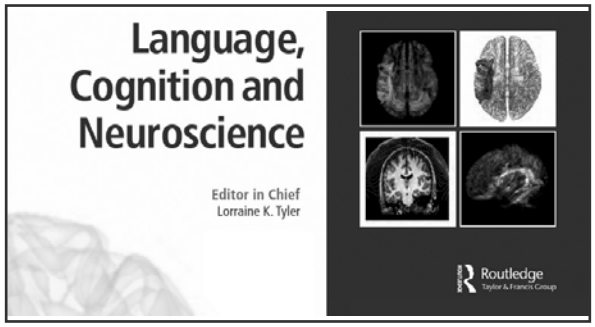

Routledge, Taylor & Francis Group

General Information

ATM

An ATM machine is located on the Arcade level.

Abstracts

The full text of poster, slide, and symposium abstracts can be found in the SNL 2015 Abstracts book, which can downloaded in PDF format from www.neurolang.org.

Audio-Visual

An LCD projector (e.g., for PowerPoint presentations) will be provided in the ballroom; however, computers will NOT be provided. Presenters must bring their own computers and set them up BEFORE the start of the session in which they are presenting. A switch box will be provided to allow several computers to be connected to the LCD projector in a room. Presenters are strongly encouraged to arrive at their scheduled room a minimum of 30 minutes before their talk, so that they know how to set up their equipment.

Baggage Check

All attendees, even those not staying at the Drake, are welcome to check their bags at the Bell Desk.

Business Center

The Business Center is open 24 hours a day. Boarding passes can be printed free of charge.

Certificate of Attendance

To receive a Certificate of Attendance, please visit the registration desk. If you require any amendments, we will be happy to email/mail a copy after the meeting (info@neurolang.org).

Contact Us

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

Copying and Printing

Copying and printing can be done at the Business Center which is located next to the Hotel Front Desk and is complimentary.

Disclaimer

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

Duplication / Recording / Photography

Photography, audiotaping, video recording, digital taping or any other form of duplication is strictly prohibited in the sessions and poster areas.

Fitness Center

Guests can enjoy the Drake's 3000 square foot fitness center featuring PRECOR endurance equipment, strengthening and cardio machines, free weights, and plasma TVs. Open 24 hours.

Food Service

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

Thursday

Continental Breakfast, 8:00 - 8:45 am, *French Room*
Coffee Break, 10:00 - 10:30 am, *French Room*
Afternoon Coffee, 2:20 pm - 2:50 pm, *French Room*
SNL Reception, 6:30 – 8:00 pm, *Grand Ballroom*

Friday

Continental Breakfast, 8:00 - 8:45 am, *French Room*
Coffee Break, 10:00 - 10:30 am, *French Room*
Afternoon Coffee, 2:30 - 3:00 pm, *French Room*

Saturday

Continental Breakfast, 8:00 - 8:30 am, *French Room*
Coffee Break, 9:50 - 10:30 am, *French Room*

Future Meetings

SNL 2016 will be held August 17-20, 2016 at the Institute of Education in London, England.

Hotel Outlets

Drake Bros.

The Drake Bros. offers Breakfast from 6:30 - 11:30 am and Lunch from 11:30 am - 2:00 p.m.

Cape Cod

Cape Cod features an oyster bar and offers fresh seafood, open 5:30 pm to 10:00 pm nightly.

Palm Court

Palm Court offers Afternoon Tea daily from 1:00 pm to 5:00 pm. Cocktail Hours Sunday -Thursday from 1:00 - 9:00 pm, Friday & Saturday Noon - 1:00 am.

Coq D'Or

The Coq D'Or is a legendary bar with a reinvented menu with a new take on traditional drinks and dishes that take you on an eighty year journey through the history of the Drake Hotel. Open from 11:00 am - 1:00 pm, with entertainment on Fridays and Saturdays from 9:00 pm - 1:00 am.

Lavassa Espression

Lavazza Espression is open Monday - Friday, 6:00 am - 4:00 pm and Saturday & Sunday, 7:00 am - 4:00 pm offering traditional Italian coffees and unique Espresso creations.

Internet

Standard wired & wireless Internet is available in the guest rooms free of charge. High speed access is available for $12.95 per 24 hours (multi-day packages are available). Internet is free in the lobby. There is free Internet in the meeting rooms.

Local Dining

The Concierge Desk maintains a comprehensive list of menus for area restaurants. The desk is open from 7:00 am - 10:00 pm.

Lost & Found

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

Meeting Rooms

All general sessions (Keynotes, the Invited Symposium, and Slides) will be held in the Grand Ballroom.

Messages

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

Mobile Phones

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

Name Badges

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

Onsite Meeting Registration

The SNL Registration Desk is located in the Drake Room and French Foyer. The Registration Desk hours are:

Wednesday, October 14, 4:00 - 8:00 pm
Thursday, October 15, 7:30 am – 6:00 pm
Friday, October 16, 8:00 am – 7:30 pm
Saturday, October 17, 8:00 am - 2:00 pm

Parking

Valet parking is $67 per night with in and out privileges. Self parking is located one block from hotel at $47 per night.

Phone Charging Station

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

Poster Sessions

Posters are located in the French and Walton Rooms.

Reception

The Welcome Reception will be held on Thursday, October 15, 6:30 – 8:00 pm in the Grand Ballroom.

Social Hour

A no-host cash bar will be located in the Venetian Room so that attendees can relax and interact with colleagues and friends after the meeting.

Wednesday, October 14, 7:00 - 9:00 pm
Friday, October 16, 7:30 - 9:00 pm.

Smoking

Smoking is not permitted at The Drake Hotel.

Speakers

Please ensure that you are available at least thirty minutes before the start of the session. See "Audiovisual" for technical information.

Slide Sessions

Slide Session A

Thursday, October 15, 1:00 - 2:20 pm, Grand Ballroom

Network Development and Reorganization

Chair: Gina Kuperberg, Tufts University

Speakers: Frank Eisner, Łukasz Bola, Fatemeh Geranmayeh, Dorian Pustina

1:00 pm

A1 The effect of literacy acquisition on cortical and subcortical networks: A longitudinal approach *Frank Eisner[1], Uttam Kumar[2], Ramesh K Mishra[3], Viveka Nand Tripathi[4], Anupam Guleria[2], Prakash Singh[4], Falk Huettig[5]; [1]Radboud University, [2]Sanjay Gandhi Postgraduate Institute of Medical Sciences Campus, [3]University of Hyderabad, [4]University of Allahabad, [5]Max Planck Institute for Psycholinguistics*

How do human cultural inventions such as reading result in neural re-organization? Previous cross-sectional studies have reported extensive effects of literacy on the neural systems for vision and language (Dehaene et al [2010, Science], Castro-Caldas et al [1998, Brain], Petersson et al [1998, NeuroImage], Carreiras et al [2009, Nature]). In this first longitudinal study with completely illiterate participants, we measured brain responses to speech, text, and other categories of visual stimuli with fMRI before and after a group of illiterate participants in India completed a literacy training program in which they learned to read and write Devanagari script. A literate and an illiterate no-training control group were matched to the training group in terms of socioeconomic background and were recruited from the same societal community in two villages of a rural area near Lucknow, India. This design permitted investigating effects of literacy cross-sectionally across groups before training (N=86) as well as longitudinally (training group N=25). The two analysis approaches yielded converging results: Literacy was associated with enhanced, mainly left-lateralized responses to written text along the ventral stream (including lingual gyrus, fusiform gyrus, and parahippocampal gyrus), dorsal stream (intraparietal sulcus), and (pre-) motor systems (pre-central sulcus, supplementary motor area), thalamus (pulvinar), and cerebellum. Significantly reduced responses were observed bilaterally in the superior parietal lobe (precuneus) and in the right angular gyrus. These positive effects corroborate and extend previous findings from cross-sectional studies. However, effects of literacy were specific to written text and (to a lesser extent) to false fonts. Contrary to previous research, we found no direct evidence of literacy affecting the processing of other types of visual stimuli such as faces, tools, houses, and checkerboards. Furthermore, unlike in some previous studies, we did not find any evidence for effects of literacy on responses in the auditory cortex in our Hindi-speaking participants. We conclude that learning to read has a specific and extensive effect on the processing of written text along the visual pathways, including low-level thalamic nuclei, high-level systems in the intraparietal sulcus and the fusiform gyrus, and motor areas. The absence of an effect of literacy on responses in the auditory cortex in particular raises questions about the extent to which phonological representations in the auditory cortex are altered by literacy acquisition or recruited online during reading.

1:20 pm

A2 Massive cortical reorganization in sighted braille readers *Łukasz Bola[1,2,9], Katarzyna Siuda-Krzywicka[1,3,9], Małgorzata Paplińska[4], Ewa Sumera[5], Katarzyna Jednoróg[2], Artur Marchewka[2], Magdalena Śliwińska[6], Amir Amedi[7,8], Marcin Szwed[1]; [1]Jagiellonian University, Krakow, Poland, [2]Nencki Institute of Experimental Biology, Warsaw, Poland, [3]École des Neurosciences à Paris, Paris, France, [4]Academy of Special Education in Warsaw, Poland, [5]Institute for the Blind and Partially Sighted Children in Krakow, Poland, [6]University College London, UK, [7]The Hebrew University of Jerusalem, Israel, [8]Sorbonne Universite´s, UPMC Univ Paris 06, Paris, France, [9]Equally contributing authors*

Neuroplasticity in the adult brain is thought to operate within the limits of sensory division, where the visual cortex processes visual stimuli and responds to visual training, the tactile cortex processes tactile stimuli and responds to tactile training, and so on. A departure from this rule is reported to be possible mainly during the large-scale reorganization induced by sensory loss or injury. The ventral visual cortex, in particular, is activated in blind subjects who read braille, and lesions of this area impair braille reading. Thus, this part of the visual cortex has the innate connectivity required to carry out a complex perceptual task – reading – in a modality different than vision. However, it is presumed that this connectivity has been pruned during years of visual experience. Here we show, that contrary to this presumption, the ventral visual cortex can be recruited for tactile reading even in sighted adults. 29 subjects (3 male, 26 female, mean age = 29) – mostly braille teachers and educators, naïve in tactile braille reading – participated in a 9-month tactile braille reading course. At the beginning and at its end, they underwent an fMRI experiment consisting of tactile braille reading and suitable control conditions (e.g. touching nonsense braille, imaging braille reading). Additionally, in both scanning sessions resting-state fMRI (rsfMRI) data were collected. At the end of the course, 9 subjects were also tested in a Transcranial Magnetic Stimulation

(TMS) experiment. Almost all subjects learned tactile braille reading and reached reading speeds comparable to blind 2nd grade children. Before-course fMRI experiment showed no significant activity specific to braille reading. After the course, however, subjects showed enhanced activity for tactile reading in the ventral visual cortex, including the Visual Word Form Area (VWFA), that was modulated by their braille reading speed. Control conditions' results indicated that this visual cortex activity could not be explained by visual imagery. In rsfMRI analysis, we observed increased functional connectivity between the VWFA and the left primary somatosensory cortex. Finally, TMS applied to the VWFA decreased accuracy of tactile word reading in a lexical decision task. Such effect was not observed during TMS stimulation of control regions. Our results demonstrate that cross-modal plasticity is possible even in the healthy, adult brain. To date, only few experiments suggested such a possibility, and none of them managed to confirm that such cortical changes are behaviorally relevant. Our study used a controlled, within-subject design and precise behavioral measures supplemented with a causal method, TMS. Its results suggest that large-scale plasticity is a viable, adaptive mechanism recruited when learning complex skills. This calls for a re-assessment of our view of the functional organization of the brain.

1:40 pm

A3 Network dysfunction predicts speech production after left-hemisphere stroke. *Fatemeh Geranmayeh[1], Robert Leech[1], Richard J. S. Wise[1]; [1]Computational Cognitive and Clinical Neuroimaging Laboratory, Imperial College, Hammersmith Hospital Campus, Du Cane Road, London, W12 0NN, UK.*

INTRODUCTION: Recovery after a stroke resulting in aphasia is usually discussed only in terms of domain-specific functions, namely phonology, semantics and syntax. This is often coupled with speculations that intact ipsilesional or contralesional regions 'take over' these functions1. However, domain-general processes also have a role, with some evidence that anterior midline frontal cortex may support residual language function (1,2). Within the restricted volume of this region there are anatomically overlapping but functionally separate components that constitute nodes within multiple distributed cognitive brain networks. These include a left and right fronto-temporo-parietal, cingulo-opercular, and the default-mode networks. The default-mode network supports 'internally directed' cognition, and becomes less active when participants are engaged in externally directed stimulus-response tasks (3,4). Activity in this network is modulated by speech comprehension and production (5,6). METHODS: In the present functional MRI study, the effects of a previous left hemisphere stroke on brain activity were investigated as patients described pictures. The design included various baseline tasks, including counting, non-verbal target detection, and a rest baseline (7). The results were related to healthy participants performing the same tasks. The analyses investigated not only local speech-related activity, but also functional connectivity both within and between distributed networks using independent component analyses and psychophysiological interaction analyses. A multiple regression model identified network predictors of speech production. RESULTS: The patients showed an upregulation of the activity in the cingulo-opercular network during propositional speech task, in keeping with the upregulation of activity in this network when task demands are increased ($P < 0.05$) (1,2). Although activity within individual networks was not predictive of speech production, the relative activity between networks was a predictor of both within-scanner and out-of-scanner performance, over and above that predicted from lesion volume and various demographic factors. Specifically, the robust functional imaging predictors were the differential activity and functional connectivity between the default mode network and the left fronto-temporo-parietal network (Beta = 0.54, $P < 0.001$), and the default mode network and the right fronto-temporo-parietal network (Beta = -0.50, $P < 0.001$). The speech-specific functional connectivity between these networks was significantly alerted in patients compared to controls. CONCLUSION: The demonstration that speech production is dependent on complex interactions within and between widely distributed brain networks, indicates that recovery depends on more than the restoration of local domain-specific functions. This argues that the systems neuroscience of recovery of function after focal lesions is not adequately captured by notions of brain regions 'taking over' lost domain specific functions, but is best considered as the interaction between what remains of domain-specific networks and the domain-general systems that regulate behaviour. REFERENCES: 1. F Geranmayeh et al. Brain. 2014;137:2632–2648. 2. SLE Brownsett et al. Brain. 2014;137:242–254. 3. GF Humphreys et al. doi: 10.1073/pnas.1422760112. 4. ME Raichle et al. PNAS 2001;98(2):676–682. 5. M Regev M et al. J Neurosci. 2013;33(40):15978–15988. 6. M Awad et al. 2007;27(43):11455–11464. 7. F Geranmayeh et al. J Neurosci. 2014;34(26):8728–8740.

2:00 pm

A4 A supervised framework for lesion segmentation and automated VLSM analyses in left hemispheric stroke *Dorian Pustina[1,3], Branch Coslett[1], Myrna Schwartz[4], Brian Avants[2,3]; [1]Department of Neurology, University of Pennsylvania, Philadelphia, PA, USA, [2]Department of Radiology, University of Pennsylvania, Philadelphia, PA, USA, [3]Penn Image Computing and Science Lab, University of Pennsylvania, Philadelphia, PA, USA, [4]Moss Rehabilitation Research Institute, Elkins Park, PA, USA.*

INTRODUCTION: Voxel-based lesion-symptom mapping (VLSM) is conventionally performed using skill and knowledge of experts to manually delineate brain lesions. This process requires time, and is likely to have substantial

inter-rater variability. Here, we propose a supervised machine learning framework for lesion segmentation capable of learning the relationship between existing manual segmentations and a single T1-MRI volume in order to automatically delineate lesions in new patients. METHODS: Data from 60 aphasic patients with chronic left-hemispheric stroke were utilized in the study (age: 57.2±11.5yrs, post-stroke interval: 2.6±2.7yrs, 26 female). Lesion prediction was obtained in ANTsR (Avants, 2015) using the MRV-NRF algorithm (multi-resolution voxel-wise neighborhood random forest; Tustison et al., 2014) which relied on multiple features created from the T1-weighted MRI; i.e., difference from template, tissue segmentation, brain asymmetries, gradient magnitude, and deviances from 80 age and gender matched controls. To establish whether a voxel is lesioned, the algorithm learns the pattern of signal variation on these features in hierarchical steps from low to high resolution, considering both the voxel itself and its neighbors. A fully automatic pipeline was achieved by running iterative cycles of "register-predict-register", where each registration improved gradually by removing the previous prediction from computations. Each case was predicted with a leave-one-out procedure using the predictive model trained on the other 59. Comparison with manual tracings was performed with standard metrics, while parallel VLSM models were built with manual and predicted lesions on 4 language measures: WAB subscores for repetition and comprehension (Kertesz, 1982), WAB-AQ, and PNT naming accuracy (Roach et al., 1996). RESULTS: The dice overlap between manual and predicted lesions was 0.70 (STD ±0.15). The correlation of lesion volumes was r=0.95 ($p<0.001$). The case-wise maximum displacement (Hausdorff) was 17mm (±8mm), and the area under the ROC curve was 0.87 (±0.1). Lesion size correlated with overlap (r=0.54, $p<0.001$), but not with maximum displacement (r=-15, p=0.27). VLSM thresholded t-maps ($p<0.05$, FDR corrected) showed a continuous dice overlap of 0.75 for AQ, 0.81 for repetition, 0.57 for comprehension, and 0.58 for naming. To investigate whether the mismatch between manual VLSM and automated VLSM involved critical areas related to cognitive performance, we created behavioral predictions from the VLSM models. Briefly, a prediction value was obtained from each voxel and the weighted average of all voxels was computed (i.e., voxels with high t-value contributed more to the prediction than voxels with low t-value). Manual VLSM showed slightly higher correlation of predicted performance with actual performance compared to automated VLSM (respectively, AQ: 0.65 and 0.60, repetition: 0.62 and 0.57, comprehension: 0.53 and 0.48, naming: 0.46 and 0.41). The difference between the two, however, was not significant (lowest p=0.07). CONCLUSIONS: These findings show that automated lesion segmentation is a viable alternative to manual delineation, producing similar lesion-symptom maps and similar predictions with standard manual segmentations. The proposed algorithm is flexible with respect to learning from existing datasets, provides an automatic registration to template, and exceeds the prediction accuracy of current methods used in big data studies (i.e., PLORAS; Seghier et al., 2008).

Slide Session B

Friday, October 16, 3:00 - 4:20 pm, Grand Ballroom

Perspectives on Language Processing

Chair: Liina Pylkkänen, New York University

Speakers: Erika Hussey, Velia Cardin, Harm Brouwer, Greig de Zubicaray

3:00 pm

B1 HD-tDCS of left lateral prefrontal cortex improves garden-path recovery *Erika Hussey[1], Nathan Ward[1], Kiel Christianson[1], Arthur Kramer[1]; [1]University of Illinois at Urbana-Champaign*

Recent research demonstrates that performance on executive control measures can be enhanced through brain stimulation of left lateral prefrontal cortex (LPFC; Berryhill et al., 2014; Coffman et al., 2014). Separate psycholinguistic work emphasizes the importance of left LPFC executive control resources during sentence processing (Ye & Zhou, 2009). This is especially the case when readers or listeners must ignore early, incorrect interpretations when faced with temporary ambiguity (i.e., garden-path recovery; Novick et al., 2005). Using high-definition transcranial direct current stimulation (HD-tDCS), we tested whether temporarily increasing cortical excitability of left LPFC had discriminate effects on language and memory conditions that rely on executive control (versus cases with minimal executive control demands, even in the face of task difficulty). Participants were randomly assigned to receive Active (anodal: n=27) or Control stimulation (sham: n=27; cathodal: n=26) of left LPFC while they (1) processed syntactically ambiguous and unambiguous sentences (see Christianson et al., 2001) in a non-cumulative self-paced moving-window paradigm, and (2) performed an n-back recognition memory task that, on some trials, contained interference lure items reputed to require executive control (Oberauer, 2005). Across both tasks, we parametrically manipulated executive control demands and task difficulty to disentangle these mechanistic contributions (see Fedorenko, 2014). Difficulty was introduced by varying the length of pre-critical sentence regions during the reading task (Witzel et al., 2012) and changing the number of to-be-remembered n-back items (Owen et al., 2005). Mixed-effects models revealed that the Active group outperformed Controls on (1) the sentence processing conditions requiring executive control, and (2) only difficult n-back conditions regardless of executive control demands. Specifically, the Active group demonstrated superior comprehension accuracy to questions following ambiguous sentences (t=2.449, p=0.01) and faster reading time of disambiguating sentence information of long sentences

(t=2.124, p=0.03). On n-back, the Active group had better target/non-target discriminability at higher n-levels relative to Controls (t=2.066, p=0.04). These findings replicate tantalizing results from neuropsychological patients with focal insult to left LPFC (Novick et al., 2010) and functional neural coactivation in healthy adults (Hsu et al., 2013; January et al., 2008) during garden-path recovery and recognition of interfering memoranda. Additionally, our results suggest a potential causal role of left LPFC-mediated executive control for garden-path recovery. Finally, we provide initial evidence suggesting that brain stimulation may be a promising method to mitigate sentence processing demands in healthy adults.

3:20 pm

B2 Does the superior temporal cortex have a role in cognitive control as a consequence of cross-modal reorganization? *Velia Cardin[1,2], Mary Rudner[2], Rita De Oliveira[3], Merina Su[4], Josefine Andin[2], Lilli Beese[1], Bencie Woll[1], Jerker Ronnberg[2]; [1]Deafness Cognition and Language Research Centre, Department of Experimental Psychology, University College London, 49 Gordon Square, London WC1H 0PD., [2]Linnaeus Centre HEAD, Swedish Institute for Disability Research, Department of Behavioural Sciences and Learning, Linköping University, Sweden., [3]School of Applied Science, London South Bank University, 103 Borough Road, London SE1 0AA, [4]Institute of Child Health, University College London*

Cortical cross-modal reorganization in humans is the result of an interplay between sensory and cognitive factors. Congenital deafness provides a unique model to understand the contribution of each of these factors, given that neural reorganization is not only caused by sensory deprivation, but also by the use of language in a visual modality (i.e. sign language and lipreading). Working memory is the limited cognitive capacity available for on-line processing and temporary storage of information (Baddeley, 2003). Behavioral studies have shown an advantage in performance in visual working memory in deaf individuals, suggesting that auditory deprivation may result in enhanced or different neural resources for cognitive processing. To address this question, we characterized plastic changes driven by auditory deprivation and sign language experience in the neural substrates supporting visual working memory. We conducted a functional magnetic resonance imaging (fMRI) experiment with three groups of participants: deaf native signers, hearing native signers and hearing non-signers. Participants performed a 2-back working memory task, and a control task, on two sets of stimuli: signs from British Sign Language or moving non-sense objects. Stimuli were presented as point-light displays to control for differences in visual features. We replicated previous findings showing stronger activations in deaf signers for all stimuli and tasks in the right posterior superior temporal cortex (STC) – a cross-modal plasticity effect for visuospatial processing driven by auditory deprivation. The group of deaf signers also showed stronger bilateral STC activation for sign language stimuli, showing that his region traditionally thought to be involved in speech processing, has a multimodal role in language processing. Our results show characteristic activations in a fronto-parietal network for working memory in all groups. However, the group of deaf participants also recruited bilateral STC during the working memory task, but not during the control task, independently of the linguistic content of the stimuli. This was accompanied by a reduction in the recruitment of parietal and frontal regions typically associated with working memory in hearing individuals. Using resting state connectivity analysis, we also found a difference in the pattern of connectivity between frontal, parietal and superior temporal cortex between the group of deaf signers and each of the groups of hearing individuals. This suggests a functional shift towards cognitive control in superior temporal cortex as a consequence of cross-modal reorganization.

3:40 pm

B3 The Electrophysiology of Language Comprehension: A Neurocomputational Model *Harm Brouwer[1], John Hoeks[2], Matthew Crocker[1]; [1]Saarland University, [2]University of Groningen*

We present a neurocomputational model of the electrophysiology of language processing. Our model is explicit about its architecture and the computational principles and representations involved. It is effectively a recurrent neural network (of the 'Elman'-type; [1]) that directly instantiates a parsimonious functional-anatomic processing network linking the N400 and the P600—the two most salient language-related ERP components—to two computational epicenters in the perisylvian cortex [2,3]. The computational model constructs a situation model of the state-of-the-affairs described by a sentence on a word-by-word basis. Each word leads to a processing cycle centred around two core operations. First, the meaning of an incoming word is retrieved/activated, a process that is mediated by the left posterior part of the Middle Temporal Gyrus (lpMTG; BA 21), and the ease of which is reflected in N400 amplitude. Next, the left Inferior Frontal Gyrus (lIFG; BA 44/45/47) integrates this retrieved word meaning with the current situation model into an updated situation model, which is then connected back to the lpMTG to provide a context for the retrieval of the next word. The effort involved in situation model updating is indexed by P600 amplitude. We discuss our model, and show that it accounts for the pattern of N400 and P600 modulations across a wide range of processing phenomena, including semantic anomaly, semantic expectancy (on nouns and articles [4]), syntactic violations, and garden-paths. Critically, our model also captures the 'semantic P600'-phenomenon, which has spawned a considerable amount of debate [see 2,5,6]. This is exemplified by a simulation of an ERP experiment contrasting different types of semantic anomalies in Dutch

[7]: Control: 'The javelin was by the athletes thrown' (literal translation); Reversal: 'The javelin has the athletes thrown' (P600-effect relative to Control); Mismatch_Pas: 'The javelin was by the athletes summarized' (N400/P600-effect), and Mismatch_Act: 'The javelin has the athletes summarized' (N400/P600-effect). Statistical evaluation of our simulation results (within-items RM-ANOVA with Huynh-Feldt correction where necessary) showed a perfect replication of the original findings. For the N400, there was a main effect of Condition ($F(3,27)=45.1$; $p<.001$), and pairwise comparisons (Bonferroni corrected) showed that the N400-effect was absent in reversal sentences ($p=.47$), while there was a significant N400-effect for the mismatch conditions (p-values<.005). As for the P600, there was a main effect of Condition ($F(3,27)=136.5$; $p<.001$), and pairwise comparisons showed a P600-effect for all three anomalous conditions (p-values<.001). The implications of our model will be discussed, and we will argue that explicit computational models and quantitative simulations are generally superior to verbal 'box-and-arrow' accounts, and necessary for settling theoretical debates, such as the one concerning the `semantic P600'-phenomenon. References: [1] Elman (1990); [2] Brouwer et al. (2012); [3] Brouwer and Hoeks (2013); [4] DeLong et al. (2005); [5] Kuperberg (2007); [6] Bornkessel-Schlesewsky and Schlesewsky (2008); [7] Hoeks et al. (2004).

4:00 pm

B4 A sound explanation for the motor cortex representations of action words *Greig de Zubicaray[1], Katie McMahon[2], Joanne Arciuli[3]; [1]Queensland University of Technology, Brisbane, Australia, [2]University of Queensland, Brisbane, Australia, [3]University of Sydney, Sydney, Australia*

Language processing is an example of implicit learning of multiple statistical cues that provide probabilistic information regarding word structure and use. Much of the current debate about language embodiment is devoted to how action words are represented in the brain, with motor cortex activity evoked by these words assumed to selectively reflect conceptual content and/or its simulation. However, there is a substantial body of psycholinguistic research demonstrating that the degree to which a word's phonology is typical of other words in its grammatical category influences online processing, particularly for verbs and nouns. Using fMRI in healthy participants (N=17) and an auditory lexical decision task (LDT), we found that monosyllabic verbs (e.g., bite, grasp, walk) denoting body-part specific (i.e., face, arm, leg) actions evoked differential motor cortex activity. This result is typically interpreted in support of language embodiment. Crucially, we conducted two additional sets of analyses that demonstrated this activity is due to phonological rather than conceptual processing. The first included a measure of the action words' phonological typicality (calculated by subtracting the average verb distance for a word from its average noun distance; Monaghan, Christiansen, Farmer, & Fitneva, 2010). This revealed a gradient of phonological typicality for the action word types (face < arm < leg) that was associated with a significant parametric modulation of activation across both premotor and primary motor cortices. A second set of conjunction analyses showed that monosyllabic nonwords matched to the action words in terms of phonotactic probability (a measure of the frequency in which phonological segments occur in a given position in a word; Vitevitch & Luce, 2004) evoked similar "body-part specific" activity in identical motor areas. Thus, motor cortex responses to action words cannot be assumed to selectively reflect conceptual content and/or its simulation. Our results clearly demonstrate motor cortex activity reflects implicit processing of phonological statistical regularities that are typically unaccounted for in studies of language embodiment.

Slide Session C

Saturday, October 17, 8:30 - 9:50 am, Grand Ballroom

Outside the Left Peri-Sylvian Cortex

Chair: Kate Watkins, University of Oxford

Speakers: Daniela Sammler, Jonathan H. Drucker, Zarinah Agnew, Nathaniel Klooster

8:30 am

C1 Dual streams for prosody in the right hemisphere *Daniela Sammler[1,2], Marie-Hélène Grosbras[2,3], Alfred Anwander[1], Patricia E. G. Bestelmeyer[2,4], Pascal Belin[2,3,5]; [1]Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany, [2]Institute of Neuroscience and Psychology, University of Glasgow, Glasgow, UK, [3]Institut des Neurosciences de La Timone, CNRS and Université Aix-Marseille, France, [4]School of Psychology, Bangor University, Bangor, UK, [5]BRAMS, University of Montréal and McGill University, Montréal, Canada*

Our vocal tone—the prosody—contributes a lot to the meaning of speech beyond the actual words. Indeed, the hesitant tone of a 'yes' may be more telling than its affirmative lexical meaning. The human brain contains dorsal and ventral processing streams in the left hemisphere that underlie core linguistic abilities such as phonology, syntax and semantics. Whether or not prosody—a reportedly right-hemispheric faculty—involves analogous processing streams is a matter of debate. Functional connectivity studies on prosody leave no doubt about the existence of such streams, but opinions diverge on whether information travels along dorsal or ventral pathways, or both. Here we show, in a novel paradigm using audio morphing of prosody combined with functional/diffusion-weighted neuroimaging (fMRI/DWI; Experiment 1) and transcranial magnetic stimulation (TMS; Experiment 2), that prosody perception takes dual routes along dorsal and ventral pathways in the right hemisphere. In Experiment 1, categorization of speech stimuli that gradually varied in their prosodic pitch contour (between statement and question) involved (i) an

auditory ventral pathway along the middle longitudinal fascicle in the superior temporal lobe, and (ii) an auditory-motor dorsal pathway connecting posterior temporal and laryngeal premotor/inferior frontal areas via the arcuate/superior longitudinal fascicle. In Experiment 2, 15 minutes of inhibitory repetitive TMS of right (but not left) laryngeal premotor cortex as a key node of the dorsal pathway decreased participants' performance in prosody categorization (but not in a control task), arguing for a motor involvement in prosody perception. Following prevailing dual-stream models of language, we propose that prosody perception resides on complementary mechanisms implemented in ventral and dorsal streams in the right hemisphere: While the ventral pathway may extract and integrate auditory features into a time-invariant "prosodic Gestalt" ('What') to map prosody to communicative meaning, the dorsal pathway is more likely to map the perceived pitch contour to (subvocal) articulation ('How') to enhance the perception of subtle vocal prosodic cues. In sum, our data draw a dual-stream picture of prosodic processing that shows plausible analogies to the established left-hemispheric multi-stream architecture of language, but with relative rightward asymmetry.

8:50 am

C2 Does right frontal activity help or hurt word retrieval? *Jonathan H. Drucker[1,2], Keith M. McGregor[1,2], Charles M. Epstein[2], Bruce Crosson[1,2,3,4]; [1]Atlanta VA Center of Excellence for Visual and Neurocognitive Rehabilitation, [2]Emory University, [3]Georgia State University, [4]University of Queensland*

Neural activity in the left frontal lobe is a hallmark of language processing, but older adults demonstrate right frontal activity as well (Wierenga et al., 2008). Increased right frontal activity in older adults, specifically in pars triangularis of the inferior frontal gyrus (PTr), is associated with poorer performance in word retrieval tasks (Meinzer et al., 2009; 2012). This phenomenon has yet to be explained. One hypothesis posits that increased right frontal activity in older adults is compensatory, mitigating age-related decline in language function. Alternatively, we suggest that increased right frontal activity in older adults is competitive with language function, reflecting diminished interhemispheric suppression. In aphasia, evidence for the competition hypothesis comes from patients with nonfluent aphasia undergoing low-frequency (1Hz) repetitive transcranial magnetic stimulation (rTMS). Suppression of right frontal (PTr) cortical excitability using 1Hz rTMS leads to faster and more accurate word retrieval in nonfluent aphasia patients (Naeser et al., 2005; 2011; Barwood et al., 2011). A parsimonious interpretation is that activity in right PTr was competitive, not compensatory, and that inhibiting this activity facilitated word retrieval. We address two related questions in the current experiment. First, does rTMS suppression of right PTr help or hurt word retrieval in healthy older adults? Second, is 1Hz rTMS facilitation of language unique to stroke patients, or does it address a more general component of the aging process? To date, we have recruited 17 neurologically normal, right-handed adults. Nine were between the ages of 65-89 (older: 8f, 1m), and eight were between the ages of 20-34 (younger: 3f, 5m). Ten minutes of low-frequency (1Hz) rTMS was applied to the experimental area of cortex (right PTr) or to a neighboring control area (right pars opercularis: POp). Sham rTMS was also applied for comparison. Immediately after real or sham rTMS, participants named 30 pictures presented on a computer screen. Reaction times for picture naming were calculated offline. Each participant experienced each of the four conditions, divided into two sessions on different days. After controlling for differences in performance between participants and in the different picture items, average response times in the real-PTr condition were compared against real-POp (controlling for location in the brain) and against sham-PTr (controlling for psychological or other non-neural effects of rTMS), for both the older and younger age groups. Older participants exhibited faster word retrieval after rTMS to PTr than they did after real rTMS to POp (location control: $\Delta = 139$ms, $p = .017$) or sham rTMS (placebo control: $\Delta = 155$ms, $p = .002$). In the younger group, there was no significant difference ($p = .333$ and $p = .081$, respectively). These results suggest that increased neural activity in the right pars triangularis is competitive with language function in healthy older adults, and that the ability to suppress this activity decreases as part of the normal aging process. The differences we observed between the age groups suggest that rTMS as a therapy for nonfluent aphasia could be more effective for older than for younger patients.

9:10 am

C3 Investigating the role of cerebellum in sensory processing during vocal behavior with theta burst stimulation *Zarinah Agnew[1], Jeevit Gill[1], Srikantan Nagarajan[2], Richard Ivry[3], John Houde[1]; [1]University of California San Francisco, Department of Otolaryngology, [2]University of California San Francisco, Department of Radiology, [3]University of California Berkeley*

The present collection of studies aimed to investigate the nature of auditory feedback processing in patients with cerebellar degeneration by measuring various aspects of vocal behaviour. It has been proposed that the cerebellum serves to generate predictions about the sensory consequences of future movements. As such, complete, or over reliance on sensory feedback is thought to result in unstable movements. In line with this thinking, patients with cerebellar damage, such as cerebellar ataxia, are known for their deficits in visually guided movement and their movements are known to improve in the absence of visual feedback. Thus it is suggested that patients with damage to the cerebellum are less able to make accurate predictions about the sensory consequences of movements and have to rely on reafferent information which ultimately

leads to unstable movements. Here we report a series of four separate sets of data, which together identify a clear role for the cerebellum in feedback processing during vocal behaviour. In order to assess vocal behaviour in this patient group, we designed auditory-motor experiments which paralleled visually guided reaching tasks. Two sets of patients with cerebellar damage were tested on a battery of vocal assessments designed to probe different aspects of vocalisation: we investigated ability to produce spontaneous voicing, pitch tracking of a moving pitch target and pitch perturbation. We investigated the hypothesis that reducing auditory feedback during vocalisation would improve vocal stability, showing that under auditory masking conditions, variability in vocal pitch is significantly reduced in patients with cerebellar damage. In order to investigate this idea further, a third experiment was carried out where we investigated how patients responded to perturbations in pitch production whereby auditory feedback is pitch shifted during vocalisation. As predicted, patients with cerebellar damage displayed significantly altered responses to the pitch shift compared to healthy age matched controls indicating an alteration in the way reafferent information is utilised. Finally continuous theta burst stimulation to cerebellar cortex in healthy controls confirmed a role for cerebellar processing in compensation for an imposed shift in auditory feedback. Together, these sets of experiments provide compelling evidence in favour of the idea of the cerebellum as a prediction system, the dysfunction of which leads to over reliance on sensory feedback and hence unstable auditorily guided vocal movements. These data will be discussed in relation to the function of the cerebellum in the neural control of vocal behaviour and current models of speech production.

9:30 am

C4 Impoverished remote semantic memory in hippocampal amnesia

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There has been considerable debate regarding the necessity of the hippocampus for acquiring new semantic concepts. It is generally accepted, however, that any role the hippocampus plays in semantic memory is time limited and that previously acquired information becomes independent of the hippocampus over time through neocortical consolidation. This view, along with intact naming and word-definition matching performance in amnesia, has led to the notion that remote semantic memory is intact in patients with hippocampal amnesia. Motivated by perspectives of word learning as a protracted process where additional features and senses of a word are added over time, and by recent discoveries about the time course of hippocampal contributions to on-line relational processing, reconsolidation, and the flexible integration of information, we revisit the notion that remote semantic memory is intact in amnesia. We tested 1) 5 patients with bilateral hippocampal damage (HC) and severe declarative memory impairment, 2) a group of 6 brain damaged comparison (BDC) participants with bilateral damage to the ventromedial prefrontal cortex, and 3) demographically matched non-brain damaged healthy comparison participants (NCs). In psycholinguistic studies, the number of features of a concept (e.g. a cucumber is a vegetable, has green skin, is cylindrical, grows on vines, grows in gardens, is used for making pickles, etc.) is an often-used measure of semantic richness. We chose target words from normed databases and gave participants 2 minutes to list as many features for each target as possible. NCs and BDCs performed indistinguishably from each other, producing twice as many features on average as the HC group. The number of senses a word can take (e.g. shot: medical injection; sports attempt; gunfire; small serving of whiskey) is another commonly used psycholinguistic measure of semantic richness. We chose target words from normed databases and gave participants 1 minute to list as many senses of each target word as possible. Again, amnesics produced significantly fewer senses than NCs and BDCs. The Word Associate Test (WAT) is a receptive measure of vocabulary depth. The test presents participants with 40 target adjectives and requires them to pick 4 correct associates or collocates from among 8 possibilities per target. Consistent with previous measures, the NCs and BDCs performed indistinguishably from each other and significantly higher than the HC group on the WAT. On both productive and receptive measures of vocabulary depth and semantic richness, we find that a group of hippocampal amnesic participants display impoverished remote semantic memory compared to demographically matched healthy participants and brain- damaged comparison participants. The performance of the BDC group, which did not differ from NCs, suggests that the observed deficits are attributable to hippocampal damage and are not a consequence of brain damage more generally. These findings suggest a reconsideration of the traditional view that remote semantic memory is fully intact following hippocampal damage. The impoverished remote semantic memory in patients with hippocampal amnesia suggests that the hippocampus plays a role in the maintenance and updating of semantic memory beyond its initial acquisition.

Poster Schedule

Poster sessions are scheduled on Thursday, October 15 through Saturday, October 17. Poster sessions are two hours, and presenting authors are expected to be present the entire time. Posters are located in the French and Walton Rooms. You may post your materials on the board assigned to you starting at the scheduled "Set-up Begins" time shown below. Please note that any posters not removed by "Teardown Complete" time will be discarded. Do not leave personal items in the poster room.

Date & Time	Posters	Topics
Poster Session A Thursday, October 15 10:00 am - 12:00 pm Setup Begins: 8:00 am Teardown Complete: 2:00 pm	A1 - A23 A24 - A32 A33 - A44 A45 - A57 A58 - A75	Auditory Perception, Speech Perception, Audiovisual Integration Gesture, Prosody, Social and Emotional Processes Language Development, Plasticity, Multilingualism Language Disorders Lexical Semantics
Poster Session B Thursday, October 15 4:30 - 6:30 pm Setup Begins: 2:00 pm Teardown Complete: 7:00 pm	B1 - B2 B3 B4 - B29 B30 - B42 B43 - B49 B50 - B61 B62 - B68 B69 - B75	Syntax, Morphology Lexical Semantics Auditory Perception, Speech Perception, Audiovisual Integration Language Development, Plasticity, Multilingualism Language Disorders Lexical Semantics Orthographic Processing, Writing, Spelling Syntax, Morphology
Poster Session C Friday, October 16 10:00 am - 12:00 pm Setup Begins: 8:00 am Teardown Complete 12:30 pm	C1 - C11 C12 C13 - C16 C17 - C27 C28 - C35 C36 - C47 C48 - C54 C55 - C63 C64 C65 - C75	Control, Selection, Working Memory Discourse, Combinatorial Semantics Control, Selection, Working Memory Language Development, Plasticity, Multilingualism Language Disorders Lexical Semantics Methods Motor Control, Speech Production, Sensorimotor Integration Signed Language Syntax, Morphology
Poster Session D Friday, October 16 1:00 - 3:00 pm Setup Begins: 12:30 pm Teardown Complete: 4:00 pm	D1 - D17 D18 - D31 D32 - D38 D40 - D46 D47 - D58 D59 - D64 D65 - D75	Discourse, Combinatorial Semantics Language Development, Plasticity, Multilingualism Lexical Semantics Motor Control, Speech Production, Sensorimotor Integration Orthographic Processing, Writing, Spelling Phonology, Phonological Working Memory Syntax, Morphology
Poster Session E Friday, October 16 5:30 - 7:30 pm Setup Begins: 4:00 pm Teardown Complete: 8:00 pm	E1 E2 - E11 E12 - E23 E24 - E31 E32 - E44 E45 - E56 E57 - E62 E63 - E75	Animal Communication Language Development, Plasticity, Multilingualsim Language Disorders Lexical Semantics Motor Control, Speech Production, Sensorimotor Integration Orthographic Processing, Writing, Spelling Phonology, Phonological Working Memory Syntax, Morphology
Poster Session F Saturday, October 17 10:00 am - 12:00 pm Setup Begins: 8:00 am Teardown Complete: 12:30 pm	F1 - F27 F28 - F39 F40 - F49 F50 - F59 F60 - F70 F71 - F74	Auditory Perception, Speech Perception, Audiovisual Integration Discourse, Combinatorial Semantics Language Development, Plasticity, Multilingualism Language Disorders Lexical Semantics Motor control, Speech Production, Sensorimotor Integration

Poster Sessions

Poster Session A

Thursday, October 15, 10:00 am – 12:00 pm, French and Walton Rooms

Auditory Perception, Speech Perception, Audiovisual Integration

A1 Nonsense word sequences elicit comparable nested oscillations in intracranial recordings from human and monkey auditory cortex *Yukiko Kikuchi[1], Ariane E. Rhone[2], Kirill V. Nourski[2], Phillip E. Gander[2], Adam Attaheri[1], Christopher K. Kovach[2], Hiroto Kawasaki[2], Timothy D. Griffiths[1,2,3], Matthew A. Howard III[2], Christopher I. Petkov[1]; [1]Institute of Neuroscience, Newcastle University, [2]Human Brain Research Laboratory, Department of Neurosurgery, The University of Iowa, [3]Wellcome Trust Centre for Neuroimaging, University College London*

Neuronal oscillations entrain to environmental events and are thought to play an important role in segmenting sensory input. For instance, a prominent model of speech segmentation based, in part, on human intracranial recordings from auditory cortex suggests that theta oscillations (4-7 Hz) entrain to speech content and couple with gamma (50-120 Hz) amplitude (Giraud & Poeppel, Nat Neurosci 15:511-7, 2012). The extent to which such processes are uniquely human or evolutionarily conserved remains unclear, requiring more direct comparisons between humans and animal models. Here we ask which auditory cortical oscillations respond to sequences of nonsense words in intracranial recordings from Rhesus macaques and human neurosurgical patients. We used an Artificial Grammar (AG) learning paradigm where the monkeys and humans were first exposed to representative rule-based sequences of nonsense words generated by the AG. In a subsequent testing phase, we presented the participants with sequences that were either consistent with the AG or created a specific violation to an AG ordering relationship. This allowed us to study the cortical oscillations in response to the nonsense words (regardless of sequencing context) and how rule-based sequencing relationships affect these responses. As the participants listened to the testing sequences, we recorded local field potentials from the auditory cortex in the monkeys and from depth electrodes along the axis of Heschl's gyrus (HG) in humans. In the two monkeys, we observed prominent nested oscillations in the form of theta phase coupling with gamma amplitude (recording sites with significant coupling, $P < 0.05$, Bonferroni corrected: 101/145, 70%). Violations of the AG ordering relationships further modulated the strength of the theta-gamma coupling over time (81/101, 80 %). Comparable results were observed in intracranial recordings from human HG with significant coupling between low-frequency phase and high-frequency (gamma) amplitude (10/16, 63% of contacts in the two patients). Furthermore, the nested oscillations in the majority of HG recording sites in the patients (6/10, 60%) were modulated by violations to the AG ordering relationships, as observed in the monkey auditory cortex. We provide evidence that monkey auditory neural responses show low-frequency coupling in response to sequences of nonsense words, in ways that are strikingly similar to results reported elsewhere (Canolty et al, Science 313:1626-8, 2006), and as seen in the results from our more direct comparisons with human intracranial recordings. The findings suggest that nested oscillations reflect general auditory processes that are unlikely to have, at least at this general level, uniquely specialised in humans. This opens the door for detailed study and manipulation of these processes in animal models, combined with more direct comparisons to human auditory neural processes. Supported by: Wellcome Trust Investigator Awards (CIP; WT092606AIA; TDG, PEG; WT091681MA), BBSRC (CIP; BB/J009849/1), NIH (MAH, AER, KN; R01-DC04290), NIH intramural contract (CIP/YK), and Japanese NeuroCreative Award (YK).

A2 An Investigation of Executive Function Resources in Audiovisual Speech Comprehension: an fMRI Study *Megan C. Fitzhugh[1,2,3], Peter S. Whitehead[2], Lisa Jonhson[2], Alvaro F. Diaz[2], Leslie C. Baxter[1,3], Corianne Rogalsky[1,2]; [1]Interdisciplinary Graduate Degree Program in Neuroscience, Arizona State University, Tempe, AZ, [2]Dept. Speech and Hearing Science, Arizona State University, Tempe, AZ, [3]Keller Center for Imaging Innovation, Barrow Neurological Institute & St. Joseph's Hospital and Medical Center, Phoenix, AZ*

Speech comprehension in everyday life engages not only sensory processes but also numerous executive function mechanisms such as selective attention, working memory and task-switching. However, most of the studies investigating how speech processes engage executive function mechanisms rely solely on auditory stimuli, omitting the important influence of visual information from the speaker. In this fMRI study, we sought to compare the brain networks recruited during audiovisual (AV) sentence comprehension to those involved in cognitive control (i.e. selective attention). A sample of cognitively normal, right-handed, Native English-speaking adults completed two fMRI paradigms: an audiovisual speech localizer and an audiovisual Stroop task (Donohue et al., 2013). In the AV speech localizer, videos and accompanying audio of a single speaker articulating sentences were presented in a sparse sampling design. Additional trials contained only audio recordings of the sentences or silent scrambled

videos of the speaker making different facial movements to act as audio-only and visual-only controls, respectively. In the AV Stroop task, subjects were presented with a written color word (e.g. "Blue") in black font and then an auditory stimulus that either matched the written word (congruent trials) or was a different color word (e.g. "Red;" incongruent trials). Participants were asked to press a button indicating the color word that was aurally presented. Audio-only and visual-only trials also were included in the Stroop task paradigm. Outside of the scanner, in 30 subjects, this Stroop paradigm elicited classic Stroop interference and facilitation effects, replicating previous audiovisual Stroop behavioral studies. Functional MRI data were processed using standard preprocessing procedures and linear regression analyses in AFNI; results were defined using a statistical threshold of $p<0.05$ in individual subjects. Audiovisual sentence comprehension recruited large bilateral networks including superior and middle temporal regions extending posteriorly into known audiovisual integration regions in the STS, and anteriorly into Broca's area and the anterior temporal lobe. To determine how this audiovisual speech network is related to cognitive control resources, we identified regions more activated by the Stroop incongruent trials than the congruent trials, i.e. an increase in audiovisual cognitive control demands. A conjunction analysis of the Stroop and audiovisual sentence contrasts identified overlapping regions in the posterior temporal lobe (in the superior temporal sulcus). However, in Broca's area, the two dissociate and activate different subregions of Broca's area with only minimal overlap. These preliminary results suggest that posterior temporal sensory integration regions are modulated by selective attention mechanisms. In addition, the contribution of Broca's area to audiovisual speech comprehension may not be fully accounted for by cognitive control mechanisms.

A3 Neuropsychological and neuroanatomical factors associated with speech-in-noise perception in aging

Kathryn Altonji[1], Jessica Hanson[1], Michelle Kassel[1], Colin Humphries[1], Merav Sabri[1]; [1]Medical College of Wisconsin

This study sought to determine whether declining speech-in-noise perception in older adults with normal hearing thresholds is associated with cognitive performance (specifically attention and working memory) and structural integrity of cortical gray matter. 18 younger adults (ages 20-41, mean= 26.1, SD= 5.7) and 18 older adults (ages 57-72, mean= 62.4, SD= 4.9) with normal hearing (audiometric thresholds ≤25 dB HL 500 - 4,000 Hz) were tested with the Montreal Cognitive Assessment, the Test of Everyday Attention, the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS), the Wechsler Adult Intelligence Scale, and the QuickSIN Speech-in-Noise Test. The QuickSIN involves 12 lists of 6 syntactically correct sentences spoken by a female and masked by four-talker babble presented binaurally through headphones. The sentences are presented at a range of signal-to-noise ratios (SNR) between 25 and 0 dB. Structural Magnetic Resonance Imaging (MRI) scans were acquired in all subjects. On average, older adults performed significantly worse on the QuickSIN 0 dB SNR than the younger adults ($p < .05$). A multiple regression was performed across both groups with age and RBANS attention tasks as predictors for QuickSIN 0. For this model, raw scores of RBANS attention-digit span (working memory) and RBANS attention-coding (processing speed) were significant predictors of speech perception performance ($p < .001$). Structural analyses revealed, for older adults only, a significant relationship between QuickSIN 0 and bilateral gray matter thickness in regions of the frontoparietal attention network (middle frontal gyrus, superior frontal gyrus, superior parietal lobule, right intraparietal sulcus), semantic network (inferior frontal gyrus, angular gyrus, precuneus, middle temporal gyrus), and speech perception regions (superior temporal sulcus) ($p < .05$). Structural correlations were subject to false discovery rate correction ($q = .05$) for multiple comparisons. This study demonstrates that in aging, speech perception in noise does indeed decline despite normal hearing and that this can be attributed to declining executive function related to attention and working memory. In addition, deficits in speech perception are also associated with decreased gray matter thickness in cortical areas involved in executive cognitive control, attention, and language processing.

A5 Structural Integrity of the Semantic Network is associated with Selective Attention Performance across Age

Michelle T. Kassel[1,2], Colin Humphries[2], Kathryn A. Altonji[2], Jessica L. Hanson[2], David C. Osmon[1], Merav Sabri[2]; [1]University of Wisconsin - Milwaukee, [2]Medical College of Wisconsin

The present study aimed to investigate the potential influence of structural brain changes in healthy aging on selective attention (SA) performance. Eighteen younger (mean=26.1, SD=5.7) and 18 older (mean=62.4, SD=4.9) healthy adults with normal hearing (audiometric thresholds ≤25 dB HL 500 - 4,000 Hz) underwent structural MRI (T1- and diffusion-weighted scans) and performed a behavioral SA-ABX task during functional MRI (activation not reported here). Participants were instructed to discriminate syllables presented in either visual or auditory modalities, with either randomized distraction (SA) or fixed distraction (control) presented simultaneously in the opposite modality. Reaction times (RT) for correct responses were computed for each of the conditions (SA, control) by modality (auditory, visual). Distraction index was computed for RT (SA RT - control RT) for performance comparison between conditions. Average gray-matter thickness for regions comprising the frontoparietal attention network (FPN; bilateral superior and middle frontal gyri, superior parietal lobule, and intraparietal sulcus) and semantic network (SN; bilateral inferior frontal, angular, supramarginal, and middle temporal gyri,

and precuneus) were extracted using Freesurfer. Mean fractional anisotropy (FA) was calculated for the superior longitudinal fasciculus (SLF) and sagittal stratum, which includes the inferior longitudinal fasciculus (ILF) and inferior fronto-occipital fasciculus (IFOF), using the Johns Hopkins University white-matter labels atlas (Mori et al., 2005; Wanaka et al., 2007; Hua et al., 2008). Integrity of the SLF has been linked to attention processing (Ptak, 2012), whereas integrity of the ILF and IFOF have been associated with semantic processing (Agosta et al., 2010; Han et al., 2013). Repeated measures ANOVA for a 2 group (young vs. old) by 2 condition (control vs. SA) by 2 modality (auditory vs. visual) analysis of RT revealed a main effect of task condition, $F(1,34)=4.80$, $p=.035$, such that RT was significantly faster in the control condition (M=552.19, Std. Err=23.71) compared to SA (M=564.98, Std.Err=23.80). In line with our hypothesis, simple effects revealed that within the older group only, RT was significantly slower during SA (M=573.24, Std.Err=33.66) compared to the control (M=554.04, Std.Err=33.53) condition, $F(1,34)=5.41$, $p=.026$. Average gray-matter thickness was significantly correlated across the age range with RT distraction index scores in regions of the SN (all $p<.05$), indicating that larger increases in RT related to distraction were associated with decreasing thickness, but not for regions of the FPN. Structural correlations were subject to false discovery rate correction ($q=.05$) for multiple comparisons. Multiple regression revealed that FA of the sagittal stratum significantly predicted RT distraction index, $F(3,32)=3.20$, $p=.036$, when controlling for age. However, FA of the SLF did not predict RT distraction index ($p>.05$). The present results indicate that structural integrity underlying the SN may aid in SA performance, at least in the case of speech stimuli, highlighting the importance of intact SN structure, which may be necessary for effective interchange between FPN and SN, required for optimal attention regulation.

A6 Cingulo-opercular interactions with auditory cortex activity during speech recognition in noise

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Speech recognition in noise often requires increased attention and elicits the engagement of cingulo-opercular activity, which is hypothesized to reflect an adaptive control mechanism to optimize task performance. Consistent with this hypothesis, elevated and more extensive cingulo-opercular BOLD contrast has been observed prior to correct responses for a range of cognitive and perceptual tasks, including speech recognition in noise (Vaden et al., 2013, 2015). These findings predict that cingulo-opercular and auditory cortices interact, which is consistent with MEG evidence that frontal cortex increases the responsiveness of auditory cortex to speech stimuli (Park et al., 2015). The current study aimed to determine the extent to which auditory cortex encoded information about the engagement of cingulo-opercular activity during a speech recognition in noise task. Younger adults (N=18, 10 female; 20-38 years of age; mean pure tone thresholds ≤ 9.2 dB HL, 0.25 to 8 kHz; Vaden et al., 2013) listened to and repeated words that were presented individually with continuous multitalker babble at a +3 dB or +10 dB signal to noise ratio (SNR). Each word was presented between scans in a sparse fMRI acquisition with TR = 8.6 sec. We used a multi-voxel pattern analyses to test the prediction that auditory cortex activity encoded high or low cingulo-opercular activity, because these analyses are sensitive to information encoded in BOLD contrast patterns across hundreds or thousands of voxels. Specifically, the Random Forest (RF) algorithm was trained to classify trials with higher than average cingulo-opercular activity on the basis of multi-voxel BOLD patterns across the superior temporal cortex. The RF model was trained and tested on distinct subsets of trials, and exhibited good generalized classification sensitivity and specificity for each subject (left: area under the curve, AUC = 82.4 ± 5.0%, range = 75 to 90%; right: AUC = 77.5 ± 6.0%, range = 66 to 89%). This level of classification performance demonstrates that auditory cortex activity patterns contained information about whether cingulo-opercular activity was elevated on a particular trial, for each of the subjects. After controlling for SNR condition and trial-level recognition, logistic regression control analyses showed that classifications were strongly related to high cingulo-opercular activity (left auditory cortex: Z = 18.92; right Z: = 16.30, both $p < 0.001$), indicating that neither SNR nor trial-level performance accounted for the classification accuracy of the RF model. Our results demonstrate that a complex interaction exists between cingulo-opercular engagement and diffuse auditory cortex activity during a challenging communicative task.

A7 Speaker information affects false recognition of unstudied lexical-semantic associates

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Investigations of spoken word recognition have not conclusively determined the treatment of indexical information, or non-linguistic information inherent to the speech signal (e.g., information about speaker identity). Some fMRI studies have demonstrated speaker invariance early in the speech stream, such as in the anterior STG (Salvata, Blumstein & Myers, 2012), suggesting that speaker information is discarded prelexically to contact an abstract lexical representation. An alternative is that indexical information is maintained throughout the stream, consistent with fMRI evidence of sensitivity to speaker information in the posterior MTG, an area associated with semantic processing (Chandrasekaran, Chan & Wong, 2011). The present study investigated the extent to which speaker information permeates the lexical-semantic network. To investigate this question, we borrowed a paradigm from the memory literature. Studies of false memory have shown that subjects are more likely to falsely recognize an unstudied word (e.g., bed) if they have

previously studied lists of either semantically (e.g., sleep, pillow) or phonologically (e.g., bid, bet) related words (Deese, 1959; Roediger & McDermott, 1995; Sommers & Lewis, 1999). Here, we examined whether subjects' rate of false recognition was affected by whether the unstudied intruder and its studied associates were produced by the same speaker. During encoding, participants listened to lists of study items that were either semantically or phonologically related to unstudied critical intruders (CIs). Lists were divided between a male and female voice. At test, subjects heard studied words, unstudied CIs and unstudied unrelated words and identified each as old or new. Crucially, CIs were either given by the same voice that produced its studied associates at encoding or by the opposite voice Results of Experiment 1 (n=96) demonstrated a higher rate of false memories for same talker CIs than different talker CIs ($p=0.019$). This effect only emerged when subjects attended to talker identity during encoding (Theodore, Blumstein & Luthra, 2015) and only for semantic lists. However, the phonological lists in Experiment 1 overlapped in sound information, potentially obscuring speaker effects. Experiment 2 (n=48) employed more discrete phonological lists, and results revealed that when listeners attended to talker information at encoding, subjects falsely recognized same talker CIs more often than different talker CIs for both phonological and semantic lists ($p<0.001$). Overall, the experiments indicate that indexical information modulates the likelihood of phonologically- and semantically-induced false memories. Results support models of spoken word recognition in which non-linguistic information about a speaker's identity can be represented within the lexical-semantic network (Goldinger & Azuma, 2003) and can affect the processing of unstudied but related words. These data challenge the view that indexical information is discarded early in processing. With regard to the underlying neurobiology, our results suggest that actively encoded indexical information will modulate processing in a fronto-temporo-parietal semantic processing network (Binder, Desai, Graves & Conant, 2009).

A8 Components of name recognition explored with fMRI during propofol sedation

William Gross[1], Christopher Robers[1], Xiaolin Liu[1], Kathryn Lauer[1], Shi-Jiang Li[1], Jeffrey Binder[1], Anthony Hudetz[1]; [1]Medical College of Wisconsin

Recognition of spoken names is a complex process including perceptual decoding in the superior temporal gyrus (STG) and surrounding cortex, phonologic access in posterior temporal regions, and semantic decoding in a distributed network including the angular gyrus, anterior temporal pole, and inferior frontal lobes. Many imaging studies have been done to explore this system, though few have addressed its changes under sedation. Understanding the effect of sedation on name recognition can help further define this system by differentiating processes driven by attention and top-down control versus stimulus driven processes. 13 healthy participants performed a name recognition (personally familiar vs. unfamiliar names) and a perceptual oddball (high vs. low tone) task during sedation with propofol in an fMRI session. Participants were scanned before and during light and deep sedation (~1 and 2mcg/ml serum propofol), targeted using a controlled infusion. Tasks were presented in a fast event-related design, analyzed using task contrasts as well as with functional connectivity measurements. During sedation, activity within semantic networks decreased in a graded fashion, while activity within primary auditory cortex remained constant. Functional connectivity maps demonstrated decreased connectivity among early perceptual and semantic regions, while connectivity within the STG was maintained, even under deep sedation. Although some activation persisted in semantic regions during light sedation, familiarity effects seen before sedation were abolished, suggesting a loss of discrimination in these regions. In contrast, connectivity within the default mode network increased with sedation (consistent with previous reports). These results extend the current literature by detailing how the language system changes during different levels of sedation. Consistent with previous work, early perceptual cortex appears to be unaffected by sedation, suggesting that it operates largely independent of top-down attentional influences. Although semantic regions appear to be functionality disconnected during sedation, global connectivity in the DMN is increased, reflecting the transition from the complex awake state (influenced by semantics and cognitive control) to the stereotypical brain states under sedation.

A9 An fMRI study investigating effects of conceptually related sentences on the perception of degraded speech

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Under suboptimal listening conditions, the perception of a degraded speech signal may be facilitated by semantic context. Semantic effects on perception have been examined in previous fMRI studies and seem to rely on components within a fronto-temporo-parietal network. Previous research, however, has primarily focused on within-sentence manipulations. In the current experiment, we examine how meaning relationships between two different sentences influence perception of degraded speech. To this end, we manipulated the relationship between two sentences in an acoustically clear-degraded sentence pair to be Related in meaning (but consisting of different content words), Unrelated in meaning, or the Same. The fMRI experiment consisted of two parts. In the first part, participants passively listened to the pairs of sentences and performed a target detection task. In the second part, participants listened to the pairs of sentences and were asked to overtly produce a response in the scanner, repeating the second degraded target sentence

(or any of the words they heard from that sentence). The behavioral results showed that the overall conceptual meaning of a sentence influences the perception of a second acoustically degraded sentence, consisting of different content words. Specifically, listeners' word recognition accuracy for the acoustically degraded sentences was significantly higher when the target sentence was preceded by a conceptually related compared to a conceptually unrelated sentence. Same sentence pairs, which share phonological and meaning information showed the highest performance on word recognition. The fMRI analysis focused on two different aspects of these findings 1) the effects of conceptual meaning between sentences on degraded speech, and 2) the effects of same sentence pairs on degraded speech. To this end, we compared differences in brain activity between the Related and Unrelated sentence pairs, and differences in brain activity between the Same sentences pairs and the Related or Unrelated sentence pairs. The effect of conceptual relatedness between sentences on the perception of degraded speech was associated with enhanced activity in middle and inferior frontal, temporal, and parietal areas. In addition, the left MFG, L IFG, and L MTG showed activity that correlated with individual performance on the Related condition. To our knowledge, this is the first study to show a relationship between increases in activity in the LMFG and semantic effects on degraded speech. The effect of same sentence pairs on degraded speech was associated with increased activation for the Same condition compared to either the Related or Unrelated condition consistent with the view that the STG is sensitive to perceptual similarity compared to the integration of meaning between the sentence pairs. Together, the fMRI findings suggest that integration between conceptual meaning and acoustically degraded speech relies on a fronto-temporo-parietal network. The results support an interactive and dynamic account of speech processing, across multiple levels of language (acoustic, lexical, syntactic, semantic).

A10 Identifying the direction of logarithmic frequency sweeps is affected both by rate and extent of frequency change

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Dynamically changing pitch is ubiquitous in our auditory environment and important for many aspects of speech perception: formant transitions consist of rapid short-duration frequency sweeps, while slower changes in frequency are an important part of speech intonation, prosody, and lexical tones. The perception of different kinds of frequency sweeps is therefore important for speech perception and production in a variety of ways. Studies of both frequency sweeps and frequency modulated (FM) stimuli suggest two complementary mechanisms responsible for the perception of dynamic frequency changes: one that operates primarily at slow rates of change and is based on neural phase-locking to the temporal fine structure of the stimulus, and one that uses spectral energy cues which are optimal especially for rapid rates of frequency change. The goal of the current study was to investigate the complementary role of these two mechanisms and, in particular, to examine the perception of frequency sweeps that more closely parallel those of speech prosody and tonal languages. To do this, we tested sweep direction identification for logarithmic sweeps with low rates of frequency change and small extents of frequency change, which is referred to here as transition span. In a single interval direction-identification task, listeners were presented with a unidirectional frequency sweep and asked whether it moved up or down. Sweeps were uniformly varied along the two dimensions of rate and transition span: the rate of frequency change was varied between 0.0147 and 0.1667 octaves/second, and the transition span was varied between 0.1 and 0.5 semitones. All stimuli were at least 50ms in length. As expected, direction sensitivity increased with increasing transition span, and subjects were better at identifying upward sweeps than downward ones. Furthermore, direction sensitivity decreased with faster rates of frequency change. Support for a phase-locking based mechanism of frequency-sweep perception is discussed.

A11 Brain mechanisms for processing phonetic and emotional information in speech

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Introduction: Speech carries both linguistic and paralinguistic information. Emotional prosody involves the manipulation of acoustic cues such as fundamental frequency, loudness, and voice quality to communicate emotion. Manipulating these cues allows speakers to communicate emotion through prosody. In the current cross-modal priming ERP study, we were particularly interested in the emotional aspect of prosody as opposed to its phonetic characteristics. Method: Twelve right-handed normal adults participated in the study. The visual primes were four photographs of a male face showing a happy or an angry expression with a mouth shape that was representative of either an /ɑ/ or an /i/ vowel. The same male speaker produced the four auditory targets, /bɑb/ ("bob") and /bib/ ("beeb") with happy or angry prosody. In each trial, the visual prime was presented for 400 ms before the onset of the target auditory stimulus. In the prosodic condition, participants were instructed to evaluate a match or mismatch between the emotion of the face and the emotion of the spoken word. In the phonetic condition, participants were instructed to evaluate congruency between the articulation and the auditory word target. Continuous EEG data were collected with a 64-channel Advanced Neuro Technology system. Auditory stimuli were presented at 60 dB sensation level. There were 160 congruent trials and 160 incongruent trials respectively for the phonetic and prosodic conditions. The ERP epoch length was 1500 milliseconds, including a pre-stimulus

baseline of 100 milliseconds. Artifact rejection criterion was set at ± 50 μV. In addition to ERP waveform analysis for the congruency effect, we performed minimum norm estimation (MNE) and trial-by-trial time-frequency analysis to examine cortical regions and oscillation rhythms mediating the processing of phonetic and emotional information in the speech signal. Results: Repeated measure ANOVA tests showed a significant congruency effect in percent correct and reaction time data, and there was a significant interaction between congruency and condition in the accuracy results. The ERP data showed clear N400 peaks followed by a late positive component (LPC) in both phonetic and prosodic conditions. Source localization patterns for the N400 response show strong left hemisphere lateralization in the phonetic condition and right hemisphere dominance with superior temporal and inferior parietal region activations in the prosodic condition. The LPC showed more distributed regions of activation for the phonetic condition, including the parietal lobe in addition to the primary motor cortex and occipital regions. Time-frequency results showed that lower frequency bands (delta, theta and beta) contributed to the N400 response and theta rhythm contributed to late positive response in the phonetic condition. In the prosodic condition, the primary contributors to both N400 and LPC were beta and gamma rhythms. Conclusion: Overall, the results suggest that cortical processing of phonetic and emotional information involves distinct neural systems, which has important implications for further investigation of language processing deficits in clinical populations.

A12 Who's laughing now? Emotional authenticity impairs the perception of indexical cues in non-verbal vocalizations.

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Introduction It has been suggested that voices behave like "auditory faces", allowing us to readily extract indexical speaker properties such as age and sex from them (Belin, Fecteau, & Bédard, 2004). This notion is, however, based on findings from studies that have almost exclusively used speech stimuli produced under full volitional control. Voices are, however, uniquely variable and flexible signals, with the vocal output being drastically affected by volitional (e.g. impressions) and involuntary (e.g. emotional experiences or changes in health) processes – by neglecting this flexibility of vocal signals, findings from previous studies may only offer limited insights into the perception of speaker characteristics from voices. In two studies, we explored how our ability of extract speaker characteristics from a range of nonverbal vocalization is affected in the presence of natural and informative variability in the vocal signal, introduced by authentic emotional content and therefore the degree of volitional control over the production. Methods and Results In a first study, we explored how authentic emotional content in nonverbal vocalizations (authentic laughter and crying) affects the perception of speaker characteristics compared to vocalizations produced under full volitional control (here: series of vowels). Participants identified speaker sex in a two-way forced choice paradigm and performed a same-different speaker discrimination task on pairs of the three vocalizations, yielding the following 6 permutations: Vowels–Vowels, Crying–Crying, Laughter–Laughter, Crying–Laughter, Crying–Vowels, Laughter–Vowels. We found that performance (measured in d') for both sex recognition and speaker discrimination was impaired when vocalizations include authentic emotional content compared to vowels. To explore whether this effect was due to authentic emotional content or an effect of vocalization type, we ran a second experiment, contrasting authentic (real) laughter with volitional (posed) laughter that does not include authentic emotional content. Performance for both sex recognition and speaker discrimination was impaired for authentic laughter only, while performance for volitional laughter and vowels was similar in both tasks. In both experiments, a failure to generalize identity information across different nonverbal vocalization categories became apparent: in the speaker discrimination task, performance for within-categorization pairs (e.g. Crying–Crying or Volitional Laughter–Volitional Laughter) was higher compared to across vocalizations pairs (e.g. Crying–Vowels, Laughter–Crying). Strikingly, performance for pairs of spontaneous laughter–vowels was not significantly different from chance in both experiments. Conclusion Our findings suggest that variability in vocal signals introduced by different communicative goals (e.g. signaling emotional authenticity) can partially override stable markers of indexical speaker properties by introducing drastic changes in the vocal output. These changes in vocal signals make it difficult to identify generalizable cues to person-related information from unfamiliar voices, leading to a failure map vocalizations produced under different level of volitional control onto the same source (a speaker's vocal tract).

A13 Amplitude and phase spectra information contribute to speech intelligibility and melody recognition differently

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Differences in speech and music processing have become increasingly apparent through neuroimaging, behavioral, and clinical population studies. Electric hearing is a clear example of these processing differences. Cochlear implants transmit impoverished signals to the auditory cortex, allowing speech to retain most of its intelligibility but rendering music nearly unrecognizable. In order to fully understand these processing differences, it is necessary to look at the signal's spectral information (the amplitude and phase values of each signal component), and determine how standard units of language, such as phonemes and syllables, affect the way it is processed. The current study

investigated how amplitude and phase information differentially contribute to speech intelligibility and music recognition. Listeners in our experiment heard either degraded sentences or degraded melodies: they identified words of the sentence for the speech task, and performed a same-different judgement in the music task. Each stimulus was degraded by first dividing it into segments; then for each segment, the amplitude and phase spectra values were each decorrelated independently relative to those of the original segment. Segments were then recombined into their original full length before being presented to the listener. We used three segment lengths: 30 ms (phoneme length condition), 250 ms (syllable length condition), and full stimulus length (non-segmented condition). We found that if the stimulus is not segmented before decorrelation, phase spectrum information is most helpful for both speech intelligibility and music recognition. For the syllable-length condition, speech becomes unintelligible when the phase spectrum correlation is 0.4 or less, even when the amplitude spectrum is unaltered. Conversely, music only becomes unrecognizable in the syllable-length condition when the amplitude spectrum correlation is below 0.5. In the phoneme-length condition, speech is unintelligible whenever the amplitude spectrum is completely uncorrelated, while music is recognizable as long as the phase spectrum correlation is 0.8 or higher. These results not only support recent findings that phase spectrum information is more critical to speech intelligibility at longer time segment lengths and but also delineate the range of amplitude and phase correlations necessary for melody recognition.

A14 Resting GABA concentration predicts induced auditory gamma power and FM discrimination thresholds

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The process of extracting linguistically relevant information from speech requires analysis of the auditory signal at multiple hierarchical timescales that coincide with the dominant frequencies of neural oscillations in auditory cortex (Poeppel, 2003). Neural oscillations in the low gamma band (30-80 Hz) are generated by excitatory-inhibitory interactions within cortex, but little is known about how levels of excitation and inhibition affect auditory processing. The power and frequency of gamma oscillations elicited in response to visual stimulation has previously been found to be positively correlated with resting measures of gamma aminobutyric acid (GABA), the major inhibitory neurotransmitter, obtained in vivo using magnetic resonance spectroscopy (MRS) (Muthukumaraswamy et al, 2009). We extend the evidence for a GABA-gamma association to the auditory domain and report the first evidence of a relationship between GABA and both neural and behavioral responses to auditory stimuli. To examine auditory frequency tuning, 16 healthy adults passively listened to 1kHz tones with amplitude modulation (AM) at 25, 30, 35, 40, 45, 50 or 55Hz (100% modulation depth) during magnetoencephalography (MEG) recording. To estimate induced oscillatory responses elicited by the AM tones at each AM frequency, we performed source reconstruction using a frequency domain beamformer at each AM frequency and extracted relative power increase (relative to a 1s prestimulus baseline) from anatomically-defined regions of primary and secondary auditory cortex. A MEGA-PRESS GABA-editing MRS sequence was used to measure GABA+ in an 18.2cc voxel placed in the left superior temporal gyrus that included portions of Heschl's gyrus and the planum temporale. GABA+ concentrations were expressed relative to creatine and adjusted for tissue composition. GABA+ concentration was positively correlated with induced power at higher frequencies, most strongly seen as positive correlation ($r=.86$, $p<.01$) between induced power at 50Hz in the left auditory cortex and GABA+. To investigate the behavioral correlates of GABA+ concentration with auditory processing, estimates of subjects' frequency detection thresholds were also obtained using a 2AFC task in which subjects had to indicate which of two successive tones was modulated (frequency modulation (FM) at 2Hz or 240Hz vs. 1kHz reference tone). GABA+ concentrations were also negatively correlated ($r=-.73$, $p<.01$) with 240Hz FM detection thresholds, but not 2Hz thresholds ($r=.06$), indicating that individuals with higher GABA+ concentrations may have increased sensitivity to the spectral cues in the 240Hz FM stimuli. These results indicate that auditory processing is dependent on excitation/inhibition balance within auditory cortex. Individuals with higher levels of inhibition showed increased neural responses to AM stimuli at higher frequencies. This suggests that increases in neural inhibition may be associated with greater sensitivity of cortical auditory processing over short, subsegmental timescales. However, we found no evidence for a correlation between GABA+ and rapid auditory processing in the 2 Hz FM discrimination task. Behaviorally, GABA + concentrations were associated with increased sensitivity to auditory spectral cues, suggesting that excitation/inhibition balance has a significant effect on auditory processing at multiple levels of analysis.

A15 Audiovisual Speech Integration in Children with ASD and TD.

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Findings from perceptual studies of children with autism spectrum disorders (ASD) strongly implicate deficits in processing of audiovisual (AV) speech. Previous research with AV stimuli has typically been done in the context of auditory noise or with mismatched auditory and visual ("McGurk") stimuli. Although both types of stimuli are well-established methods for testing typically developing (TD) participants, they may create additional processing

problems for children with ASD beyond difficulties with AV integration: the auditory noise may be especially disruptive for individuals with ASD and the conflict between auditory and visual signals in the mismatched McGurk stimuli may create decision-level difficulties in executive functioning, an area of weakness for those with ASD. To more precisely examine AV speech perception in children with ASD, we employ a novel measure of AV processing that involves neither noise nor AV conflict. This new AV paradigm uses perceptual discrimination of synthesized auditory speech stimuli in auditory and AV conditions. Speech stimuli include clear exemplars of the auditory syllable /ba/ and a modified version of /ba/ in which the auditory cues for the consonant are substantially weakened so that the consonant is not detected (heard as "/a/"). These are dubbed with a video of the speaker saying /ba/. Critically, the same video is used for all stimuli, so that only the acoustic stimulus varies. For an auditory-only (AO) baseline, the mouth and jaw are pixelated to remove all articulatory information. For the AV "/a/" stimulus, audiovisual integration should result in the visual information effectively "restoring" the weakened auditory cues so that the stimulus is perceived as a /ba/. This was confirmed in behavioral pilot data with typically developing (TD) participants: the AV "/a/" tokens were not perceived as different from AV /ba/ tokens. We combine ERP and eye tracking methodology (to confirm listeners are fixated on the face of the speaker) in combination with this novel AV paradigm. We employ an auditory oddball approach in which the token /ba/ serves as the frequently occurring standard and the /"a"/ token serves as the infrequent deviant. Critically, the AV /"a"/ should be perceived as deviant only if AV integration is weak or does not occur. We include both blocks where children are asked to press a key when they hear /a/, in order to examine P300 response and blocks where children passively watch, in order to examine MMN response. Findings thus far reveal larger P300 and MMN amplitudes for ASD children relative to TD children in the AV condition, indicating that children with ASD appear to integrate less (they continue to hear the reduced auditory signal as "/a/"). This preliminary evidence indicates that children with ASD exhibit weaker AV integration for speech.

A16 Audiovisual integration in the presence of auditory and visual noise: Analysis of behavior and eye movements

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Audiovisual integration (AVI) is of great interest in the study of cortical language organization, and is especially important in language-impaired patient populations, such as aphasia. Of note are several recent studies from our lab: Fridriksson et al. (2009) showed that adding visual speech cues to auditory cues during aphasia treatment greatly improved treatment outcome. Fridriksson et al. (2012) described a phenomenon called speech entrainment, in which patients who were largely non-fluent were able to produce fluent speech while performing online mirroring of an audiovisual speech model. However, real world situations can vary substantially from the ideal conditions in a controlled experiment, and understanding of how audiovisual integration operates in noisy contexts may be crucial for understanding implications for patients. The current study is a behavioral experiment on AVI in the presence of auditory or visual noise. Additionally, we collected information on participants' eye movements, to better understand how information utilization might change in the presence of stimulus degradation. Stimuli throughout the study consisted of video clips of one of three highly visible syllables (/da/,/pa/,/wa/). Each syllable was masked by either auditory or visual noise. Half of the trials were AV matched (e.g. hear /da/, see /da/) and half were mismatched (e.g. hear /da/, see /pa/). Mismatch pairs were chosen so as not to induce McGurk effects. After each stimulus, subjects were asked to choose whether the stimulus was AV matched or mismatched and to respond as quickly and accurately as possible via button press. The first two runs of the experiment consist of an adaptive threshold task (60 trials each, separately for audio/visual noise), which gave estimates of each subject's perceptual abilities, and constrained the stimulus set for the rest of the experiment. The remaining two runs of the experiment (120 trials each) used each subject's threshold as the highest noise level, and each of four lower noise levels were decreased by a constant amount. Eyetracking data were collected only during the fixed levels portion of the experiment. For the adaptive threshold portion of the experiment, average threshold for auditory noise was -10.37 dB SNR (sd=11.10, range=-22.27-11.24) and average threshold for video noise was 0.88 Alpha units (sd=0.13, range=0.45-0.97). For the fixed level portion of the experiment, accuracy values decreased with increase in noise, which was significant via one-way ANOVA for both auditory, $F(4,80)=3.44$, $p=0.012$, and visual noise, $F(4,80)=2.87$, $p=0.028$. There were also differences in performance for the individual syllable pairings. For the analysis of eye movements, we focused on fixation time for five interest areas (IA; left and right eyes, nose, mouth, and entire face), and conducted two-way (difficulty x IA) ANOVAs. For auditory, there was a main effect of IA, $F(4,400)=689.39$, $p=<0.0005$, but no effect of difficulty or interaction. Similarly, for visual, there was a significant effect of IA, $F(4,400)=755.32$, $p=<0.0005$, but no effect of difficulty or interaction. The mouth was the area of greatest fixation time in both auditory and visual conditions. Additionally, we will discuss unanticipated patterns of audiovisual fusion in the presence of noise.

A17 Examining the neural correlates of Rapid automatized naming (RAN) in dyslexia

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Introduction: Rapid automatized naming, which is the ability to automatically and correctly retrieve labels for abstract visual stimuli, is highly predictive of reading ability. Yet, the neural processes involved in rapid naming and its relationship with reading processes remains unclear. In the present study, we aim to investigate the neural correlates of rapid naming tasks between skilled readers and individuals with dyslexia to better understand the RAN-reading relationship. Methods: Using functional magnetic resonance imaging (fMRI), both normal and dyslexic participants (Skilled readers; N=19; Mean age = 21.4 years, Dyslexia; N=14, Mean age = 24.2 years) were assessed on RAN (letters, digits and objects) and reading (real word, and nonword) tasks. Images were acquired on a 1.5T Siemens Sonata scanner. For each condition (RAN and reading) 136 volumes of 36 slice, axial spin, echo planar images (EPIs) were obtained with the following parameters: TR = 1970ms, TE = 40ms, voxel size 4x4x4mm, base resolution 64 x 64 with a 128 x 128 reconstruction matrix , scan time 4.41 minutes (i.e., steady state images (15 seconds) + (25 second task card + 25 second rest card) * 5). A region-of-interest (ROI) approach, with percent signal change (PSC) as the dependent variable, was implemented to examine gradient patterns (i.e. differential task activations) within/across the brain regions, as well as group differences within the brain regions. Regions corresponding to cortical and subcortical areas, particularly, caudate, cerebellum, inferior frontal gyrus, midbrain, precentral gyrus, putamen, supplementary motor area, superior temporal gyrus, thalamus, visual word form area, were selected. Participants also completed the RAN and reading tasks in the behavioural lab where average response time was measured. Results: Increase in PSC was observed during RAN-object and RAN-digit task in the cerebellum, inferior frontal gyrus, superior temporal gyrus, and thalamus in skilled readers as compared to the dyslexia participants. While, increased PSC was observed in the caudate, cerebellum, midbrain, precentral gyrus, putamen, supplementary motor area, and the visual word form area during RAN tasks in dyslexia participants. Skilled readers during RAN and reading tasks showed similar pattern of brain activation for visual word form area, inferior temporal gyrus and superior temporal gyrus, unlike dyslexia participants. The observed different pattern of neural activation was localized to cerebellum, precentral gyrus, supplementary motor area, and the visual word form area during both RAN and reading tasks in skilled readers and dyslexia participants. Conclusion: Skilled readers showed increased activation in areas associated with articulatory processes such as the inferior frontal gyrus, superior temporal gyrus, and thalamus as compared to dyslexic readers. However, individuals with dyslexia showed more activation in areas associated with motor skills and planning, such as the precentral gyrus, caudate, and putamen, suggesting a compensatory system for translating visual stimuli to verbal expression that parallels compromised behavioral performance on RAN tasks on standardized measures. In addition, the observed increase in activation in the brain areas associated with motor planning might reflect impairment in the phonological-decoding pathways and consequential reliance on semantic and visual-word processing by individuals with dyslexia.

A18 Speech-evoked brainstem responses relate to KIAA0319 variants and phonological skills in pre-reading children: a biomarker for dyslexia?

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Developmental dyslexia is a disorder most often accompanied by deficits in phonological awareness, phonemic categorization and speech-in-noise perception. Very early signals of the auditory pathway indicate an abnormal encoding of speech stimuli in reading impaired children. Their speech-evoked brainstem responses are less consistent and distinctive. An insufficient signal-to-noise ratio at the brainstem level may be a generator of established behavioural and neural irregularities found in poor readers. However, dyslexia is familial and moderately heritable but very little is known about the function of identified candidate genes. Knockdown of the dyslexia associated gene Kiaa0319 impairs temporal responses to speech stimuli in rat auditory pathway. We studied, whether KIAA0319 polymorphisms relate to phonological skills, phoneme discrimination, speech-in-noise perception and speech-evoked brainstem responses in a group of pre-reading children at familiar risk of dyslexia and in aged-matched control children. KIAA0319 was associated with the consistency of speech-evoked brainstem responses as well as with pseudoword repetition. KIAA0319 was not associated with speech perceptual acuity, phonological awareness, or speech-in-noise perception in pre-reading children. It remains to be shown, to what extend reading outcome will be related to the pre-reading physiological measures and to the genotype.

A19 Sensitivity to speech distributional information in children with autism: a MEG study

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Deficits in language are frequently found in children with autism spectrum disorder (ASD), including weakness in phonology and syntax (Tager-Flusberg, 2006; Dawson et al., 2002). It is largely unknown what learning mechanisms lead to impaired language in ASD. Ample evidence suggests that typically developing children are exquisitely poised to capture the distributional information embedded in speech, through which they learn various aspects of phonotactic and syntactic rules (Saffran et al., 1996; Newport and Aslin, 2004). Children with ASD, however, demonstrate impaired performance in sequence learning (Gordon & Stark, 2007; Larson & Mostofsky, 2008) and lack neural sensitivity to probabilistic cues during exposure to an auditory artificial language (Scott-Van Zeeland et al., 2010). However, it is not established whether children with ASD are incapable of applying knowledge about probabilities or incapable of detecting probability information at the first place. Auditory mismatch negativity / field (MMN/F), a measure of automatic deviant detection, provides an objective index of discrimination accuracy. The MMN/F amplitude can be modulated by deviant-stimulus probability (Näätänen et al., 2007; Haenschel et al., 2005). Here we asked whether language impairment in school-aged children with ASD is related with their lack of sensitivity to distributional information by examining magnetoencephalography (MEG) responses to auditory deviants with different occurrence frequencies. Children with ASD (7-15 years) and age-matched typically developing (TD) children performed a visual target detection task, while a train of single-syllable stimuli was played in the background. Syllable "ba" spoken by one female speaker was presented 1000 times, while deviants consisted of the same speaker's "da" (syllable deviant) or a different female speaker's "ba" (voice deviant) each occurring 100 (rare) or 200 (frequent) times. The probability manipulation of the two deviants was counterbalanced across the two experimental blocks. In order to investigate neural response related to the differences of abstract features of the stimuli (i.e., syllable content or speaker identity), as opposed to merely acoustic differences, we included 50 different exemplars for each stimulus type. Children with ASD exhibited an overall reduced sensitivity to the difference between the syllable and voice deviants. A significant interaction between groups (ASD vs. TD) and deviant types (voice vs. syllable) was found in left superior temporal gyrus between 150 and 300 ms. Specifically, the TD group showed a significantly greater difference in response to frequent syllable deviants vs. rare syllable deviants than the ASD group. The size of the frequency effect was positively associated with performance in reading comprehension measured by the Woodcock-Johnson 3 Test of Achievement across all participants, as well as within the ASD group alone. In contrast, both TD and ASD groups were equally sensitive to probability manipulation in voice deviants. These findings provide new evidence highlighting the important role of sensitivity to speech probability cues in language development. Children with ASD showed specific deficits in detecting changes in frequency of occurrence related to speech content, but not speech acoustics in general. Impaired reading skill in ASD was associated with the atypical sensitivity to frequency of syllables.

A20 Neural impairment of tone language speakers with congenital amusia: An fMRI study *Caicai Zhang[1,2], Gang Peng[2,3], William S-Y. Wang[2,3]; [1]The Hong Kong Polytechnic University, [2]Shenzhen Institutes of Advanced Technology, [3]The Chinese University of Hong Kong*

Congenital amusia is a neurodevelopmental disorder primarily influencing musical pitch processing. Whether the pitch impairment extends to the language domain or not remains debated. Earlier studies suggest that pitch impairment in amusics is limited to the music domain. However, recent studies with more refined design suggest that the pitch deficit does extend to intonation processing in speakers of non-tone languages. Tone language provides a unique opportunity to shed additional light on this debate, for the reason that pitch is systematically used to distinguish lexical meanings in tone languages. To this end, we examined the neural impairment of Cantonese-speaking amusics in an fMRI study. We adopted a group (amusics, controls) x domain (speech, music) x pitch interval (repetition, fixed pitch interval, varied pitch interval) design. Pairs of Cantonese level tones and pitch-matched musical tones in piano timbre were separately presented to the amusics and controls in three conditions: (1) repetition condition, in which a pair of Cantonese tones or musical tones was simply repeated eight times; (2) fixed pitch interval condition, in which eight pairs of Cantonese tones or musical tones with fixed pitch interval but varied pitch height were presented; and (3) varied pitch interval condition, in which eight pairs of Cantonese tones or musical tones with varied pitch interval and varied pitch height were presented. Brain regions sensitive to the processing of pitch interval are expected to show similar levels of habituation in the repetition and fixed interval condition, and to show a release from adaption (i.e., increased activation) for the varied pitch interval condition (varied interval > fixed interval ≈ repetition). The results from 8 amusic and 20 controls reveal that the functional abnormality of amusics underlying the processing of relative pitch interval lies in the bilateral STG. In normal controls, bilateral STG are selectively activated in the processing of pitch interval in lexical tones. However, the activation of bilateral STG is absent in the amusics, irrespective of lexical tones or musical tones. The finding that the functional abnormality of amusics lies in the bilateral STG is consistent with a previous study (Albouy et al., 2013). Findings of this study shed light on the relationship of language and music.

A21 Perceptual Restoration of Masked Speech in Human Cortex

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Our listening environment is filled with interference, yet we can understand speech under significantly adverse conditions – to the extent that we may be unaware that segments of the speech signal are not even physically audible. Phoneme restoration is a perceptual phenomenon where part of a word is replaced by noise, and listeners not only report hearing the missing sound, but also are unable to report which phoneme was replaced. There are two competing theories for phoneme restoration. Interactive models posit that this behavior arises from top-down biasing effects where higher-order linguistic knowledge changes the representation of the perceived phoneme online. In contrast, autonomous models favor a separate decision module, obviating the need for feedback between processing levels. Both influential approaches account for a range of speech behavior, but to date, in the absence of neural evidence, it has been difficult to distinguish their predictions. To understand how the brain perceptually restores masked speech, we recorded neural activity directly from the surface of the brain in human subjects implanted with multi-electrode electrocorticography arrays. Participants listened to word pairs that differed in a single phoneme ('original'; e.g., /fæstr/ vs. /fæktr/). They also heard words where the critical phoneme was replaced with broadband noise ('restored'; /fæ#tr/), and reported which word they heard. Subjects perceptually restored stimuli with noise differently on individual trials, and neural responses closely correlated with what word was perceived. For example, when subjects reported hearing /fæ#tr/ as "factor", the neural response to the noise closely matched the response to /k/ in the original stimulus, /fæktr/. Distributed population activity in superior temporal and inferior frontal electrodes represented the fine-scale spectrotemporal acoustic features of the perceived phoneme, demonstrating a moment-by-moment restoration of missing sounds. We trained a classifier to decode the identity of the perceived word from the population neural activity across time. Maximal classification accuracy was 75% for original trials and 70% for restored trials, and occurred ~200ms after critical phoneme onset. Both effects were localized primarily to bilateral superior temporal gyri. Remarkably, perceptual restoration could also be predicted accurately before the critical phoneme. This pre-stimulus bias was localized to neural populations in left inferior frontal cortex. Together with the observation that listeners were more likely to hear whichever original word in the pair they heard previously during the task, it is suggested that neural states are influenced by lexical priming, which has top-down predictive influences on auditory neural populations. These results demonstrate that missing acoustic content is not simply inferred from contextual cues, but is synthesized as a result of incoming sensory cues and the internal dynamics that bias word-level expectation and prediction.

A22 Category specificity, hubs, and time course of semantic brain activation: a neurocomputational model

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Neuroimaging and patient studies indicate the existence of so-called 'semantic hubs', that is, areas in cortex where the meaning of all types of signs and symbols is processed. However, a growing number of studies involving both healthy subjects as well as brain-damaged patients have shown that other cortical areas contribute to semantic processing in a more selective fashion, being particularly relevant for specific semantic categories. Why are there both semantic hubs and category-specific semantic areas in the human brain? Why are these, respectively, located in multimodal association cortex and in modality-preferential cortical areas such as the visual and motor systems? Here, we present a neurobiologically grounded computational model of language, which explains the emergence of both on the basis of cortical area structure and connectivity and associative learning mapping neuronal correlations. We applied a neural-network model replicating anatomical and physiological features of realistic properties of the human cortex to simulate (i) the learning of semantic relationships between word forms and specific object perceptions and motor movements of the own body and (ii) the neurophysiological responses to perception of learned object and action words. The model architecture mimics the left perysilvian cortex involved in processing spoken words and their corresponding auditory-phonological signals (primary auditory, auditory belt, auditory parabelt areas in superior-temporal, and articulatory primary-motor, premotor and prefrontal areas in inferior-frontal cortex) and areas outside the perysilvian cortex, involved in visual object perception (early visual, temporo-occipital and anterior-temporal areas) and the execution of manual actions (primary-motor, premotor and adjacent prefrontal cortex). Known cortical features of within- and between-area connectivity were implemented, as were important neurophysiological properties, including long-term synaptic plasticity, adaptation, and neural mechanisms of inhibition and competition. The learning of object and action related words by means of a Hebbian rule was simulated via co-activation of specific sets of "cells" in primary articulatory motor and auditory "cortex", along with grounding referential-semantic "neurons" (primary visual "area" for object words and primary motor "area" for action words). After training the network we analyzed the time course of "word recognition" processes, simulated

by confronting the network with the acoustic component (pattern in primary auditory area) representing the auditory word forms of the learned object and action words. The model showed spontaneous emergence of stimulus-specific, tightly interlinked cell assemblies, connecting the processing of word-form information with that of sensorimotor semantic information. These simulations (i) explain the presence of category-specificity in the cortical distribution of word-related circuits, with highly-connected hub areas situated at the center of the network architecture exhibiting an only moderate category specificity, and (ii) predict a symmetric activation time-course in the sensorimotor systems for both object- and action-related word recognition, with analogous temporal dynamics in the hub areas. The present results account for the spontaneous emergence of both category-specific and general semantic hub areas in the human brain and show that realistic neurocomputational models can elucidate aspects of semantic processing in the human cortex.

A23 Individual differences in visemic representations and their relationship to lip-reading and speech-in-noise perception – an event related potentials (ERP) study

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We examined electrophysiological correlates of visual articulatory movement representations associated with specific words (i.e., visemes) and evaluated the relationship between the strength of these representations and two measures of visual speech perception – namely, the degree of improvement on the speech-in-noise (SIN) task when seeing the talker's face and lip-reading accuracy (i.e., understanding speech based on visual information only). Twenty-two young healthy adults participated in two related tasks. One was a cross-modal repetition-priming paradigm, in which participants first heard a word referring to a common object (such as a pumpkin) and then had to decide whether the subsequently presented visual silent articulation matched the word they had just heard. In half of trials, the presented articulation matched the heard words (congruent trials), and in another half it did not (incongruent trials). This task was combined with event-related potentials (ERP) recordings, with the focus on two well-established measures of lexical processing – the N400 and the late positive complex (LPC). In the second task, the same words used in the repetition priming paradigm described above were embedded in a two-talker babble with a -5 dB SIN ratio. Participants were asked to report what they heard in two conditions. In one, no visual speech cues to words' identity were provided. In another, participants saw the talker's articulation while listening to target words. The goal of this task was to measure the degree of SIN perception improvement in each participant afforded by the presence of visual speech cues. We found that visual articulations that were incongruent with preceding auditory words elicited significantly larger N400s compared to those visual articulations that were congruent. Importantly, the degree of the N400 enhancement to incongruent articulations was associated with greater improvement on the SIN task in the presence of the talker's face but was not at all related to one's lip-reading ability. We also found that the LPC component was larger to congruent compared to incongruent articulations, indicative of word recognition on congruent trials. The mean amplitude of the LPC component to congruent trials was predictive of participants' performance on the lip-reading task (with smaller LPC being associated with better performance) but was not related to the SIN improvement in the presence of the talker's face. Our results yield themselves to several conclusions. First, hearing words primes memory representations of how such words look when articulated (visemes). Second, individuals with strong visemic representations (as measured by a larger difference between N400 to congruent and incongruent articulations) benefit more from seeing the talker's face when listening to speech under noisy conditions. Given that visual speech movements typically precede the onset of sound, strong visemic representations likely facilitate the selection of a target lexical item among multiple competitors. Lastly, using visual speech cues during audiovisual speech perception and during lip-reading appear to depend on at least partially separate neural mechanisms.

Gesture, Prosody, Social and Emotional Processes

A24 Phrasing in language and music: same or different? An event-related potential study.

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Similarities between the neurocognitive mechanisms underlying language and music processing have received much attention in the last decades. However, the reliability of methods used to qualify multiple neural and/or cognitive patterns as relying on common neurocognitive substrates remains questionable. In our experiment, we addressed this issue in an event-related potential (ERP) study of linguistic and musical phrasing. Intonational phrasing in language is reflected by an ERP component called the Closure Positive Shift (CPS). A component similar to the CPS in language has also been reported for musical phrases (i.e., the so-called 'music CPS') in musicians. However, the morphology and timing of the music-CPS differ significantly from those of the speech-CPS. Moreover, previous findings pertaining to whether the music-CPS can be elicited in non-musicians are mixed, whereas elicitation of the language-CPS is relatively independent of an individual's level of language proficiency. Our study probed the shared nature of mechanisms underlying musical and intonational phrasing by (1) investigating whether the music-CPS is present where the speech-CPS has been originally reported (i.e.,

at the onset of the pause between phrases); (2) comparing the CPS in music and in language in non-musicians (n=16) and professional musicians (n=14); and (3) studying the effects of factors known to modulate the speech-CPS (i.e., syntactic phrasing cues, acoustic boundary strength, and item predictability) on the music-CPS. Participants listened to sentences with and without an intonational phrase boundary, as well as to melodies with either acoustically strong, medium, or weak phrase boundaries. Half of the musical phrases ended with a strong syntactic closure (i.e., a full cadence), and the other with a weaker, comma-like syntactic cue (i.e., a half cadence). Item predictability was studied by presenting each phrase twice and comparing repeated items to phrases presented for the first time. The results revealed that although effects tied to the ERP component previously referred to as the music-CPS were not robust, as predicted, a stable positive shift, the characteristics of which were most reminiscent of the speech-CPS, was present at offset of the pre-boundary phrase. Similar to the language-CPS, this component was modulated by acoustic phrasing cues (i.e., the absence/presence of the pause) rather than by syntactic boundary markers. While no difference in this early component was found between musicians and non-musicians, the speech-CPS in musicians was less prominent than in non-musicians, indexing that more efficient processing of intonational phrases is linked to higher musical expertise. Alongside the local phrasing effect (likely a real analogue of the language-CPS in the music domain), we found global effects of musical phrasing reflected by earlier, slow-emerging shift-like ERP differences elicited by the level of item familiarity and degree of syntactic closure. The local phrasing component superimposed these drifts and was independent of syntactic and familiarity factors. Taken together, first, these findings suggest, that intonational and musical phrasing relies on common neurocognitive mechanisms, and that transfer between music and language domains exists at the level of phrasing. Second, our results emphasize the importance of studying larger-scale ERP effects on the whole-phrase (and whole-sentence) level.

A25 Prosody activates theory of mind areas during speech act comprehension – fMRI evidence

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One main goal of human interpersonal conversations is to communicate one's intentions. According to speech act theory, utterances transfer information at (at least) two levels: (1) the propositional content codes the lexical meaning of the words, and (2) the illocutionary force expresses the intended meaning of the speaker (speech act). Importantly, the illocutionary meaning is rarely coded in the words as such, but is often expressed via additional communicative channels. Speech prosody—i.e. the vocal tone of an utterance—has been shown to successfully convey different speech acts, as carriers of the communicative intentions. The neural mechanisms that decode the speaker's intention from prosody, are, however, still unclear. The current fMRI study addresses the question which processes are used when listeners identify speech acts purely based on prosodic cues in the speech signal. Single word stimuli (e.g., "beer") were recorded by four speakers with varying intonations, expressing the speech acts criticism, doubt, and suggestion. 7-step morphed continua were created for each pair of speech acts to obtain gradual prosodic transitions, e.g., from criticism to suggestion. Participants performed a simple categorization task. For the analysis, the clear—communicative—prosodies at the outer ends of the continua (morph steps 1, 2, 6, 7) were compared with the ambiguous—non-communicative—prosodies in the center of the continua (morph steps 3, 4, 5). The clear intentional prosodies compared to the ambiguous stimuli revealed stronger activations in the amygdala, posterior cingulate gyrus and precuneus, as well as medial prefrontal cortex, left middle frontal gyrus, and left middle temporal gyrus. These areas have been related to theory of mind and emotional processes suggesting that listeners inferred the intention and emotion of the speaker during the recognition of speech act prosodies. In the reverse contrast, higher activations for the ambiguous, non-communicative prosodies were found in the paracingulate gyrus, the IFG, and the anterior insula extending into orbito-frontal regions. These areas have been previously associated with (subvocal) speech production suggesting that participants may have used internal simulation mechanisms as additional aid when trying to decode the non-communicative signal. In general, our results show that prosody understanding of speech acts involves brain regions beyond the typical perisylvian language network, and that prosodic cues alone are able to elicit inference processes for communicative signals. These novel findings in the sparsely examined field of prosodic intention understanding might open new views on the role of prosody for successful communication and its various paralinguistic functions.

A26 Prosodic influences on question/answer focus in English ditransitives: An auditory ERP study

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[INTRODUCTION] Previous ERP research examining brain responses indexing the processing of prosodically marked focus have reported positive-going shifts in connection with contextually appropriate presence (versus absence) of focus marking. Absence of expected focus has previously yielded a negative-going waveform, most prominent in posterior areas, while unexpectedly focused elements have not been shown to yield significantly different results from appropriately focused stimuli (Hruska et al 2001; Ito & Garnsey 2004). Hruska et al (2001) showed these results for German, and Ito & Garnsey (2004) for Japanese. [PRESENT STUDY] Question/answer

prosodic mismatches involving direct/indirect objects were examined in an auditory ERP study. Target sentences involved prosodic prominence marked on either the first or second object (e.g., "Steve only gave [BORIS] [the bulldog] last week" / "Steve only gave [Boris] [the BULLDOG] last week"). In addition to these double object constructions, dative constructions were also employed, so that the direct/indirect object NPs occurred equally often in both the first and second positions in the verb phrase (e.g., "Steve only gave [the BULLDOG] to [Boris] last week" / "Steve only gave [the bulldog] to [BORIS] last week). Collapsing over the construction types, here we examine the contrast between prosodic PROMINENCE on first object (OBJ1) versus the second (OBJ2). Prominence was crossed in a 2x2 design with expected semantic FOCUS on OBJ1 versus OBJ2, determined by lead-in questions. These questions had the effect of either rendering the answer prosody felicitous (e.g., Q: "Who did Steve give the bulldog to last week?" A: "Steve only gave [BORIS] [the bulldog] last week"), or not (e.g., Q: "What did Steve give to Boris last week?" A: "Steve only gave [#BORIS] [the bulldog] last week"). Native English speaker participants (N=16) listened to these question/answer pairs and performed match/mismatch judgments after every pair. [RESULTS & DISCUSSION] Question/answer mismatch judgments following each pair demonstrated that these violations were highly salient for speakers (not a single mismatch case was incorrectly judged as a match). ERPs were examined for -100 to 800 ms epochs (-100 to 0 ms baseline) time-locked to the onset of OBJ1. The dominant response in our data was a main effect of FOCUS, with the cases where semantic focus was expected on OBJ1 showing a significant relative positivity compared to cases where OBJ2 should be focused (Focus Positive Shift – FPS; Toepel et al. 2007). Similar to previous findings (Hruska et al. 2001; Ito & Garnsey 2004), superfluous PROMINENCE on OBJ1 (when FOCUS was OBJ2) did not appear to yield a mismatch effect (in fact this condition tracked the OBJ2 prominence/focus match condition). In contrast, missing PROMINENCE on OBJ1 (i.e., where FOCUS was OBJ1) both shortened the onset latency and increased the amplitude of the FPS effect. We did not find any indication of a relative negativity connected with Focus/Prominence mismatches (contra Hruska et al.). We discuss the FPS as an integration effect arising when New information is encountered (Toepel et al. 2007). Prosodic facilitation via prominence marking of new information reduces the integration difficulty, attenuating the FPS response.

A28 Developmental changes in the perception of emotional vocalizations

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Crying and laughing sounds are the first two vocalizations that infants express to interact with their environment. These two vocalizations continue to be crucial expressions when we experience positive and negative emotional states over the lifespan. However, the way we express happiness and sadness changes across age: laughter increasing and crying reducing in frequency. Yet it is clear that how the perception of these emotional vocalizations also changes as expression changes. In our previous experiments, we found that healthy adults perceived crying and laughing sounds differently – they correctly differentiate involuntary and voluntary emotional vocalizations, but they perceive crying sounds in general less genuine than laughing sounds. In this study, we aim for investigating the perception of emotional vocalizations differs across age. These emotional vocalizations were involuntary and voluntary positive (laughter) and negative expressions (crying). The emotional sounds were rated on 5-point Likert scales for their perceived authenticity (How real you think the emotion is?), and the degree to which they perceived contagion (How much do you want to join in?). The study was conducted in the Science Museum in London, 1,847 participants were tested and 1,723 (1,010 females; 1,107 from United Kingdom) of them pass the criterion of catch trials then were further analysed. Among these participants, 318 participants are between 3 to 9 years old; 346 participants are between 10 to 17 years old; 362 participants are between 18 to 23 years old; 259 participants are between 24 to 29 years old; 399 participants are between 30-59 years old; 39 participants are between 60 to 76 years old. The results show that participants perceived involuntary emotional sounds more genuine (laughter: $R2 = 0.040$, $F(3,1719) = 24.009$, $p < 0.001$; crying: $R2 = 0.053$, $F(3,1719) = 32.035$, $p < 0.001$) and voluntary emotional sounds less genuine (laughter: $R2 = 0.133$, $F(3,1719) = 87.880$, $p < 0.001$; crying: $R2 = 0.157$, $F(3,1719) = 107.056$, $p < 0.001$) across age groups. In the results of contagion ratings, voluntary emotional sounds were perceived less contagious across age groups (laughter: $R2 = 0.188$, $F(3,1719) = 132.607$, $p < 0.001$; crying: $R2 = 0.142$, $F(3,1719) = 95.001$, $p < 0.001$); however, the perception of involuntary sounds were less affected by age differences in contagion ratings (laughter : $R2 = 0.002$, $F(3,1719) = 1.186$, $p = 0.314$; crying: $R2 = 0.010$, $F(3,1719) = 5.892$, $p = 0.001$), which may suggest that the feeling of joining in the involuntary sounds might be less affected by the social influence over the lifespan.

A29 The neural integration of pointing gesture and speech in a visual context: An fMRI study

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Pointing gestures are a fundamental part of human communication. By producing them in everyday life we directly connect our communication to entities in the world around us. Previous neuroimaging work investigating the comprehension of index-finger pointing gestures has presented the gestures in a context that lacked both a larger visual triadic context and co-occurring speech.

However, in everyday human referential communication pointing gestures often occur in a context in which one perceives not only the person pointing but also the entity she points at (the 'referent') and the speech she may concomitantly produce. It is currently unclear how in such situations input from different modalities (visual: speaker, pointing gesture, referent; auditory: speech) is integrated in the brain. Compared to the large number of studies looking at the integration of iconic gestures and speech, the lack of empirical neurocognitive research in the domain of pointing-speech integration is surprising, because comprehending and integrating our interlocutors' referential gesture and speech in a visual context is often critical to understand what they are talking about and a core feature of everyday communication. The current study therefore investigated the neural mechanisms underlying the semantic integration of manual pointing gestures with speech in a visual, triadic context. In an event-related functional magnetic resonance imaging (fMRI) study, 24 Dutch participants were presented with images of a speaker who pointed at one of two different objects as they listened to her recorded speech. We employed a mismatch paradigm, such that speech either referred to the object the speaker pointed at or to the other visible object. As such, speech and gesture were individually always correct, but there was congruence or incongruence when semantically integrated in the larger visual context. The match-mismatch comparison thus taps into the semantic integration of pointing gestures and speech. In addition, a bimodal enhancement manipulation (audiovisual match > audio-only + visual-only) was employed. A whole-brain analysis comparing the match to the mismatch condition (mismatch > match) showed increased activations in pars triangularis of the left inferior frontal gyrus (LIFG; $k = 220$ voxels; $p < 0.05$ family-wise error corrected across the whole brain). The reverse contrast did not reveal any significant cluster. The bimodal enhancement manipulation showed that bilateral auditory and visual areas and left premotor regions were involved in the concomitant perception of speech, gesture and referent. Together, these findings suggest an important role for primary areas in audiovisual binding and highlight the importance of LIFG in the semantic integration of referential gesture and speech in a triadic context. In line with previous work looking at the integration of iconic gestures and speech, the current results confirm LIFG's status as a multimodal integration site that plays a crucial role in the semantic unification of information from different modalities. This study can be informative as a starting point for studies investigating specific populations with impairments in the comprehension and integration of pointing gesture and speech and the subsequent establishment of joint attention in everyday life, as in autism spectrum disorders.

A30 Regular meter facilitates semantic integration during silent reading *Heechun Moon[1], Sonja Kotz[2,3], Cyrille Magne[1]; [1]Middle Tennessee State University, USA, [2]Max Planck Institute Leipzig, Germany, [3]University of Manchester, UK*

Speech meter (i.e., the pattern of stressed and unstressed syllables) is a prosodic property that is known to influence speech segmentation, language acquisition, and word recognition. Recent ERP studies have shown that it also interacts with semantic (Magne et al. 2007) and syntactic processing (Schmidt-Kassow & Kotz, 2009) during sentence parsing. In addition, a regular metric context seems to facilitate auditory language comprehension in both healthy adults (Rothermich, Schmidt-Kassow, Kotz, 2012) and patients with basal ganglia lesions (Kotz & Schmidt-Kassow, 2015). The present ERP study examined whether sensitivity to speech meter plays a role during silent reading, by comparing the effects of semantic expectancy in written sentences in regular or irregular metric contexts. To this end, written sentences were created, in which the fourth to last word was either semantically expected (e.g., "Richard strongly challenged Billy's written statement about the accident.") or unexpected (e.g., "Richard strongly challenged Billy's written doughnut about the accident."). The critical word was always bisyllabic and stressed on the first syllable. In addition, the metric context leading up to the critical word was either regular or irregular. Metrically regular contexts consisted of five bisyllabic words stressed on the first syllable (e.g., "RI-chard STRONG-ly CHAL-lenged BIL-ly's WRIT-ten …") while metrically irregular contexts were composed of five words with varying syllable length (1 to 3) and stress location (e.g., "JEN AN-gri-ly CHAL-lenged Na-THA-niel's FIERCE …"). EEG was recorded from 19 participants while they performed a semantic judgment task on the written sentences. Results of cluster-based permutation tests showed that semantically unexpected words elicited a more robust centro-frontal N400 effect in metrically irregular (382-900 ms, $p = 0.003$) than metrically regular contexts (340-480 ms, $p = 0.028$). In addition, semantically incongruous words presented in irregular contexts were also associated with a late increased posterior positivity (576-900ms, $p = 0.013$). The present results support the idea that information about the stress pattern of words is automatically retrieved during silent reading (Magne, Gordon, Midha, 2010), and that a regular metric context may facilitates lexico-semantic integration by providing temporal scaffolding for forming better predictions. Broader implication of these findings for reading disorders and models of reading acquisition will be discussed.

A31 Semantic integration of speech and iconic gestures: bringing the face into the picture *David Vinson[1], Pamela Perniss[2], Gabriella Vigliocco[3]; [1]University College London, [2]University of Brighton*

When understanding language in natural contexts, comprehenders rely on more information than the speech signal alone; visual cues such as head, face and body movement facilitate comprehension whether by providing additional information correlated to the acoustic

signal, or related to the meaning a speaker wishes to express. The latter include iconic gestures: hand/arm/body movements depicting a referent, such as a twisting movement accompanying the speech "Open the bottle". Behavioural studies show that comprehenders cannot avoid semantically processing iconic gestures: when gestures and speech are incongruent there is a cost even when gestures are explicitly task-irrelevant. Neurally, various studies attribute semantic integration of speech and iconic gesture to some combination of bilateral temporal regions (MTG, posterior STS) and left inferior frontal gyrus. Incongruent speech-gesture combinations have been used as essential evidence for integration, especially increased activation for incongruent > congruent comparisons in left IFG but also in pSTS. To date all the studies using incongruent speech-gesture combinations in this manner used faceless materials, using headless videos, masking or digitally altering the speaker's face to avoid incongruence between lip movements and speech. However, when comprehenders can see gestures, it is rare that they cannot also see the speaker's face, and visual cues like mouth movements contribute to speech comprehension with temporal regions heavily engaged in their integration. In the present fMRI study, we created incongruent speech-gesture combinations (verb+iconic gesture, e.g. "sawing" with the gesture TWISTING) by digitally altering congruent videos in a manner that did not obscure the face; the speaker's face was always congruent with the speech signal. We also created speech-only (still body) and gesture-only (silent, still face) videos from the same sources. 16 native English speakers viewed the videos (40 per condition) and attended to their meanings whilst monitoring for a dot probe (filler trials). We tested for speech-gesture integration by comparing conditions with combined speech and gesture (congruent/incongruent) against the other two (speech-only, gesture-only), using the "max" criterion: Combined > max(speech-only, gesture-only). Extensive bilateral temporal activations were observed including superior and middle temporal gyri (encompassing pSTS), as well as bilateral fusiform gyrus; no significant activations were found in left IFG or nearby frontal regions. Comparable results were obtained with the "mean" criterion: Combined > mean(speech-only, gesture-only). We also tested more specifically for semantic integration by directly comparing incongruent and congruent: no regions were more active for incongruent > congruent, while for congruent > incongruent there was increased activity mainly in left superior frontal and medial gyri. Overall the results underscore the importance of temporal networks, including pSTS, in combining visual information provided by gestures with the multimodal expression of speech (acoustic signals, head and face movements). The lack of activation differences in left IFG suggests that it may not be involved in semantic integration of speech and gestures per se. Findings of left IFG activation from previous similar studies may be related to the additional difficulty associated with processing speech and gestures without seeing head and face movements: the cues that naturally bring speech and vision together.

A32 Functional brain networks underlying word and gesture production

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Brain organization and evolutionary principles put forth an expectation of commonalities between language and non-language domains, such as actions (Ullman, 2004). Previous investigations of the overlap between language and action have focused on the comprehension of action words or the observation of actions (Pulvermueller, 2005), but much less attention has been placed on the overlap between the production of language and action. For this purpose, we investigated the brain activity underlying the production of words and gestures. We hypothesized that words and gestures would show large overlaps in the semantic processes necessary for the selection and retrieval of tool-action associations and specifically examined this hypothesis using functional connectivity with left posterior middle temporal gyrus (Davey et al., 2015). 12 right-handed native speakers of English (6 females; mean age = 25 years, range = 23-29) were tested on a tool-action association task. Participants were presented with a stimulus followed by a green circle cueing their response. In the experimental conditions, stimuli consisted of tool nouns (e.g., scissors) and participants were instructed to overtly produce an action verb or hand gesture semantically related to the stimulus (e.g., cut). In the control conditions, stimuli consisted of a meaningless symbol string and participants were instructed to overtly produce the same pre-trained responses, nonsense word (/gaga/) or pinching gesture. Task-related brain activity was measured following the onset of the stimulus using a Siemens 3T Trio MRI. Data were preprocessed with SPM8 and analyzed with PLS. The results show activity common to both action verb and gesture production (but not the meaningless control conditions) in a left-lateralized fronto-temporo-parietal network of areas, including inferior frontal and dorsolateral prefrontal gyri, posterior middle temporal and fusiform gyri, medial and lateral precentral gyri, as well as inferior parietal and superior temporal sulci, hippocampus, and thalamus. Functional connectivity analysis revealed a functional network related solely to gesture production and included left inferior and middle temporal as well as supramarginal gyri, and posterior hippocampus. Our results show that the neural activity underlying language and gesture production overlaps in a left-lateralized fronto-temporo-parietal network. This finding is in line with previous analyses of word production (e.g., Geranmayeh et al., 2014) but extends them by showing that the language-related network may also be engaged during gesture production. In addition, functional

connectivity analysis showed that gesturing engages a unique left-lateralized temporo-parietal network, which subserves conceptual representations of tool use.

Language Development, Plasticity, Multilingualism

A33 The neural basis of language development: Changes in lateralization over age

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Language has long been known to be lateralized to the left hemisphere (LH) in most adults (Broca, 1865; Wernicke, 1874). In addition to clinical evidence from aphasia, there are also hemispheric differences in the sizes of the planum temporale and inferior frontal gyrus (Geschwind, 1968; Falzi et al., 1982) and in auditory evoked potentials to language (Molfese, 1975). These structural and functional asymmetries are also present in infants (Molfese, 1975; Dehaene-Lambertz 2002; Witelson 1973), suggesting LH specialization for language from birth. However, clinical observations suggest a different picture: during infancy, lesions in either hemisphere are equally likely to result in abnormal language (Baser, 1962; Lenneberg, 1967; Bates & Roe 2001), suggesting that language is symmetrically distributed, with lateralization developing gradually over age. fMRI studies using a Lateralization Index (LI: difference between LH and RH activation in regions of interest) to examine this question have found lateralized activation throughout childhood. However, while these have investigated whether the degree of lateralization changes over age, most have not included an adult comparison (Holland 2001; Berl et al 2014). Also, the LI does not indicate language function in the hemispheres separately, so it is not clear whether LH and/or RH activation changes over age. The present study addresses these questions by examining patterns of fMRI activation during a language listening and decision task (sentences like 'A large gray animal is an elephant' compared to the same items played backwards, Berl et al 2014) in 39 children and 14 adults, all right-handed, ranging in age from 4 to 29. Task difficulty was roughly equalized by decreasing word frequency over age. For analysis, children were separated into three age-groups: youngest: 4-6.9yrs., n=10; middle: 7-9.9yrs., n=14; oldest: 10-12.9yrs., n=15. Adults were aged 18.4-29.1yrs. All participants performed with high accuracy. Data analysis was first performed across the whole brain to examine areas of activation in each group. Voxel-wise 'collective penetrance' indicated the percentage of subjects in each group that were reliably active (cluster-level FWE corrected; $p < 0.05$). All age-groups activated traditional LH language regions. Right-hemisphere activation was also reliably observed in inferior frontal areas for the youngest and middle groups, and in temporal areas for all three groups of children. Next, children were compared to adults by generating a Z-map for each child based on the adult mean and standard deviation (Mbwana et al 2009). Overall, children had greater activation than adults primarily in right inferior frontal and temporal areas. Children in the youngest and middle age groups had less activation than adults in the right cerebellum. Finally, we correlated activation with age across the whole brain and found that even when restricted to children alone, activity within the right Insula/IFG remained significantly correlated with age. These findings suggest that the development of lateralization for language continues throughout childhood. While LH activation to language remains stable over age, RH activation is present especially in very young children and decreases with age. Importantly, this early RH language activation may represent a mechanism for recovery following early stroke.

A34 Experience in learning new languages modulates rapid formation of cortical memory circuits for novel words

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Rapid formation for neural memory traces for novel spoken words can be indexed by an electrophysiological response increase during a short repetitive exposure to new lexical items (Shtyrov et al., J Neurosci, 2010). Moreover, this neural index of rapid word learning shows specificity to native phonology and appears to be independent of attention (Kimppa et al., Neuroimage, 2015, in press). Here, we investigate the reliance of such automatic memory-trace formation mechanism on prior individual experience of language learning. EEG responses to ten phonologically native and non-native novel word-forms were recorded, while each word was presented 150 times in pseudo-random fashion to healthy adults in either ignore or attend conditions. Dynamics of amplitude changes in brain responses to these items were quantified in both signal (ERP) and source (LORETA) space. The number of acquired non-native languages, their average age of acquisition (AoA), time since acquisition and self-reported average proficiency were entered as predictors in linear regression analyses, in order to estimate the influence of these factors on the exposure-related changes in brain activation elicited by novel word-forms. We found that AoA served as a significant predictor of response increase for novel words with native phonology: the later the average AoA was, the stronger increase for novel native words was found in the attend condition. In contrast, a composite score of the number of acquired languages and AoA significantly predicted the non-native response change in the ignore condition: the more languages the volunteers had learnt and the earlier their average AoA was, the more did the response increase for non-native novel word-forms. A trend for this was also found in the

attend condition although its significance did not survive FDR-correction for multiple comparisons The results suggest that individual language experience does have an effect on the neural mechanisms of word learning, and that it interacts with the phonological familiarity of the novel lexicon. On the one hand, later AoA of non-native languages leads to enhanced online plasticity for new L1 words, possibly reflecting better tuning of neural linguistic circuits to native phonology. On the other hand, the successful neural acquisition of words with non-native phonology benefits from larger number of previously acquired languages combined with early AoA, suggesting greater flexibility for rapid acquisition of novel lexicon with novel phonology. This result implies that the brain's readiness to develop new memory circuits for novel words of familiar or unfamiliar phonology is affected by the availability and the extent of pre-existing networks for different languages with variable phonologies. More generally, this study demonstrates that fine-grain details of lexicon acquisition in the human neocortex can be successfully studied online by using continuous ERP measures of brain activity during exposure to novel items and linking them to individual language history.

A35 Neuro-physiological adaptation to bilingual and monolingual environments begins in infancy

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Bilingual infants, as opposed to monolingual infants, must be able to perceptually and functionally discriminate their two languages, moreover they have to compute the linguistic regularities (e.g., at the phonetic, lexical, and syntactic levels) within each of their inputs. Despite such considerable differences in their linguistic experience, monolingual and bilingual infants reach the developmental milestones of language acquisition on the same schedule. What is behind the learning success of bilingual infants? One of our previous near-infrared spectroscopy (NIRS) studies demonstrated that 4-month-old Spanish-Basque bilingual infants, as compared to their monolingual peers, recruit their right hemisphere to a greater extent when processing their native language(s) (Molnar et al., 2013). In addition, we have also observed in another NIRS study that when the resting state networks of the same populations are measured, bilingual infants have more and stronger inter-hemispheric connections than monolingual infants at the same age (Molnar et al., 2014). Taken together these findings, it appears that bilingual infant brain development is characterized by greater activation level in the right hemisphere and a greater degree of inter-hemispheric synchronization as compared to monolingual development. Our general hypothesis is that the different patterns across the populations are the result of neural adaptations to the monolingual vs. bilingual environments. To further understand this phenomenon, in the current study, we measured the physiological responses of the same populations. We focused on the differences in eye-movements (e.g., micro-saccades). Micro-saccade frequency changes as a function of attentional and cognitive modulations: increased cognitive load is associated with decrease in micro-saccade production that has been linked with inhibitory processes in general (Martinez-Conde et al., 2009; Betta & Turatto, 2006; Otero-Millan et al., 2008). Saccades are also present and can be measured in young infants, and a link between saccade frequency and the attentional value of stimuli has been proposed (e.g., Aslin & Salapatek, 1975; Hainline et al., 1984). Relevant to the idea of the current project, the sampling frequency of saccadic movements and the oscillatory activity of the right hemisphere overlap at rest (4-5 Hz). Therefore, we measured the micro-saccade activity of Spanish-Basque monolingual and bilingual infants between 4 and 7 months of age in two experiments. In Experiment 1, infants were engaged in a language task that required them to produce anticipatory looks. In Experiment 2, we presented the infants with still images without any specific task (similarly to Otero-Millan et al., 2008). Our preliminary findings suggest that by 7 months of age, bilingual infants produce less micro-saccades in both experiments than monolingual infants. Also, the lower amount of saccadic activity is accompanied with longer visual fixation durations in the bilingual population. In sum, our results suggest that not only neural but also physiological adaptation to the monolingual vs. bilingual environment begins in early infancy.

A36 Functional maturation of the sentence comprehension network in children

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Introduction. A review of the last 22 years of functional MRI research suggests that activation in the receptive language network increases with age in low-level sensory cortices and higher-level semantic processing regions during childhood and adolescence, (Croft & Baldeweg 2015, revisions submitted). However, this review also highlighted several methodological limitations which make it difficult to distinguish whether these findings relate to age, task performance or effort. We aimed to overcome these limitations by investigating developmental changes in the sentence comprehension network in healthy children using a functional magnetic resonance imaging (fMRI) protocol which tightly controlled for age-related differences in task performance. Based on findings from our review, we hypothesised increasing activation in auditory processing regions as well as semantic processing regions (inferior frontal and middle temporal gyri).

Methods. Thirty four healthy children (17 females, 6-16 years, mean age=11 years, mean verbal IQ = 119, SD=13.14) underwent fMRI scanning with age-adjusted difficulty levels and pre-scan preparation, including age-appropriate information leaflets, mock scanning and pre-scan task practice. During fMRI scanning participants performed an auditory comprehension task with overt speech responses (the Listen and Name Game) and a high-level sensory-motor baseline task to control for auditory processing, word retrieval and articulation (the Alien Game). During the Listen and Name Game participants heard sentence-level descriptions of animals and objects spoken by a male and a female and were instructed to say the name of the item being described. During the Alien Game participants heard spectrally rotated versions of the item descriptions and were asked to say if the alien speaking was a boy or girl (inducing word retrieval but with minimal semantic load). By contrasting these two tasks we aimed to identify regions associated with sentence-level semantic and syntactic processing. Results. In-scanner task performance was well controlled by our age-adjusted task difficulty levels, showing no change with age ($p>0.25$). The auditory comprehension task induced activation in known auditory comprehension regions (Price, 2012; Scott & Johnsrude, 2003) including bilateral superior temporal gyrus and temporal pole, left pars orbitalis and triangularis and left anterior fusiform gyrus ($p<0.05$, FWE corrected). Within this network, linear age-related increases in activation were seen in the right insular cortex and left superior temporal gyrus, in proximity to Heschl's gyrus (small volume corrected). These changes were not related to age effects in the baseline condition. Conclusions. The most pronounced maturational changes during late childhood in the functional organisation of the receptive language network occur in auditory processing regions. In contrast, we found no robust evidence for changes in semantic processing regions when lexical demands were tightly controlled.

A37 Auditory evoked potentials to speech and nonspeech stimuli are associated with verbal skills in preschoolers

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Children's obligatory auditory event-related potentials (AERPs) to speech and nonspeech stimuli have previously been associated with reading performance in children at risk or with dyslexia and their controls (Bruder et al., 2011; Hämäläinen et al., 2013). However, very little is known of the cognitive processes these responses reflect. To investigate this question, we recorded cortical responses to semi-synthetic consonant-vowel syllables and their acoustically matched nonspeech counterparts in 63 typically developed six-year-old children, and assessed their verbal skills with an extensive set of neurocognitive tests. These tests included phonological skills, the ability to name letters and read small syllables (pre-reading skills), verbal short-term memory, rapid alternating naming of colors, numbers, letters and objects, object naming, and comprehension of instructions. All children were born full term, had no family background of neurological or psychiatric disorders, and performed at or above age-typical level in verbal and nonverbal reasoning. Our results showed that P1 and N2 amplitudes were larger for nonspeech than speech stimuli, whereas the opposite was true for N4. Furthermore, left-lateralized P1 amplitudes were associated with better phonological and pre-reading skills, the effect being stronger for speech than nonspeech stimuli. In addition, larger P1 amplitudes to nonspeech than speech stimuli were associated with poorer verbal reasoning performance. Moreover, the size and lateralization of N2 and N4 were associated with the speed of naming colors and objects. Namely, left-lateralized N2s to both stimuli, and equal-sized N4s to speech and nonspeech stimuli were associated with slower naming. In contrast, children with equal-sized N2 amplitudes at both left and right scalp locations, and larger N4s for speech than nonspeech stimuli, performed fastest. Our findings suggest that typically developing children's AERPs reflect not only neural encoding of sounds, but also sound identification, memory-trace build-up, and lexical access. Additionally, they are associated with verbal cognitive skills. Since the children whose verbal cognitive functioning was above age expectations had equal-sized P1s in the two conditions, the larger nonspeech than speech P1 might index immaturity of cortical sound identification. Moreover, left-lateralization of P1 to speech sounds was associated with better phonological and pre-reading skills, implying that P1 might reflect the strength of phonological memory traces. On the other hand, the later components N2 and N4 were associated with the rapid alternating naming task, suggesting that they are related to the speed of lexical access. Surprisingly, left-dominance of N2 was associated with slower naming, which might reflect slower activation of phonological memory traces. Larger N4 amplitudes to speech than nonspeech stimuli were associated with faster naming, suggesting that N4 reflects successful activation of memory traces for syllables, or other processes related to lexical access. The results corroborate previous findings that the speech and nonspeech sounds are processed by at least partially distinct neural substrates. Overall, our results demonstrate that AERPs are particularly useful indexes of maturation of specific auditory cortical speech functions, such as phonological encoding, verbal reasoning, and lexical access.

A38 Neural mechanisms supporting successful speech comprehension in normal aging

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Although declines in hearing ability typically occur during normal aging, many older adults retain high levels of speech comprehension ability. However, older listeners differ in their degree of success, and the reasons for this variability are unclear. In the present fMRI study we recruited a group of 39 older adult listeners (mean age=65.9 years). Participants underwent scanning while listening to sentences varying in both syntactic complexity (subject-relative vs. object-relative embedded clause) and acoustic richness (acoustically rich vs. acoustically degraded using noise vocoding). For each sentence, participants indicated the gender of the character performing the action via button press. We split the older adults into better-performing (n=19) and worse-performing groups (n=20) based on their behavioral performance. The better performing older adults show accuracy scores and reaction times comparable to those of the young adults (n=26). Hearing acuity is well matched across the two groups of older subjects, while significantly worse than that of young adults (Figure 1A). Neural activity for these groups of subjects is shown in Figure1B. The good-performing older adults show activity that is statistically indistinguishable from the young adults. By contrast, the poor-performing older adults show increased activity in frontal cortex and cerebellum compared to their good-performing counterparts. Because these patterns of activity were associated with correct responses, we conclude that these additional regions are recruited to maintain high levels of speech comprehension in the poor-performing older group (Figure 1C). Taken together, our findings demonstrate more dynamic interplay of task demands, neural recruitment, and behavioral performance during spoken language comprehension.

A39 Online build-up of neocortical memory traces for spoken words: specific facilitatory effects of novel semantic associations and articulatory programmes

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Recent breakthroughs in neurophysiological investigations of language acquisition have shown that the brain is capable of a rapid build-up of novel cortical memory traces for words on the fly, during mere perceptual exposure to new lexical items (Shtyrov et al. J Neurosci 2010, Front Psych 2011). This has been shown as an online (within minutes) increase in electrophysiological activation elicited in response to new word forms even when they have no specific meaning attached and are not attended to or rehearsed by the learners. This rapid learning mechanism is, on the one hand, automatic and, on the other hand, specific to native language phonology (Kimppa et al. NeuroImage 2015). However, the operation of this fast cortical language-learning mechanism in (a) online acquisition of word meaning and (b) in building new articulatory programmes for novel word forms has not been yet investigated. To address these two issues, we presented adult volunteers with a set of novel word forms in a word-learning task taking place during an 80-minute MEG recording session. In a counterbalanced design, novel words were either learned perceptually only through auditory exposure or had to be overtly articulated by the study participants. Orthogonally to this articulation-perception manipulation, the stimuli were either assigned a clear semantic reference through a word-picture association task, in which they were presented in conjunction with novel objects, or remained as meaningless reference-free word forms. Real familiar words were used as control stimuli. The results show that, already early-on in the training session, all novel lexical items elicited larger MEG responses than acoustically matched real word controls, presumably reflecting the online lexical search and encoding processes in the neocortex. By the end of the training session, novel stimuli learnt through semantic association in the absence of articulation demonstrated stronger activation than perceptually acquired word forms that lacked semantic reference. This result suggests a more efficient process of novel word memory trace build-up in the presence of semantic reference. This could be due to more widespread concurrent brain activations resulting in a more robust Hebbian-type associative learning ultimately creating novel memory circuits. Furthermore, the responses were stronger for those newly learned forms that involved overt articulation as compared to the non-articulated trials, similarly suggesting facilitation of the memory circuit build-up by creation of an action-perception link (cf. Pulvermuller et al. Cortex 2012). However, within the articulation condition taken separately, the responses were virtually unchanged by the presence or absence of the semantic association, suggesting that the immediate facilitatory effect of building an articulation-perception linkage is substantially more robust than that of meaning acquisition. This possibly mirrors early stages of language development when acquisition of simple phonological forms precedes semantic learning. The observed sensor-space response dynamics were strongly lateralised and originated from left perisylvian recording loci. The results confirm rapid formation of memory traces for novel words over a course of a short exposure. Furthermore, they suggest differential facilitatory effects on the neocortical memory trace formation, both by active articulation of novel words and by novel semantics acquisition.

A41 Comparing statistical learning of syllables and pure tones using NIRS

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Successful language acquisition requires learners to segment meaningful units embedded within larger structures; for example, phrases within sentences, or words within phrases. Infants and adults employ a learning mechanism that facilitates this segmentation process. This learning mechanism—termed "statistical learning"—tracks the statistical regularities that define the linguistic input in order to accurately segment speech (e.g. syllables within a word co-occur more frequently than syllables across word boundaries). While there is an abundance of behavioral evidence in support of statistical learning as a mechanism involved in language acquisition, the specific neural correlates of statistical learning remain undefined. The few neuroimaging studies that have investigated the neural activation associated with statistical learning have utilized disparate methodologies and have shown inconsistent patterns of brain activation. Furthermore, these studies were unable to obtain both temporal and spatial resolution within a subject. In this research, we utilized near-infrared spectroscopy (NIRS) to measure changes in blood oxygenation in the left temporal cortex (Broca's area) during two statistical learning tasks; a tone statistical learning task and a syllable statistical learning task. Undergraduate participants were first familiarized with the words in the artificial languages in an effort to conceptually replicate a prior study involving NIRS and tone statistical learning (Abla & Okanoya, 2008). After familiarization with the words in the artificial language, the participants heard 30 second blocks of continuous sound interspersed with 30 seconds of silence. The blocks of sounds alternated between statistically structured stimuli and unstructured stimuli. In the prior study involving only statistical learning of tone sequences, participants demonstrated increased blood oxygenation in the left temporal cortex for blocks of tones with statistical structure compared to both silence and to blocks of tones without statistical structure. Unlike the prior study, participants in the present research did not show changes in the level of blood oxygenation for blocks of structured tones compared to silence or to blocks of unstructured tones. However, participants did show decreased blood oxygenation during blocks of unstructured tones compared to silence. In the syllable statistical learning task, participants showed heightened blood oxygenation during blocks of syllables with statistical structure compared to both silence and to blocks of syllables without statistical structure. There were no differences between blocks of unstructured syllables and silence. The pattern of activation in the syllable statistical learning task was very similar to the pattern of activation recorded by Abla & Okanoya (2008) in their tone statistical learning paradigm. The results of the current research suggest that the brain activation in Broca's area that is associated with recognition—and perhaps statistical learning—may be specific (or more detectable) for speech. The failure to replicate the findings from Abla & Okanoya (2008) with the present tone statistical learning task may be associated with differences in methodology and analysis. While further investigation is necessary, these results suggest differences in the neurological underpinning of statistical learning for syllabic and tonal materials.

A42 The sound-symbolic P3 effect: how sound-symbolism affects novel word learning

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Introduction: Sound-symbolism, or the non-arbitrary link between form and meaning, has been most often investigated with non-words like bouba/kiki or maluma/takete. Such non-words, designed for maximal contrast, are open to experimenter bias and do not reflect natural language. We used ideophones, which are sound-symbolic lexical words that depict sensory imagery, are found across language families, and generally exhibit cross-modal correspondences between sound and meaning. We have previously shown that Dutch speakers with no knowledge of Japanese are sensitive to Japanese ideophones in both meaning guessing and learning tasks (Lockwood, Dingemanse, & Hagoort, submitted), and we ran this study again with EEG. There has been very little EEG research into sound-symbolism, but components identified so far are the P2, N400, and late positive complex (Asano et al., 2015; Lockwood & Tuomainen, accepted). Methods: 40 Dutch participants learned 38 Japanese ideophones; 19 with the real Dutch translations (i.e. where there was a sound-symbolic match), 19 with the opposite Dutch translations (i.e. where there was no sound-symbolic match). Participants heard the ideophone, then saw the translation. There were two learning rounds, and then a test round where participants decided whether they had learned a particular word pair or not. Afterwards, participants were informed of the manipulation and asked to select what they thought the real translation was in a two-alternative forced choice test. Continuous EEG was recorded throughout the experiment at 500Hz sampling frequency with a 64-channel headset. Epochs were calculated from the onset of the ideophones during the test round. 11 participants were discarded due to too many behavioural errors and/or EEG artefacts. Results: Behavioural: Participants were better at identifying the words they learned in the real condition (Wilcoxon test: V=17, p=0.000037). Participants correctly remembered the real word pairing 86.7% of the time, but correctly remembered the opposite word pairing only 71.3% of the time. In the 2AFC test after the experiment, participants guessed the real meanings of the Japanese words with 72.96% accuracy, which was comfortably above chance (μ= 0.5, t= 13.86, df= 28, p<0.0001). ERP: A cluster-based permutation test in Fieldtrip (Oostenveld, Fries, Maris, & Schoffelen, 2011) established a difference between real and opposite conditions across the entire averaged epoch. The average amplitude for the real condition was more positive, and this difference was driven by one cluster starting at 320ms and ending at 786ms (p=0.0027).

This cluster informed selection of time windows for traditional ANOVAs, which revealed significant main effects of condition in a delayed N280 window (320-350ms: F=4.85, df=1,28, p= 0.036), P3 window (F=14.56, df=1,28, p= 0.00069) and late positive complex window (400-786ms: F=12.21, df=1,28, p=0.0016). Conclusion: Sound-symbolism in a foreign language is detectable and affects word learning. The search for its neural correlates is ongoing, and in this paper we show that the P3 and late positivity appear heavily implicated. We argue that P3 amplitude is an index of the degree to which the sounds of a word cross-modally "match" the word's sensory meaning.

A43 Rapid changes in STG and MTG underlying automatic online build-up of novel memory traces for visually presented unattended words: MEG evidence

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Acquisition of large vocabularies is a pre-requisite for language use and efficient linguistic communication. Word learning is extremely fast in children, but it occurs also in adulthood, and, for spoken words, it has been shown to lead to changes in the brain response occurring within minutes of passive repetitive exposure to novel items (Shtyrov et al., J Neursci 2010). Neurophysiologically, this is reflected in an amplitude increase of oddball ERPs elicited by novel words with native-like phonology after mere minutes of exposure to these words and this rapid learning-related functional response re-organisation can take place automatically, regardless of the individual's focused attention on the speech input (Kimppa et al., NIMG 2015). Given that language is a multi-modal function subserved by at least the auditory and the visual systems, it seems plausible that similar rapid and automatic plastic changes in brain's activity may also underlie acquisition of written language. However, putative operation of such automatic mechanisms in visual modality for learning written words has remained unexplored to date. To address this, we used MEG and a classical oddball paradigm to probe lexical memory trace activation. We presented visually, orthographically and phonologically matched known words and novel word-forms ("pseudo-words"), displayed tachistoscopically on the visual field periphery, to adult volunteers occupied by a central non-linguistic dual colour-detection task. We then compared differences between the temporal dynamics of MEG responses to known words and novel pseudo-words throughout the ~15-minute passive exposure session. We utilised distributed source reconstruction techniques (minimum-norm current estimates) to assess cortical generators of neural activity underlying surface MEG dynamics. We found specific neural dynamics that appear to reflect automatic rapid memory trace formation for written words, previously described for spoken language only. Rapid changes of brain activity patterns as a result of exposure to unattended novel lexical stimuli manifest as early (~100 ms) bilateral enhancement of source amplitudes in the anterior part of superior temporal gyri. In contrast, exposure to familiar words led to a decrement in bilateral STG responses only, likely due to repetition-related habituation. We suggest that this activation increase for novel word-forms reflects formation of novel memory traces for newly acquired visual items, leading to more robust early activations in the anterior-temporal cortical circuits, which are formed online to encode these new lexicon entries. Furthermore, while in the beginning of the exposure session, new pseudo-words produced an increased neural activity in the posterior part of the left middle temporal gyrus at a later latency (~200 ms), possibly associated with unsuccessful processes of lexical search, this N400-like dynamic subsided over the course of exposure, possibly reflecting integration of the new items into the brain's "mental lexicon". Our results show, for the first time, the temporal dynamics of rapid and automatic build-up of neural memory traces for new visually-presented words, reflected by complex changes in early (~100-200 ms) cortical activation dynamics underpinned by sources in STG and MTG. The results suggest a common neural mechanism underpinning "fast mapping" of novel linguistic information, shared by the auditory and visual modalities.

A44 Brain and behavioral differences in speech segmentation between typically developing children and children with ASD

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Speech segmentation, or identifying syllables and words in a continuous linguistic stream, is foundational for language acquisition. Yet, the neural and cognitive mechanisms underlying this ability remain unknown. The present study investigated the neuro-cognitive mechanism of speech segmentation by comparing typically developing children to children with Autism using Magnetoencephalography (MEG) neuroimaging during a language-based statistical learning task. Typically developing children are able to utilize regularities in speech (e.g. transitional probabilities, TP) in order to detect word boundaries. Although Autism Spectrum Disorders (ASD) is characterized by delays in language acquisition, it is generally unknown whether children with ASD can take advantage of statistical regularities in naturally spoken language. Thus, in the present study we investigated learning ability and concurrent brain activation within a statistical learning paradigm in typically developing children and children with ASD. Monolingual English-speaking children with ASD (ages 8-12, n=15) and healthy controls (n=14) listened to three repetitions of a 2 minute passage in a

new language (Italian) while brain activity was measured with MEG. The passages were produced in a child-directed manner and included two target words with high (TP = 1.0; HTP) and two words with low (TP = 0.33; LTP) internal predictability between syllables. Behavioral testing at the end of the session revealed that typically developing children outperformed children with ASD on both the HTP ($t(24) = 3.00$, $p < 0.01$) and LTP ($t(26) = 4.39$, $p < 0.001$) target words. MEG measures of neural coherence and word-level event related (N400m) responses also show differences between the groups. The findings contribute new insights to better understanding of how the developing brain segments the naturalistic linguistic stream and the etiology of language impairments in ASD.

Language Disorders

A45 The dyslexia-susceptibility candidate genes Kiaa0319 and Kiaa0319-Like are not required for neuronal migration in the developing mouse cortex

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The capacity for language is a key innovation underlying the complexity of human cognition and its evolution but little is understood about the molecular and neurobiological mechanisms underlying normal or impaired linguistic ability. Developmental dyslexia is a specific impairment in reading ability despite normal intelligence, educational opportunity or major sensory defects, and it is the most common neurodevelopmental disability in school-aged children [1]. Molecular genetics studies have linked several genes to susceptibility to dyslexia and, amongst these, KIAA0319 emerges as a prime candidate based on consistently replicated associations [2], with some genetic overlap with other neurodevelopmental disorders [3]. Interestingly, the paralogous gene KIAA0319-Like is the only other member of this gene family and has also been linked to dyslexia [4]. ShRNA-mediated knockdown of the rat homologues Kiaa0319 or Kiaa0319-Like were shown to impair neuronal migration in the developing neocortex [5-8], similarly to other main dyslexia-susceptibility candidate genes [e.g. 9]. Combined with human histopathological and neuroimaging studies, these findings led to the hypothesis that dyslexia is a neuronal migration disorder [10]. To test this hypothesis and other putative function of these genes, we generated constitutive and conditional knockout mouse lines targeting the Kiaa0319 and Kiaa0319-Like loci. Immunohistochemical analyses of single and double global KO mutants using cortical layer-specific markers (Ctip2 for V-VI, Cux1 for II-IV, Ctgf for subplate) revealed no differences in lamination between mutants and wildtype control mice. In addition, acute reduction in gene expression levels via in utero electroporation to express Cre-recombinase in single and double floxed mice did not affect the position of transfected neurons during radial migration. We also found that Kiaa0319/Kiaa0319-Like KO mice did not exhibit deficits in interneuron tangential migration, neurogenesis or lamination of hippocampal or cerebellar structures. These results indicate that Kiaa0319 and Kiaa0319-Like are not required for neuronal migration in mouse cortical development, in contrast with previous reports using shRNA in rats [5-8]. This discrepancy may derive from species divergence or indicate potential methodological differences, possibly due to off target effects of shRNA [11]. We are currently investigating other putative functional roles for Kiaa0319 and Kiaa0319-Like at the anatomical, physiological and behavioural levels to uncover the neurobiological function of these genes so as to understand the mechanisms through which they may underlie susceptibility to dyslexia and associated disorders.

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A46 Dual stream model guided treatment of aphasia

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The dual stream model proposed by Hickok and Poeppel (2003, 2007) is perhaps the most influential contemporary neuroanatomical model of speech processing. The purpose of this study was to investigate if the dual stream model can be used to inform aphasia treatment by comparing outcomes. In a crossover design, each participant underwent aphasia treatment using approaches that primarily tax the dorsal and ventral streams. We hypothesized that participants who had greater damage to the dorsal stream would benefit more from dorsal stream focused treatment and participants whose damage primarily involved the ventral stream would benefit more from ventral stream focused treatment approaches. METHODS: Eleven persons (6 female; mean age = 65.3 years, range = 52-83 years) with chronic stroke-induced aphasia participated in this study. High-resolution (voxel size=1mm3) T1- and T2-MRI was used to appreciate brain damage on participant-by-participant basis. Participants were selected for study inclusion if their structural brain damage primarily involved one processing stream with relative sparing of the other stream. All participants underwent behavioral testing at baseline. To assess the effects of treatment on language processing, participants underwent testing of picture naming before and after each of the two treatment phases. Each participant received approximately sixty-five minutes of treatment daily for

two weeks using either dorsal stream treatment or ventral stream focused treatment followed by a two-week break and then another two weeks of treatment with the alternate treatment. Ueno et al. (2011) suggested that damage to the dorsal stream results in impaired phonological output and speech articulation whereas lesions affecting the ventral stream are associated with lexical-semantic errors. Accordingly, ventral stream treatment focused primarily on lexical retrieval, phonological input and semantic processing whereas dorsal stream treatment focused more on articulation and phonological output. Instead of designing new treatment tasks, the current study relied on treatment approaches that have already been tested and described in the literature. Neither approach managed to isolate processing at the level of one stream without involvement of the other though we suggest that each task used places relatively greater weight on one stream than the other. RESULTS: For the ventral group there was a significant increase in correct naming following the ventral treatment (p=.05) but not the dorsal treatment (p=.09). For the dorsal group there was a significant increase in correct naming following both treatments (dorsal p=.013, ventral p=.014), but change of greater magnitude following the dorsal treatment. CONCLUSION: We found that processing stream specific treatment improves language functioning in aphasia. We suggest that these data provide support for future research on dividing patients into groups based on damage to the two streams and using largely stream specific treatment approaches.

A48 "She will drive the _____": Verb-based prediction in individuals with Parkinson disease. *Kelsey G. Santerre[1], Angela Roberts[1], JB Orange[1], Mary Jenkins[1], J. Alexander Fraser[1], Ken McRae[1]; [1]University of Western Ontario*

Recently it has been reported that cognitive changes in Parkinson disease (PD) result in effects on language processing, including sentence comprehension impairments, word retrieval difficulties (verbs more than nouns), and discourse impairments (in production and processing). In many theories of language comprehension, efficient language processing is dependent on successful implicit prediction of upcoming concepts and syntactic structures. Such prediction processes, in part, may be regulated by the neural dopaminergic system, which is markedly impaired in PD. In non-language tasks, persons with PD are impaired in prediction, sequencing, and probabilistic learning. However, the contributions of these dopaminergic-mediated prediction and probabilistic learning processes to language processing impairments in PD remain unexplored. We tested whether persons with PD (PWPD) are impaired in implicit prediction during auditory language processing. The visual-world paradigm (VWP) was used to investigate implicit predictive eye movements based on verb meaning. PD and matched control participants listened to semantically restrictive and non-restrictive sentences (canonical, future-simple structures, e.g., "She will drive the car") while viewing four picture stimuli, arranged in quadrants on the computer screen. In the restrictive sentences, the verb fit unambiguously with one of the objects on the screen (drive - car), but not the others (e.g., hat, banana, and flashlight). In the nonrestrictive sentences (control trials) the verb plausibly fit with all of the pictured stimuli. Analyses of fixation proportions on the target picture were performed using growth curve analyses. PWPD and controls showed prediction in the time period between verb and noun onset (Intercept to Quadratic time terms: all p's < .01). The prediction effects (restrictive vs. nonrestrictive) were the same for the PD and control groups (Intercept to Quadratic time terms: all p's > .1). During this prediction time period, the PD and control fixation proportion curves overlapped substantially. Contrary to our initial hypothesis, PD participants performed equivalently to controls, a surprising finding given the existing literature. Because this was the first study to use the VWP to explore language comprehension in PD, the prediction task used was relatively simple and may not have been challenging enough to reveal linguistically-based predictive impairments in PD. Semantic plausibility was based on the verb alone, and sentences were short and syntactically simple with minimal to no demands on working memory. Additionally, visual stimuli were present. In normal conversation and reading, the language is more complex, and it often is not accompanied by relevant visual cues. Furthermore, unlike previous research on prediction impairments in PWPD, prediction was measured via unconscious eye movements, rather than explicit responses (e.g., verbal or button-presses). Therefore, follow-up studies may include constructing situations in which prediction is more complex by having it rely on multiple cues to disambiguate targets and distractors. Furthermore, ERP studies could also provide insight by measuring prediction in the absence of visual cues.

A49 Pure word deafness. A clinical, linguistic, neuroimaging and funtional case report. *Ismael Luis Calandri[1], Federico Carpani[1], José Manuel Pastor Rueda[1], María Cristina Medina[1], María Alejandra Amengual[1], Ricardo Allegri[1]; [1]Institute for Neurological Research Dr. Raúl Carrea, FLENI, Argentina*

Background: Pure word deafness (PWD), or auditory verbal agnosia is the inability to understand spoken words with preserved sound discrimination, reading, writing and speaking. It is unfrequent due to several anatomical and clinical reasons such as the complexity of the language processing network. Materials and Methods: We present a patient with sudden PWD, studied with structural MRI, DTI-based tractography (compared to 5 healthy controls), functional MRI (fMRI) with oral and written comprehension paradigms and neurolinguistic evaluation. Our aim is to describe the clinical and anatomical findings of a rare symptom close related with the functional understanding of language comprehension network. Results: A 62-years old man

with a past medical history of lung adenocarcinoma with multiple brain metastases (located in right frontal lobe, right temporal pole, left subinsular white matter, and left temporal uncus) previously treated with radiosurgery, presented with sudden deficit in speech understanding and transient partial-motor seizures of the right arm. The workup revealed a normal EEG and brain MRI showed no acute changes of known lesions. Neurolinguistic evaluation confirmed the diagnosis of PWD. DTI-based tractography was used to reconstruct language related pathways (Arcuate Fasciculus –AF-, superior longitudinal fasciculus –SLF-, uncinate fasciculus (UF) and inferior fronto-occiptal fasciculus –IFOF-) showing left SLF and right UF impairment, related to previous injuries. In fMRI no activation response was obtained during an oral comprehension paradigm, while written comprehension showed cortical activation in left superior and middle, temporal gyri and left suprangular and supramarginal gyri. Discussion: Combination of a vulnerable language network (due to previous injuries in multiple critical areas) and a reversible functional injury as epileptic discharge developed this rare symptom. The possibility of anatomical and functional assessment in acute, enables us to make a step forward in the understanding of the complexity of language comprehension.

A50 Modality-specific memory impairments in non-semantic primary progressive aphasia

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Primary progressive aphasia (PPA) is a neurodegenerative dementia involving the progressive loss of language function. Despite language deficits, individuals in the early stages of PPA retain other cognitive abilities including perception and episodic memory. Indeed, some studies have reported poor memory performance based on clinical neuropsychological tests (i.e. MMSE). However, these tests rely heavily on verbal memory and cannot alone distinguish poor language from poor memory in PPA. Episodic memory depends on both effective stimulus processing and successful binding of stimuli into a cohesive memory representation. Poor verbal memory performance could therefore be due to impairments in the stimulus processing itself. Individuals with PPA have distinct patterns of left-lateralized cortical atrophy, and the superior temporal gyrus (involved in speech processing and comprehension) is an initial target of neural degeneration in non-semantic PPA. However, the inferior temporal gyrus (involved in object processing), and the hippocampus (critical for associative binding) are relatively spared. Therefore, we hypothesize that patients with PPA will show impairments of memory related to a selective vulnerability for auditory verbal stimuli, and not visual object stimuli. To test this, patients with non-semantic PPA (n=21, mean age=66.62) and healthy age-matched controls (n=14, mean age=64.73) were given a memory paradigm using visual and auditory stimuli. Participants studied modal-specific stimuli (either object pictures, spoken words, or written words). To ensure adequate stimulus-directed attention, participants were first asked to make a perceptual judgment for each stimulus. After a 20-minute delay, participants were given an incidental yes/no recognition memory test to identify the studied targets amongst novel foils. Within each condition, responses were converted to proportions of hits (correctly identifying a studied target) and false alarms (identifying a non-studied foil as a studied target). PPA patients had lower hit rates compared to age-matched controls ($p=0.034$), but hit accuracy did not interact with stimulus type across groups ($p=0.58$). PPA patients had significantly different false alarm rates ($p=0.04$) and response times ($p=0.0012$) compared to controls, and these group effects significantly interacted with stimulus-type ($p=0.048$, $p=0.012$, respectively). This interaction was driven by a trend for higher false alarm rates ($p=0.05$) and significantly slower responses ($p=0.00025$) to spoken word stimuli compared to object-picture stimuli in PPA patients. These preliminary results suggest that processing spoken-word stimuli can hinder memory for episodic information in patients with PPA.

A51 Functional and structural connectivity following A Right-Hemisphere Stroke: An f-MRI-DTI Case Study

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Distinct clinical profiles of communication and cognitive impairments are observed after right hemisphere (RH) stroke. No anatomical correlates have yet been described, suggesting contribution of a more widespread network. Nowadays, neuroimaging techniques such as diffusion tensor imaging (DTI) or functional connectivity with resting-state (rs-fMRI) are used to study brain connectivity in stroke patients in relation with clinical manifestations. The aim of this study is to describe the role of specific networks and white matter pathways involved in executive and communicative behaviors in the RH. Four domains of communication have been assessed: lexical-semantics, prosody, pragmatic, and discourse. Furthermore, executive functions were assessed. Five RH stroke patients and two healthy controls underwent a rs-fMRI and DTI to assess the integrity of the Default Mode Network and of five white matter pathways: the uncinate fasciculus (UF), the arcuate fasciculus (AF), the inferior fronto-occipital (IFOF), the inferior (IFL) and superior longitudinal fasciculus (SLFII). §To the best of our knowledge, it is the first time that a study explores the links of such impairments in RH stroke patients. We confirm that the integrity of the default mode network is directly related to attention abilities but also with successful communication functions, more specifically with the pragmatic component. Also, integrity of UF in the RH can be related to better communicative performances.

The ventral pathway (including UF and IFOF) may be involved in higher-level semantic representations. More specifically, right inferior prefrontal cortex and IFOF are involved when the demands on executive semantic processing are particularly high. Meanwhile. SLF and AF disruption seem to be linked with prosodic impairment. Conversely, preservation of the ILF does not impede the apparition of cognitive disorders. This study highlights the fact that communicative and executive functioning after stroke can be better explained when analysing white fibre matter in addition to cortical damages. A combined analysis of grey and white matter lesion site seems more appropriate to establish proper referral and intervention guidelines in cognitive rehabilitation.

A52 Attention and Coherent, Cohesive Connected Speech in Mild Stroke *Gail A Robinson[1], Megan S Barker[1], Breanne Young[1]; [1]Neuropsychology Research Unit, School of Psychology, The University of Queensland, Brisbane, Australia*

Spoken language production theories and lesion studies highlight several important prelinguistic conceptual preparation processes involved in the production of cohesive and coherent connected speech. Broader cognitive functions such as attention may mediate these processes. Sustained and selective attention are two attentional processes recently highlighted as potential candidates integral for connected speech. The aims of this study are to investigate 1) whether stroke patients without significant aphasia exhibit impairments in cohesion and coherence in connected speech, and 2) the role of sustained and selective attention in the production of connected speech. Stroke patients (N = 18) and matched healthy controls (N = 21) completed two self-generated narrative tasks designed to elicit connected speech. The tasks comprised the retelling of a fairy tale from memory and discussion of a topic chosen by participants. A multi-level analysis of within and between-sentence processing ability was conducted on speech samples. The results revealed impairments in cohesion and coherence of connected speech for the stroke group relative to controls. For stroke patients, production of coherent connected speech at the global level, that is fewer propositional repetitions, was related to better performance on selective and sustained attention tasks. Selective attention performance also negatively correlated with global coherence errors. Sub-group analyses showed that for right hemisphere stroke patients, cohesive speech was associated with increased selective attention while coherent speech was related to increased sustained attention. Thus, connected speech deficits were revealed in a heterogeneous stroke group without prominent aphasia. Furthermore, broader cognitive processes, such as sustained and selective attention, appear to play a role in producing connected speech at the early formulator or conceptual preparation stage.

A53 Anatomical connectivity and communication impairments in moderate to severe traumatic brain injury *Marie-Pier Mc Sween[1], Pamela F. Ross[1,2], Maxime Descôteaux[4], Caroline Arbour[2], Nadia Gosselin[2,3], Karine Marcotte[1,2]; [1]School of Speech Language Pathology and Audiology, University of Montreal, Montreal, Canada, [2]Research Center at Sacré-Coeur Hospital of Montreal, Montreal, Canada, [3]Department of Psychology, University of Montreal, Montreal, Canada, [4]Sherbrooke Connectivity Imaging Lab, University of Sherbrooke, Sherbrooke, Canada*

BACKGROUND Patients who suffered from a moderate to severe traumatic brain injury (TBI) often present significant long-term cognitive impairments in multiple domains including communication skills. Diffusion tensor imaging (DTI) has been proven effective at locating lesions in the white matter. Although there is an increasing literature in the use of DTI in TBI, there are no studies as of today who approached the communication impairments in relation to the white matter changes in adults presenting a moderate to severe TBI in the chronic phase. Thus, the main aim of the present study is to characterize the chronic changes in white matter fiber bundles and associated with cognitive-communication impairments in a group of TBI patients as compared with healthy controls. METHODS Seventeen moderate to severe TBI patients and seventeen matched healthy controls participated in this study. TBI patients were tested at least one year post-TBI. Cognitive-communicative skills were evaluated using the Protocole Montreal Evaluation de la Communication 1 and the LaTrobe questionnaire 2. DTI was acquired on a 3T Siemens Trio scanner using the following parameters: eight-channel coil, 65 noncollinear directions with a b=1000 and one unweighted image (TR=9500 ms, TE=93 ms, 120 X 120 matrix, 240 mm FOV, 2 mm slice thickness). Diffusion tensor estimation and corresponding fractional anisotropy (FA) map generation were done using MRtrix33. Fiber orientation distribution function was computed using the spherical deconvolution of the single fiber response. Then, we used a whole brain DTI tractography algorithm that was randomly seeded in a FA mask 3. Based on the FreeSurfer parcellation, the Tract-Querier 4, a novel open-source tool, was used to extract fiber bundles known for their role in language processing, i.e. the inferior longitudinal fasciculus, arcuate fasciculus and uncinate bilaterally, as well as the genu and the splenium, which have been reported as being damaged in TBI. For now, the analysis focused on the fiber count and the mean length of each bundle and correlated with the communication measures in TBI patients. RESULTS TBI patients present chronic cognitive-communication impairments, most importantly in conversational skills and indirect language interpretation. Mean length of the right uncinate was significantly smaller in the TBI group when compared with the control group uncinate (p=0.015). Unexpectedly, the mean length of the fibers in the right uncinate was negatively correlated with the conversational

standardized scores (Spearman correlation: r=-0,645; p=0,32). CONCLUSION These preliminary results suggest that probabilistic tractography provides evidence that structural compromise is still observed in chronic moderate to severe TBI patients. Furthermore, these results provide evidence that structural compromise to the right uncinate might be associated with conversational impairments in TBIs. Thus, these preliminary findings suggest that other diffusion scalars, such as the number of fiber orientations, might eventually be a good predictor of communication impairments in moderate to severe TBI. 1. Joanette, Y., et al. 2004, Isbergues, France: Ortho Édition. 2. Douglas, J.M., et al. Aphasiology, 2000. 14(3): p.251-268. 3. Tournier, J.-D., et al. Int. J. Imaging Syst. Technol., 2012. 22: p.53–66. 4. Wassermann, D., et al. in MICCAI. 2013.

A54 Hyper-synchronization of brain activity in ASD during face-to-face conversation *Kyle Jasmin[1,2], Stephen J. Gotts[1], Yisheng Xu[3], Siyuan Liu[3], Cameron Riddell[1], John Ingeholm[1], Allen R. Braun[3], Alex Martin[1]; [1]NIMH, NIH, [2]ICN, UCL, [3]NINDS, NIH*

People with autism spectrum disorders (ASD) find face-to-face communication difficult. While previous neuroimaging studies have examined brain function in ASD during task and rest conditions and found abnormal differences in sensory, motor, social, and language networks, little is known about the function of these networks in an on-line, naturalistic conversation task. Here, we scanned 19 high-functioning autistics and 20 matched controls with fMRI while they conversed with an experimenter about their interests, hobbies, work and school life. Microphones, headsets and cameras were used to support face-to-face interaction. Using an unbiased, data-drive approach we found that the ASD participants showed greater whole-brain synchronization (timeseries co-variation) than the typically developed (TD) participants (voxelwise P<.05, cluster corrected). Additional analyses isolated 24 "hyper-synchronized" regions during face-to-face communication in the ASD, relative to the TD subjects (no regions showed the reversed pattern). K-means and multi-dimensional scaling were used to identifiy regions showing similar patterns of correlation. Three "networks" were identified composed of 1) right hemisphere perisylvian regions, 2) cortical motor and somatosensory regions, and 3) visual, cerebellar and limbic regions. Tests for group differences in correlations (ASD>TD) between all 24 regions revealed that most of the hyper-synchronization occurred within Network 2, and between Networks 2 and 3 (P<.05, two-tailed, Bonferroni corrected). . Our results suggest that ASD brains may be less differentiated or functionally specialized than TD brains and that abnormal sensorimotor processing may relate to the difficulties ASDs have with face-to-face conversation.

A55 Quantifiers in speech production in corticobasal syndrome and behavioral variant frontotemporal dementia *Sharon Ash[1], Kylie Ternes[1], Christopher Olm[1], Teagan Bisbing[1], Nam Eun Min[1], Eileen Moran[1], Collin York[1], Corey T. McMillan[1], Murray Grossman[1]; [1]Perelman School of Medicine at the University of Pennsylvania*

Background: A characteristic feature of patients with corticobasal syndrome (CBS) is difficulty in performing simple arithmetic operations, such as adding two single-digit numbers. Previous studies have found that the deterioration of number knowledge in these non-aphasic patients is correlated with an impairment in their comprehension of quantifiers, a type of determiner, and that this deficit appears to be related to posterior temporal-parietal cortical atrophy. Non-aphasic individuals with a behavioral variant of frontotemporal dementia (bvFTD) have also been found to be impaired in the comprehension of quantifiers, and this deficit appears to be related to atrophy in frontal regions. In contrast, patients with the semantic variant of primary progressive aphasia (svPPA) have intact number knowledge but impaired comprehension of object concepts. Studies of quantifier expression in speech by these subjects are lacking, despite the frequency of these words in everyday use. The objectives of the present study were to assess the production of quantifiers in spontaneous speech by these groups of patients and to identify their neuroanatomical correlates. Methods: We studied 31 CBS patients, 52 bvFTD patients, 23 svPPA patients, and 21 healthy seniors. The participants produced a speech sample of 60 to 90 sec describing the Cookie Theft picture from the Boston Diagnostic Aphasia Examination. The descriptions were digitally recorded, transcribed, and coded for features of fluency, grammatical sufficiency, and the frequencies of object nouns and quantifiers. Structural MRI scans that were available for a subset of patients were analyzed for cortical atrophy and correlations of atrophy with performance on language measures. Results: Non-aphasic CBS and bvFTD patients were impaired relative to svPPA and controls in the production of quantifiers per 100 words, while svPPA patients did not differ from controls on this measure. In contrast, svPPA patients were impaired in the production of object nouns per 100 words relative to controls, CBS, and bvFTD, who did not differ from each other on this measure. CBS patients exhibited a correlation of quantifier production with cortical atrophy in left inferior parietal regions, while bvFTD patients exhibited a correlation of quantifier production with cortical atrophy in bilateral dorsolateral prefrontal and inferior frontal regions. svPPA patients exhibited a correlation of noun production with cortical atrophy in areas including left inferior lateral temporal cortex. Discussion/Conclusions: This study found a double dissociation in the production of object nouns and quantifiers in spontaneous speech by CBS and bvFTD patients in contrast to svPPA patients: CBS and bvFTD patients were impaired in the production of quantifiers but not nouns, while svPPA patients were impaired in the production of nouns but not quantifiers. Consistent with results of studies of the comprehension of quantifiers in

CBS and bvFTD, we found evidence that a frontal-parietal network is critical for quantifier production in connected speech. This conclusion is supported by the contrasting evidence of svPPA patients, whose deficit in the production of object nouns in spontaneous speech corresponded to cortical atrophy in left inferior temporal regions that are important for object comprehension.

A56 Brain Regions Mediating Recovery of Word Reading in Phonological Aphasia: An Event-Related fMRI Study

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Damage to the perisylvian phonologic system is common in aphasia and can cause severe deficits on oral reading and naming tasks, yet most patients with damage to this system recover the ability to read at least some words. Neuroimaging studies show a variety of brain activity changes in in people with chronic aphasia, but whether these changes truly support successful performance or reflect increased task difficulty is not clear. The variable success observed in people with aphasia on overt reading tasks makes it possible to examine separately the neural responses associated with correct and incorrect responses, using event-related fMRI. By integrating neurophysiological and concurrent behavioral data, a direct comparison between brain states was made to identify areas that specifically support successful performance. Participants included 21 chronic left hemisphere ischemic stroke patients (10 women) with an isolated phonologic retrieval deficit (impaired rhyme matching with intact semantic matching on forced-choice matching tasks). All patients were at least 180 days post-stroke, native English speakers, and pre-morbidly right-handed. The fMRI task required participants to read aloud 72 concrete nouns. Stimuli were separated by a variable inter-stimulus interval. Responses were recorded using an MRI-compatible active noise-cancelling microphone and scored off-line. Anatomical and functional images were morphed to a stereotaxic template using a nonlinear constrained cost-function incorporating the lesion as a mask. Correct and incorrect trials were identified in each patient and used as regressors of interest in a deconvolution analysis. The Correct – Incorrect contrast images were then used in a second-level group analysis, thresholded at voxel-wise $p < .01$, and cluster corrected to $p < .05$. An index of each patient's phonological impairment severity was included as a covariate in the group analysis to improve detection by accounting for between-subject variability. Mean accuracy on the reading task was 76% (SD = 20). Successful word reading was associated with activation (relative to incorrect responses) in the left angular gyrus. In contrast, activation in bilateral posterior inferior frontal cortex (pars opercularis and precentral gyrus) and supplementary motor area was greater for incorrect word trials. These data show for the first time the brain regions where neural activity is correlated specifically with successful phonological retrieval in chronic aphasia. The angular gyrus has been linked with semantic processing in healthy controls (Binder et al., 2009, Cereb Cortex). This suggests that additional recruitment of the semantic system contributes to successful word production when the phonological retrieval mechanism is damaged. Greater activation of posterior inferior frontal cortex and SMA during incorrect trials may reflect secondary engagement of attention, working memory, and error monitoring processes when phonological retrieval is unsuccessful. Supported by NIH grants: R01 NS033576, R01 DC003681, R03 NS054958 and AHA grant 13PRE16510003

Methods

A57 A Random Forests analysis of the relationship between reading-related skills and white matter tractography

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Introduction: Random Forest analysis is a popular machine learning method which can determine the relative importance of predictors for a dependent variable (Strobl et al., 2009). It is particularly helpful for addressing issues of model overfitting and collinearity among measures (Matsuki, et al., in press). We applied this method to explore which measures from an extensive battery of linguistic and cognitive skill assessments are the best predictors of key indices of reading- and language-relevant white matter tracts. Method: Diffusion-weighted images were acquired from 74 adults, aged (16-25, M=21; 35 Females) on a 3T scanner. Adults were recruited as part of a community-based sample in New Haven, CT (USA). Images were processed using Freesurfer's TRACULA probabilistic tractography method (Yendiki et al., 2011). Analyses focused on left and right homologues of the arcuate fasciculus (AF), the parietal portion of the superior longitudinal fasciculus (SLFp), the uncinate fasciculus (UF), and the inferior longitudinal fasciculus (ILF), as well as the corpus callosum (CC) major and minor tracts (10 tracts in total). Prior to scanning, all participants were tested on a battery of 29 standardized neuropsychological assessments. These were combined into the following 15 composite measures: Complex Memory Span (WM), Spatial Memory (SPACE), Inhibition (INHIB), Reading Experience (READEXP), Reading Comprehension(READCOMP), IQ (IQ), Vocabulary (VOCAB), Word Reading (WORDREAD), Non-word Reading (NWREAD), Fluency (FLUENCY), Oral Comprehension (ORALCOMP), Syntactic ability (SYNTAX), Phonological Awareness (PHONOAWARE), Phonological Memory (PHONOMEM), and Rapid Naming (RAN). These 15 predictors were submitted to a Random Forests analysis of four dependent measures for each tract: fractional anisotropy (FA), mean diffusivity (MD), tract volume, and average pathway length. Results: The number of variables passing the importance threshold and

their relative ranking was determined using standard best practice methods within the Random Forest literature. Variables are listed in order of importance; negative associations are in lower case, positive in upper case. (Due to space and formatting limitations, we report only FA and MD here.) FA: Left AF: syntax, RAN, readcomp; Right AF: READCOMP, INHIB, SYNTAX; Left SLFp: INHIB; Right SLFp: READCOMP, fluency; Left UF: syntax, PHONOAWARE; Right UF: none; Left ILF: READCOMP, IQ; Right ILF: INHIB, ORALCOMP, NWREAD; CC major: ran; CC minor: space, inhib, syntax MD: Left AF: syntax, wordread; Right AF: wordread, iq, readcomp, nwread, vocab, readexp; Left SLFp: wordread; Right SLFp: wordread, vocab, readcomp; Left UF: none; Right UF: none; Left ILF: readexp, readcomp; Right ILF: SYNTAX, READEXP, ORALCOMP; CC major: ran; CC minor: syntax, phonomem, wm; Conclusion: Results are discussed in relation to previous findings regarding functional relationships between white-matter indices and reading and language processes (e.g., Ben-Shachar et al., 2007; Friederici & Gierhan, 2013; Horowitz-Kraus et al., 2015; Yeatman et al., 2012). Consistencies were found, especially in relation to SYNTAX, READCOMP, WORDREAD and NWREAD, attesting to the robustness of the Random Forest method in this application. Novel associations suggest new areas for research into possibly overlooked functional relationships and contribute to theorizing about functional connectivity within the brain.

Lexical Semantics

A58 Semantic predictions during sentences processing: A Readiness Potential (RP) study

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Recent approaches of semantic and conceptual "grounding" emphasize the possible links connecting perceptual and motor knowledge with the concepts and words that relate to such knowledge (Barsalou, 2008). In the field of electrophysiology (M/EEG) researchers have focused their attention on early latency motor responses (within 200 ms from word recognition point) which index semantic processing, demonstrating their automatic, unconscious activation of long-term memory trace for words (Pulvermüller, et al. 2014). Although word-induced motor activations have thus far always been reported after word recognition, action-induced motor activations have been shown to start much earlier. Indeed, half a century of Readiness Potential (RP) research has shown that the most interesting and prominent motor activations associated with action executions happen before - and not after - the movement onset (Kornhuber and Deecke, 1965). Here, we sought to determine whether a reliable RP would therefore also be present, although it has yet been investigated, when processing predictable sentence-final action words in a sentence context. To this end, Affirmative High Predictable (AHP) sentences were built with the intent to have face- or hand-related words as the expected ending of each sentence (e.g. "I go to the blackboard and I write"). Any effects that the predictability variable could play was assessed by means of Negative Low Predictable (NLP) sentences, where the negation, always placed at the beginning of the phrase, reduced the predictability of the sentence-final action words (e.g. "I do not go to the blackboard and I write"). Furthermore, in order to test the effects that the negation may have on the RP, we presented the Negative High Predictable (NHP) condition, in which the negation did not affect the sentence cloze probability (e.g. "I go to the blackboard but I do not write"). Predictable contexts (AHP and NHP) produced negative deflections before the onset of final action-related words. These anticipatory signals were coherent with the RP profile in terms of both latency and scalp distribution. A strong modulation depending on the final word predictability was also observed, where the NLP showed no deflection before word onset. Finally, source estimations revealed in both predictable contexts a somatotopic effect, with hand motor area being more active for hand-related word predictions, and stronger activations in proximity of face motor regions for face-related word predictions. Our results strongly support action semantics and for the first time reveal solid evidence that semantic processing may indeed start before the perception, or even the utterance, of predictable action words. • Barsalou, L. W. (2008). Grounded cognition. Annu Rev Psychol, 59, 617-645. • Pulvermüller, F., Moseley, R., Egorova, N., Shebani, Z., & Boulenger, V. (2014). Motor cognition - motor semantics: Action-perception theory of cognitive and communicative cortical function. Neuropsychologia, 55, 71-84. • Kornhuber, H. H., & Deecke, L. (1965). Hirnpotentialanderungen bei Willkurbewegungen und passiven Bewegungen den Menschen: Bereitschaftspotential und reafferente Potentiale. Pflugers Archiv fur die gesamte Physiologie des Menschen und der Tiere, 284, 1–17.

A59 From sound to meaning: Neural dynamics of lexical access to conceptual representations

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How do we access meaning through speech? Understanding the meaning of a concept requires co-activation of concept's features within a distributed semantic network. The distributed cohort model (DCM, Marslen-Wilson, 1987) of speech comprehension proposes that candidate lexical representations are activated in parallel as the speech unfolds. Parallel activation of candidate representations creates transient competition until the point in the spoken word where the word is uniquely identified (uniqueness point, UP). The model predicts that following the UP the partial activation of the

target word's representation is boosted and conceptual representations are accessed. Here we test this model by looking at how form-based representations activated by speech evolve into semantic representations following phonological and semantic competition. We adopt a distributed feature-based model of semantics, the Conceptual Structure Account (CSA; Tyler & Moss, 2001) and the DCM. We (1) investigate the spatiotemporal dynamics of phonological and semantic competition as the speech unfolds; (2) ask whether the UP marks a transition between competition and the activation of target word's semantic representation; and (3) ask whether the target word's semantic representation will prime its neighbours through spreading activation. We collected magnetoencephalography (MEG) data while fourteen participants listened to spoken words and performed a lexical decision task. Each of the 296 spoken words denoted a concrete concept (e.g. hammer, donkey). To define and segregate distinct spatiotemporal signatures associated with key cognitive processes that take place during spoken language comprehension, an innovative multivariate pattern analysis method called the spatiotemporal searchlight representational similarity analysis (ssRSA) was performed (Su, Fonteneau, Marslen-Wilson, & Kriegeskorte, 2012). ssRSA uncovers the representational geometry of specific oscillatory MEG signatures diffused over both cortical networks and time, and relates them to the representational geometry of theoretical models of cognition. Using ssRSA we tested four theoretical models that captured cohort competition, semantic competition, access to unique conceptual representations and shared category-level features. The ssRSA revealed early parallel activity in the L inferior frontal gyrus (LIFG) for models of phonological and semantic competition prior to the UP, supporting the view that LIFG resolves both phonological and semantic competition by selecting the target representation among competing alternatives (Moss et al., 2005; Novick et al., 2005). Resolution of both types of competition involved co-activation of LIFG aditionally with L supramarginal and L superior temporal gyri for phonological, and with the L angular gyrus (LAG) for semantic competition model. After the UP we found rapid access to unique conceptual features involving in LAG and R inferior frontal gyrus. Overall, results show that when conceptual representations are accessed through speech, concepts that match the auditory input will initially be partially activated. As soon as the pool of candidate concepts is narrowed down to a single concept, the unique conceptual features of that concept alone are rapidly accessed.

A60 When a hit sounds like a kiss: an electrophysiological exploration of semantic processing in visual narrative *Mirella Manfredi[1], Neil Cohn[2], Marta Kutas[2]; [1]Cognitive Neuroscience Laboratory and Developmental Disorders Program, Center for Health and Biological Sciences, Mackenzie Presbyterian University, Sao Paulo, Brazil, [2]Kutas Cognitive Electrophysiology Lab, Department of Cognitive Science, University of California, San Diego, CA, USA*

We investigated the cross-modal processing of written language embedded in visual narratives (e.g., comics). In comics, audiovisual information is often presented visually by means of written onomatopoeia. The onomatopoeia often is positioned within an "action star," a conventionalized star shaped "visual flash" that indicates the culmination of an event. We thus used action stars to introduce different types of written information (word, onomatopoeia) from which inferences about the ongoing event could be drawn. In Experiment 1, we investigated whether (inferential) processing would vary based on the semantic congruity of the action star content with the narrative sequence. In Experiment 2, we contrasted the processing of the action star content when it was a lexico-semantic congruity versus an onomatopoetic-semantic congruity. In both experiments, we presented 100 Peanuts comic strips minus words to 28 University students. In Experiment 1, we recorded ERPs to the critical panel which had been replaced by an action star containing: (1) an onomatopoeic word (e.g., pow!) congruent with the context, (2) a word (e.g., hit!) describing an unseen action also congruent with the context, (2) an onomatopoeic word (e.g., smooch!) anomalous in the context, and a so-called "Grawlix" containing a string of symbols (e.g., @$*%?!) that could be construed as a swear word. In Experiment 2 the Grawlix condition was replaced by with a word (e.g. kiss!), describing an action anomalous in the context. In Experiment 1, all but the Grawlix panel elicited a large N400, larger to Anomalous onomatopoeia and congruent Descriptive words and smallest to the congruent Onomatopoeic word, suggesting that the Onomatopoea was easier to interpret. In addition, we observed a greater fronto-central late positivity in response to the Descriptive panels, suggesting continued processing of the word and its relation to the visual narrative and maybe indicating that this class of words could be considered plausible but low probability lexical items in comics. This is consistent with corpus data showing that far fewer descriptive actions word appear than onomatopoeia in comics. Experiment 2 revealed a remarkably similar congruity (N400) effect for the lexical and onomatopoeia stimuli, suggesting the same semantic-level processes are engaged as they are processed in the ongoing visual narrative, albeit with a slightly earlier onset for non-onomatopoeic words over occipital sites. Both the congruent and anomalous Descriptive panels elicited a small fronto-central LP compared to the onomatopoeic panels. These results suggested that the fronto-central positivity might reflect a response to a low probability lexical item related to the category of the word (i.e., onomatopoeia vs. descriptive) given the context of comic strips, regardless its semantic appropriateness.

Taken together, Experiments 1 and 2 reveal relatively rapid integration of both written words and onomatopoetic "audiovisual" action information into a visual narrative.

A61 On the screen, in the mind: An ERP investigation into the interaction between visuospatial information and spatial language during on-line processing *Emily Zane[1,3], Valerie Shafer[1], Sandeep Prasada[1,3]; [1]CUNY Graduate Center, [2]Hunter College, [3]Emerson College*

The visual world involves infinite possible spatial configurations between objects; however, the set of terms used to describe these configurations is limited. This disparity requires that complex visual information be translated into a finite set of spatial primitives, and vice versa- a set of spatial primitives must be applied to a complex visual world. While the neural mechanisms involved in this translation process are not yet understood, previous neurophysiological research has found that the processing of spatial language and the processing of visual-spatial information activate overlapping regions in the brain. This project builds on previous research by exploring neurophysiological responses to spatial phrases involving three-dimensional, real-world objects after the presentation of various photographs of these objects. Event-related potentials (ERPs) were used to examine neural correlates of processing spatial phrases headed by "in" or "on" and non-spatial phrases headed by "and" ("in/on the plate", "and the plate"). ERPs were recorded from 28 adult participants using a 128-channel Geodesic net, as they performed a simple recall task. Different photographic versions of the objects in the phrases (e.g., a photograph of plate) were presented for 500ms before each phrase. In the photographs, objects were depicted in a way that was more appropriate for "in" (a concave plate) or more appropriate for "on" (a flat plate). Nouns whose characteristics did not match the preceding preposition ("plate" in "in the plate") yielded a relatively large centro-parietal negativity, consistent with the N400. This result suggests that prepositions create semantic predictions, so that reading the word "in" primes the word "bowl" more than it does "plate", and vice versa for "on". A larger frontal negativity resulted when nouns followed spatially mismatching pictures (a flat plate before "in the plate") as compared to spatially matching pictures (a concave plate before "in the plate"). The difference in scalp topography of the negativity between this picture-noun mismatch and the one to the preposition-noun mismatch suggests that there are distinct neural processes contributing to these responses. Spatial phrases elicited a late sustained, negativity over lateral occipital sites. This pattern is similar to ERPs reported during non-linguistic spatial reasoning tasks, suggesting that similar mechanisms are involved. This occipital negativity increased in amplitude and expanded to parietal regions for phrases following spatially matching pictures compared to spatial mismatches. This pattern may reflect integration of visual information with linguistic information when they concord spatially. Furthermore, after spatially matching pictures, nouns predicted by the preposition ("on the plate") yielded a bilateral parieto-occipital negativity peaking earlier, while nouns that were less predictable ("in the plate") elicited a left-lateralized occipital negativity peaking later. This result suggests that visual information is integrated earlier when linguistic information is expected based on phrasal context and later when it is unexpected. Differences in topography suggest that underlying neural processes involved in integrating visual information with online sentence processing differ when a noun is predicted by linguistic context. Overall, results reveal a complex and multifaceted interaction between phrasal expectations and visual priming during the processing of natural spatial language about real-world objects.

A62 Presentation Modality shapes the imageability effect on N400 *Chih-Ting Chang[1], Chia-Ju Chou[1], Chia-Ying Lee[1,2,3]; [1]Institute of Neuroscience, National Yang-Ming University, Taipei, Taiwan, [2]Institute of Linguistics, Academia Sinica, Taipei, Taiwan, [3]Institute of Cognitive Neuroscience, National Central University, Taipei, Taiwan*

The aim of the present experiment was to examine whether the imageability effect on N400 would be modulated by the presented modality (e.g. auditory versus visual presentation). The dual-coding theory (Paivio, 1991) proposes that the human mind operates with two distinct classes of mental representation (or "codes"), verbal representations and visual imagery. Studies have suggested that the memory of the stimuli is enhanced if it is coded in both ways than it was only coded in one way. Recent studies on multimedia learning also demonstrated that the efficiency of imagery-based learning could be different according to the modality of presentation (written presentation versus oral presentation) (Rao et al., 1996; Beni & Moe, 2003). The effective of imagery-based strategy was mainly found in oral presentation, but not in written presentation. Imagery is a process that consumes mental resources and therefore can compete with other visual task, such as reading. When the resources that are used in process imagery are the same as those used in reading, the selective inference between imagery and reading was expect to undermine learning performance. This study reexamines these phenomena by using imageability effect on N400 as a marker and to see if presentation modality would shape the effect. The imageability (high versus low) and word frequency (high versus low) of the target words were manipulated in a two-by-two factorial design. Participants were asked to perform a semantic category judgment. The same set of stimuli was presented in visual or auditory modalities in two separate experiments. Participants would only attend one of the experiments. Results from both modalities showed the typical frequency effect on N400, in which the low frequency words elicited a greater N400 than the high frequency words did in central to posterior cites. In addition, we found a significant interaction between modality and imageability. The

imageability effect revealed that the high imageability words elicited a greater N400 than the low imageability words did with frontal-to-central distribution. However, this effect was mainly evident in the auditory modality, but not in the visual modality. These findings supported that, in compared with listening, reading word may occupied the same mental resources for imagery process and thus reduced the imageability effect on N400.

A63 Cumulative effects of prior knowledge and semantic coherence during speech perception: an fMRI study

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Semantic coherence and prior knowledge enhance perceptual clarity of degraded speech. Recent study by our team has shown that these two effects interact such that the perceptual clarity of noise-vocoded speech (NVS) is still enhanced by semantic coherence when prior knowledge is available from text cues and prior knowledge enhances perceptual clarity of NVS even when semantic coherence is low (Signoret et al., 2015). Here, we investigated the neural correlates of this interaction. We predicted 1) an effect of matching cues for both sentences with high and low semantic coherence in left-lateralized perisylvian areas (Zekveld et al., 2012) and right superior temporal gyrus (Wild et al., 2012), but stronger for low than for high coherent sentences since more resources are required to process sentences with low semantic coherence in the left inferior frontal gyrus (Obleser and Kotz, 2010) and 2) an effect of semantic coherence in temporal and inferior frontal cortex (Lau et al., 2008). The additive effect of semantic coherence when matching cues were provided should be observed in the angular gyrus (Obleser and Kotz, 2010). Twenty participants (age; M=25.14, SD=5.01) listened to sentences and performed an unrelated attentional task during sparse-imaging fMRI. The sentences had high or low semantic coherence, and were either clear, degraded (6-band NV) or unintelligible (1-band NV). Each spoken word was preceded (200 ms) by either a matching cue or a consonant string. Preliminary results revealed significant main effects of Cue ($F(1,228) = 21.26$; $p < .05$ FWE) in the left precentral gyrus, the left inferior frontal gyrus and the left middle temporal gyrus confirming the results of Zekveld et al (2012), but neither the main effect of Coherence nor the interaction between Cue and Coherence survived FWE correction. In accordance with our predictions, contrasts revealed a greater effect of matching cues for low than for high coherent sentences ($t(19) = 6.25$; $p < .05$ FWE) in the left superior temporal gyrus as well as left inferior frontal gyrus (BA 44 and 45), suggesting greater involvement of both top-down and bottom-up processing mechanisms during integration of prior knowledge with the auditory signal when sentence coherence is lower. There was a marginally greater effect of semantic coherence ($t(19) = 3.58$; $p < .001$unc) even when matching cues were provided in the left angular gyrus, the left middle frontal gyrus and the right superior frontal gyrus, suggesting greater involvement of top-down activation of semantic concepts, executive processes and the phonological store during integration of prior knowledge with the auditory signal when the semantic content of the speech is more readily available.

A64 Neural correlates of visual emotion word processing

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How we process written emotion words is an important issue for word recognition as well as affective neuroscience. Emotion words can be described as having high arousal values and either positive (e.g., "smile," "trust") or negative (e.g., "blood," "wrong") valence. Previous research has mainly utilised ERPs (event-related potentials) to investigate the neural basis of this processing. Here, we present data from a delayed-response lexical decision paradigm that was designed for the analysis of oscillatory activity associated with visual word processing. Participants were presented with 270 words and 270 length-matched nonwords while their EEG was recorded. Words were emotionally positive, negative, or neutral. Time-frequency analyses were performed on the data. When comparing words with nonwords, preliminary analyses yielded power changes in distinctive frequency bands mainly over fronto-central sites and over the right hemisphere. In the low theta band (2-4 Hz), words elicited an early (i.e., ~400 ms) increase in power. In the alpha band (10-12 Hz), words elicited a late (i.e., ~700 ms) decrease in power. The theta power enhancement seemed to be particularly pronounced for negative words. Alpha suppression following word presentation has been linked to the neural 'gating' of lexical integration, whereas theta enhancement might be linked to more emotion-specific processes. Our results point towards dissociable processes, indexed by brain oscillations in different power bands and time ranges, in the recognition of written emotion words.

A65 Emotion in word processing – from neurolinguistic to social significance

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Both language and emotion have intrinsically communicative functions but they differ in their evolutionary age, iconicity and elaborateness. Emotion has been often neglected in neurolinguistic studies, although classic cross-cultural studies using the semantic differential technique have identified three simple fundamental dimensions of word meaning, namely

evaluation, activation, and potency. These are remarkably similar to dimensions that have been suggested as constitutive for emotional processing (valence, arousal, and dominance). In emotion research, behavioral and physiological correlates of these dimensions have been identified during responding to environmental stimuli such as picture or sound media. The present talk will focus on neurophysiological effects of emotional content in single word processing. It will give an overview of electroencephalographic studies from our group that address how the processing of words with emotionally relevant contents differs from the processing of neutral words under various experimental conditions. Firstly, I will demonstrate the basic finding that that during reading, emotional words induce a larger early posterior negativity (EPN) between 200 and 300 ms after word onset, particularly over the left hemisphere. This component is sometimes followed by a larger late parietal positivity around 500 ms. Secondly, I will address the issue of processing speed, revealing that emotional words are processed faster than neutral words, which is reflected both in lexical decision reaction times and in brain event-related potentials. Behavioral responses are particularly fast for positive words and the concomitant electrophysiology reveals a specific response facilitation for positive contents, whereas perceptual facilitation applies for both positive and negative words. Faster access to the mental lexicon also applies for both positive and negative compared to neutral words. Turning to the intrinsically interactive role of language, recent research addressed the question of how word processing changes even in minimal social contexts, such as supposed evaluation by humans versus intelligent machines. This work confirms the prioritized processing of emotional content and further demonstrates sustained cortical response amplification starting with the P2 potential when participants think that they are interacting with another human rather than a machine, even when in actual fact both conditions are perceptually identical. Source reconstructions reveal that both emotional content and interactive context amplify processing particularly in the fusiform gyri. Context modulates processing also in left temporal, somato-sensory and pre-motor areas. This specifies how even implied communicative context is implicitly taken into account when humans process language stimuli, starting from early processing stages. Finally, I will sketch an integrative model of the above findings, identifying mechanisms of emotional language processing that appear common to a range of emotional stimuli, such as attentional highlighting via re-entrant processing in the brain, as well as those that seem more specific to language stimuli, such as engagement of left hemisphere semantic structures, proposing a dynamic interaction of the two.

A66 EMG-recorded motor cortex response during passive action sentence processing

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Functional neuroimaging [1,2], electroencephalography [3] and transcranial magnetic stimulation [4] studies have shown a response of the cortical motor system during the processing of action language, such as action verbs and tool names. More recently, sub-threshold peripheral motor activity has been recorded through a hand-held force sensor during manual action language processing and has been shown to vary as a function of linguistic parameters [5]. Despite prior evidence, there is still debate regarding whether or not the motor system is necessary to comprehend action language, and whether it plays a role in early linguistic processes or in later post-linguistic conceptual processes [6]. The present study aims to (1) determine whether the motor cortex's response to manual action sentence processing, captured through electromyographic (EMG) recordings of the FDI muscle activity, is modulated by specific linguistic parameters (sentence type [affirmative, negative], semantic context [action, non-action, neutral], prosody [ascending, descending]), and (2) characterize the time-course of this motor response. To this aim, 19 right-handed healthy adults, aged 20 to 50 years, passively listened to action sentences containing a manual action verb (e.g. "With her pencil, Joanne signs the contract"), while completing a visual distraction task to prevent them from focusing on the linguistic stimuli. The EMG signal was filtered, rectified, baseline corrected and segmented into 300ms windows. Preliminary results show that motor responses recorded through EMG during and after action verb processing (i.e. during the three 300ms time windows from action verb onset to end of sentence) varies as a function of sentence type, showing a significant increase in activity during processing of affirmative sentences compared to negative sentences. These preliminary results suggest that cortical motor activity captured through EMG recordings increases automatically during passive processing of affirmative manual action language, consistently with previous literature suggesting an online flexibility of motor response. Further analyses, currently underway, will focus on the impact of the name (manipulable tool or non-manipulable location) of the first phrase of the sentence on the motor response during the processing of the action verb located in the second phrase of the sentence. Taken together, these analyses will shed light on the characteristics of motor response during processing of complex two-phrase action sentences. [1] Tremblay & Small (2010) Cerebral Cortex. [2] Hauk et al. (2004) Neuron. [3] van Elk et al. (2010) NeuroImage. [4] Tremblay, Sato & Small (2012) Neuropsychologia. [5] Aravena et al. (2012) PlosOne. [6] Mahon & Caramazza (2008) Journal of Physiology.

A67 The shape of things to come in speech production: An fMRI study of visual form interference during lexical access *Greig de Zubicaray[1], Katie McMahon[2], Kori Johnson[2], Marcus Meinzer[2], David Howard[3]; [1]Queensland University of Technology, Brisbane, Australia, [2]University of Queensland, Brisbane, Australia, [3]Newcastle University, Newcastle-upon-Tyne, UK*

Naming a picture, a fundamental task in speaking, takes more time when objects are presented in categorically related compared to unrelated contexts, an effect known as semantic interference. Lexical selection by competition models of spoken word production explain semantic interference by assuming targets (e.g., fox) and related concepts (e.g., lion) are represented as whole conceptual nodes, connected via a common category node (e.g., four legged animal) and to other conceptual nodes representing features. When presented in context, the related concepts prime each other, increasing the activation levels of their lexical representations, thus making the selection of the target representation more time-consuming due to the resulting competition (e.g., Levelt, Roelofs & Meyer, 1999). Alternative production models assume target and related concepts are represented by multiple, distributed feature nodes (e.g., has four legs, a tail), with activation shared between organized sets of arbitrary features, i.e., no single representation of the whole concept is used to access the lexical representation, nor is a common category node necessarily assumed. Instead, single features have access to lexical representations (e.g., Howard et al., 2006). This has been termed a decompositional view of conceptual representation, in contrast to the non-decompositional view of meaning representation in terms of whole lexical concepts. In the present study, we conducted an fMRI experiment (N=17) with the picture-word interference (PWI) paradigm to determine whether lexical access is influenced by a single feature - visual surface form similarity - in the absence of a category coordinate relation, and thus distinguish non-decompositional and decompositional accounts. Visually similar B/W picture stimuli were selected from normative databases and rated for similarity by a separate sample of undergraduate students. Picture names also served as distractor words. However, visual form interference could also occur at the level of concept identification, due to temporary uncertainty about whether one is seeing one object or the other. We therefore tested contrasting hypotheses of differential activity in left lateral temporal cortical regions (middle and superior temporal gyri) associated with lexical-level processing observed reliably during semantic interference vs. occipito-temporal (lingual and fusiform gyrii, perirhinal cortex) regions responsible for earlier perceptual/conceptual feature-level processing. A visual form interference effect was demonstrated in naming latencies along with significant differential activity solely in the left posterior middle temporal gyrus (similar < dissimilar). These results support decompositional accounts in which single conceptual features have access to lexical representations.

A68 Form-based pre-activation during semantic priming: Evidence from ERPs *Trevor Brothers[1], Tamara Y. Swaab[1,2], Matthew J. Traxler[1,2]; [1]University of California, Davis, [2]UC Davis Center for Mind and Brain*

If comprehenders can use contextual information to pre-activate upcoming linguistic information, then it is crucial to understand the representational levels at which this pre-activation is occurring. Previous studies have revealed that unconscious, masked priming affects multiple, dissociable stages of word processing (Holcomb & Grainger, 2006). Compared to an unrelated word, masked repetition primes have been shown to reduce the amplitude of the N400 - which is thought to reflect semantic retrieval - as well as the N250 which has been tied to orthographic and word-form processing. In the present study we used these two distinct ERP components as tools to investigate the nature of anticipatory language processing. If predictive semantic contexts (SALT – PEPPER) activate upcoming words only at the level of semantic features we would expect semantic priming to interact with masked repetition priming at the level of the N400 while leaving N250 priming unchanged. In contrast, if predictive semantic contexts also lead to pre-activation at the orthographic level, this should result in prime by context interactions at the level of the N250. In the current study, a group UC Davis undergraduates (n=24) read a series of associatively related word pairs (TABLE … CHAIR … SALT … PEPPER) while EEG was recorded from the scalp. Both unprimed words (SALT) and primed words (PEPPER) were immediately preceded by a masked prime (50ms duration) that was either a repetition of the upcoming word or fully unrelated (pepper – PEPPER vs doctor – PEPPER). Participants were instructed to attend to the semantic relationships between words, but to only make overt responses to infrequently presented, non-critical animal names. For semantically unexpected items we observed standard masked repetition effects on the N250 and N400. In contrast, for semantically primed words we observed an elimination of the N400 masked priming effect and an enhancement in the N250 priming effect (0.6 μV to 2.9 μV). We propose two alternative accounts for these interactions: 1) a model in which semantic pre-activation also spreads to relevant orthographic features, and 2) a model in which masked prime words provide a head-start to lexical access, shifting the time-point at which target words make contact with their semantic representations. Future directions for distinguishing between these two models will be discussed.

A70 Top-down semantic influence on the left ventral occipitotemporal cortex in Chinese reading *Jin Wang[1], Yuan Deng[1]; [1]Chinese Academy of Sciences*

Left ventral occipitotemporal cortex (vOT), which connects low-level visual cortex and high-level language area, is consistently found to play a critical role in reading. One prediction made by an interactive account is that the activation in vOT is determined by the interaction between feedforward information (visual features) and backward prediction (e.g. semantics, phonology). However, it has been unclear how this interactive process influences activation in vOT. We used masked repetition priming paradigm to explore how high-level backward predictions influence activation in vOT during word recognition. Chinese characters that can form into reduplicative words were used for masked repetition priming in both short- and long-SOA conditions. A reduplicative word consists of two consecutive identical characters. The single character's meaning is vague and different from the whole-word's meaning (e.g. "太太" as a whole-word means "wife", but "太" as a single character means "very"). Therefore, for repetition priming condition, the combination of prime (e.g. "太") and target ("太") can be concatenated into a meaningful compound word ("太太"). This process is more likely to occur during the long-SOA (150ms) priming, in which the prime is visible, than the short-SOA (33ms) priming. By these means, we are able to examine how high-level semantic feedback influences vOT activation over time during word recognition. Homophone priming and different priming were used to serve as baselines. Seventeen native Chinese skilled readers were recruited, eight in the short-SOA priming group and nine in the long-SOA group. Participants were asked to judge whether the target character is a real character or not. A total of three experimental fMRI runs were conducted with ER design. We identified the classical visual word form area in the left vOT as a region of interest (ROI) and extracted brain activations in this area for each participant and each condition. ROI analysis showed that (1) in short-SOA priming, overall repetition effect (lower activation in repetition condition than in different condition) was significant for real-character targets, but not for pseudo-character targets; while it was significant for both real- and pseudo-character targets in long-SOA priming. (2) There was no phonological priming effect (difference between homophone and different priming conditions) in short-SOA or long-SOA. (3) More importantly, repetition effect for reduplicative condition and for non-reduplicative condition didn't show significant difference in short-SOA, suggesting no semantic influence on vOT in very early stages of word recognition. As expected, repetition effect for reduplicative condition was significantly lower than that for non-reduplicative condition, indicating a robust semantic influence on vOT activation. Overall, our findings suggest both an early subliminal feedbackward of lexicality and a later semantic influence in the left vOT in Chinese character recognition. Key words: left ventral occipitotemporal cortex, Chinese character, semantic, repetition priming, fMRI

A71 Effects of Cloze Probability and Orthographic Neighborhood on Lexical Processing During Reading.

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This study examined neural pre-activation of orthographic information in sentences. Specifically, the modulatory effect of predictability on orthographic processing was examined by comparing the N400 to words with many orthographic neighbors to words with few orthographic neighbors in three conditions: high predictable (HP), low predictable (LP), and not predictable (NP). If HP words do not elicit orthographic neighborhood effects, this would suggest pre-activation of the predicted word forms, whereas if orthographic neighborhood effects are still observed even for HP words it would suggest that the word form was not pre-activated. Critical words with high neighborhood (HN, average 6.89) and low neighborhood (LN, average 1.41) size were selected from a previous study; these words were matched on all other lexical characteristics (Vergara & Swaab, 2013). Three sentence contexts were created for each of the critical words. Sentences were normed for cloze probability in 55 participants, to establish the three levels of predictability. This resulted in a set of 105 sentences containing a HN critical word and 105 containing a LN critical word (cloze probability: HP = 61-100%; LP = 0-27%; NP = 0%; no difference between HN and LN). Selected sentences were used in an ERP experiment with 15 participants. Participants read sentences, presented one word at the time (SOA=500ms, ISI=200ms) while their EEG was recorded. ERPs were time locked to critical words in mid-sentence position. (Sample stimuli: (HN) HP: We gazed at the stars and the large pale moon at the….; LP: We looked at the prints with the large pale moon at the….; NP: We dusted off the furniture and the large pale moon at the….; (LN) HP: The bride covered her face with a veil before ….; LP: The artist covered the piece with a veil before ….; NP: The writer corrected the error with a veil before ….). A significant main effect of cloze probability was found on the N400; relative to non-predictable words, the N400 was reduced to predictable words across both low and high neighborhood conditions ($p<.0001$). Furthermore, a significant interaction of neighborhood X predictability X electrode was detected at midline sites ($p< 0.05$). Significant interactions of neighborhood, predictability and anteriority were detected at medial and lateral sites ($p< 0.05$). Follow-up pairwise comparisons showed that the effect of orthographic neighborhood was maximal over left central electrode sites in the high predictable condition, whereas this effect was maximal over central-posterior electrodes in the low predictability condition. Our results indicate that effects of orthographic neighborhood interact with predictability during real-time reading comprehension. Effects of orthographic neighborhood were found for all predictability conditions, but differed in topographic distribution: the more typical central-posterior maximum

of the N400 was found for the neighborhood effect in the LP condition, however this effect was maximal over left-central electrodes in the HP condition. Overall, these results suggest that, while the results of orthographic neighborhood are not equivalent for HP and LP words, a high degree of predictability does not eliminate the influence of neighborhood on orthographic processing of incoming words during reading.

A72 Foveal load and parafoveal processing. An ERP study *Pedro Javier López Pérez[1], Julien Dampuré[2,1], Juan A. Hernández-Cabrera[1], Horacio A. Barber[1]; [1]University of La Laguna, Spain, [2]University of Poitiers, France*

In this experiment we tested if the lexical frequency of a word perceived in the fovea modulates the level of parafoveal word processing. Participants read words presented in triads at the centre of the computer screen. Each word was flanked by two words, in the left and right parafoveal field respectively. Whereas left flankers were always unrelated words, right flankers varied according to three experimental conditions defined by the relationship between the flankers and the central word: a) repeated b) semantically related and c) unrelated words. ERPs to triad presentation showed a larger N400 component for the unrelated compared to the repeated word condition. Interestingly this effect was greater for words with a high lexical frequency presented in the fovea. Differences in the same direction between the unrelated and the semantically related condition did not reach statistical significance. These results suggest that foveal load can constraint parafoveal processing during reading.

A73 Interplay between semantic and syntactic information in Chinese Classifier-noun agreement: An ERP comparison *Chia-Ju Chou[1], Chih-Ting Chang[1], Jie-Li Tsai[3], Chia-Ying Lee[1,2]; [1]National Yang-Ming University, Taiwan, [2]Academia Sinica, Taiwan, [3]National Chengchi University, Taiwan*

Two contrasting models have been proposed to account for how semantic and syntactic information interact during sentence comprehension: syntactic-first model and constraint-satisfaction model. The syntactic-first model claims that syntax plays the major part whereas semantics has only a supporting role for sentence comprehension. In contrast, constraint-satisfaction model claims that both syntactic and semantic processes work together to determine the meaning of a sentence. The goal of this study was to examine these two accounts by investigating how the semantic constraint of classifiers modulate the semantic and syntactic violation during reading Chinese classifier-noun agreement. In Mandarin Chinese, Chinese classifiers are said to carry syntactic information and meaning about the semantic features of the entities being classified. Our previous work has demonstrated that readers make use of the semantic constraint of classifiers to predict the pairing noun. In this study, semantic constraint strength of classifiers (strongly and weakly) and three types of completions (expected noun, implausible noun, implausible verb) were manipulated. Based on the syntax-first model, syntactic violation shall be found, regardless of semantic constraint. On the other hand, the constraint satisfaction model would predict modulation effect of semantic constraint on syntactic violation for the implausible verb condition. Eighteen participants first read a classifier and then a paring completion on the center of screen and they were asked to perform an acceptability judgment for the completion. Event related potentials (ERPs) were recorded to a classifier and its subsequent completion. Strongly constrained classifiers elicited an enhanced P200 and a reduced N400 relative to weakly constrained classifiers, suggesting that readers used the preceding classifier to predict the upcoming word, even before the pairing noun appeared. For ERPs elicited by the paring completions, analyses focused on the N400 and P600, which have been used to reflect the semantic integration and syntactic processing, respectively. For both strongly or weakly constraining conditions, both implausible noun and implausible verb elicited significant larger N400s than expected noun did. However, there was no difference between implausible noun and implausible verb on N400, suggesting that the N400 was not affected by the additional syntactic violation. Importantly, the results showed an interaction between semantic constraint and syntactic violation on the P600. The syntactic violation effect, which showed that implausible verb elicited largest P600 than the expected noun and semantic violation did, was only observed in strongly semantic constraining condition, but not in the weakly constraining condition. The finding supports the constraint-satisfaction model. When the classifier provides weakly semantic constraint for its completions, the comprehension system need to allocate most of resources for resolving the semantic plausibility. The syntactic appropriateness would only be considered or processed when the classifier provides strong semantic constraint for its completions.

A74 Dissociating neural effects of semantic and syntactic category on lexical processing *Natalia Lapinskaya[1], Uchenna Uzomah[1], Marina Bedny[2], Ellen Lau[1]; [1]University of Maryland, [2]Johns Hopkins University*

Dissociations in brain areas involved in processing different word classes have been extensively documented, in particular for nouns and verbs. However, the properties driving these differences are still unresolved; in particular, which differences can be ascribed to their grammatical properties and which to their semantic properties. Studying subcategories of these classes that pull apart their syntactic and semantic properties is one way to shed light on this question. Here we present results of an EEG-MEG study that compares responses to concrete nouns and verbs with a subcategory of nouns known as events (e.g. 'hurricane'). Event nouns share semantic properties with verbs, and therefore can be used to determine whether observed noun-verb differences are due to semantic or

syntactic features. We replicate the design of a previous fMRI study by Bedny et al. (2014), which reported that response to events was more similar to verbs than to nouns in left middle temporal gyrus, indicating that word class differences in this area were due to semantic properties. We aimed to investigate the mechanisms driving this differential response by using methods with high temporal resolution to elucidate the timecourse of differences across the trial. As in the fMRI study, participants saw 150 two-word sequences belonging to the category of object nouns (e.g. 'orangutan'), event nouns (e.g. 'lecture') or verbs (e.g. 'pounce') and made a similarity judgment. Experiment 1 used EEG recordings (n=24) and Experiment 2 used MEG recordings (n=24). We find that EEG responses to event nouns pattern with verbs rather than object nouns. Event noun to verb similarity is observed over left anterior electrodes as early as 300-500ms post-stimulus. This time window is known to be important for semantic access; cf. the N400 effect. This similarity of event nouns and verbs thus may be due to their access of shared semantic properties, such as temporal extent, or the fact that events and verbs both involve constructing relations between primitives: e.g. 'pounce' relates a pouncer and a victim, 'lecture' relates an audience and a speaker. We also find a second, later effect of word class that occurs after word 2 of the pair. Object nouns again diverged from event nouns and verbs, but this time in an increased posterior positivity 400-800ms post-word 2. Since the timing of this late dissociation coincides with semantic similarity judgments, it may be attributable to an impact of semantic category on execution of the task, although the reason for this interaction is so far unclear. The EEG timecourse data thus suggest that the noun-event/verb differences observed in fMRI could be due to both task dependent and task independent processes. Experiment 2 addresses this with source localization in MEG; preliminary results show a pattern similar to EEG at W1 over left anterior sensors. Together, these data indicate that differences in the semantic properties of events and entities impact processing between 300-500ms, and that integrating fMRI localization with timecourse-sensitive measures such as EEG/MEG is critical for determining the functional locus of these effects.

A75 Dynamic interactions between frequency and predictability in sentential context

Yoana Vergilova[1], Heiner Drenhaus[1], Matthew Crocker[1]; [1]Saarland University

We examined the unfolding interplay between higher-level sentence predictability and lower-level word frequency in ERPs at different stages of lexical access. Previous studies of sentence predictability and lower-level factors, such as word frequency or length, report either additive effects or interactions, depending on presentation rate and time-window of interest (Sereno et al., 2003; Penolazzi et al. 2007; Dambacher et al., 2009, 2012). N400 investigations show diminishing modulations, especially to low frequency words, as preceding sentential context increases (Van Peten & Kutas, 1990, Halgren et al., 2002). Word frequency effects index lexical access, thus interactions between frequency and predictability could be interpreted as evidence of interdependent processing between feed-forward and feedback neural pathways (Sereno et al, 2003). Interactions at early windows, therefore, indicate that sentential predictability may even mold expectations for a specific upcoming word form (Dambacher, et al., 2009). We set out to replicate a recent study in German (Dambacher et al., 2009; 2012 Exp. 3) where frequency of target words (high/low) and predictability of context sentences (high/low) were manipulated (fully counterbalanced). The predictability-manipulating context sentence introduced an otherwise neutral sentence in which target words of varying frequency were embedded, and additive effects of the two factors in both the 50-90ms and N400 time-windows. Our replication employed shortened word presentation time (200ms instead of original 250ms), but kept the original inter-stimulus interval of 30ms, resulting in a faster SOA (230ms). Twenty-two right-handed German participants read 144 tandems of context (high/low predictability) + target (high/low frequency words) sentences. The first sentence was presented in its entirety, followed by the second sentence (word-by-word presentation). We analyzed the time-windows between 50-90ms as reported by Dambacher et al. 2009 and the N400 time-window (Dambacher et al. 2012, Exp. 3). 50-90ms window: Frequency and predictability showed a significant two-way interaction, such that high frequency words exhibited a global negative modulation (N1) in low compared to high predictability contexts. Low frequency words showed no sensitivity to supporting contexts at this time-window. These results differ from the main effect of predictability across frequency conditions as reported by Dambacher et al., 2009), perhaps due to the larger processing load imposed by the faster SOA. N400 window: We found a main effect of predictability and a significant two-way interaction with frequency most evident in centro-parietal regions. N400 amplitude modulations of low- compared to high-predictability contexts were inversely proportionate to target word frequency. High frequency words in low predictability conditions showed a smaller, but significant, N400 modulation compared to low frequency words in low predictability conditions, which yielded a larger N400 effect. We take this as evidence for the dynamically unfolding constraints context puts on progressively harder to access target words. Importantly, both frequency conditions benefitted from predictability, with effects detected earliest for high frequency words and later for low frequency words. The current study replicates early indices of predictability, and further paints a dynamic picture of contextual influences on lexical access from the earliest moments of activation up to N400 windows, even at faster, natural reading rates.

Poster Session B

Thursday, October 15, 4:30 – 6:30 pm, French and Walton Rooms

Syntax, Morphology

B1 Genetic variation in the effects of familial handedness on language processing

Thomas Bever[1], Roeland Hancock, Dane Bell; [1]University of Arizona, [2]University of California at San Francisco, [3]University of Arizona

Clinical and experimental research has pointed to behavioral and neurological differences in right-handers as a function of their familial handedness (ALL SUBJECTS IN THIS DISCUSSION ARE RIGHT-HANDED). Behaviorally, subjects with familial left handedness (FS+) are more immediately sensitive to words and less immediately to syntactic patterns than those without familial left handedness (FS-) (Bever, et al, 1989; Bever, 1992, 2013). Neurologically, FS+ have more bilateral cortical representation and activity during language processing than FS- subjects (Luria, 1954; Kutas et al, 1988; Tzourio-Mazoyer, et al., 2010; Lee & Federmeier, 2015). Our presentation first briefly reviews examples of FS+/FS- behavioral and neurological differences relating to syntactic order vs. lexical processing. We then demonstrate that a genetic model of left handedness predicts the degree to which an FS+ subject shows neurological patterns typical of all FS+ subjects. SYNTACTIC VS LEXICAL PROCESSES. FS- subjects are systematically sensitive to the syntactic location of a probe word following sentence presentation, while FS+ subjects have faster recognition latencies but are not sensitive to original probe location (Townsend et al, 2001). FS- subjects show masked auditory priming only to high frequency words; FS+ subjects show such priming to all words (data from Fisher et al, 2012). An fMRI study contrasts the silent formation of a syntactic sequence (3 phrase sentences – e.g., "cats chase dogs") with the silent formation of a semantically governed sequence of three words (successive class inclusion – e.g., "oak tree plant"): FS+ subjects show a shorter latency to the lexical task than to the syntactic task in the RH IFG; FS- subjects show no such latency differences (new analysis of data from Chan, 2007). A GENOMIC MODEL AND INDIVIDUAL DIFFERENCES. We collected family handedness pedigrees on 4,000 subjects. Bayesian multifactorial threshold models were used to estimate additive genetic effects associated with left hand preference (Hancock, 2011. 2013, Hancock and Bever, 2012). With heritability of ~.3, individual estimates of additive effects enable an individual differences approach to examining the continuum of neurolinguistic differences between FS+ and FS-. Several new analyses show systematic correlations between the modeled genetic load for left-handedness and language-stimulated RH neurological activity in FS+ subjects. For example, in a semantic word category judgment task, FS- subjects show a greater N400 to unexpected words in the LH; while FS+ subjects show an increasing RH N400 as a function of their genetic load for left handedness (data from Bell et al, 2015); FS- subjects show a consistent ELAN (Early Left Anterior Negativity) to an anomalous sentence, while FS+ subjects actually show an increasing ERAN (Early Right Anterior Negativity) as a function of their genetic load for left-handedness. (based on data from Sammler et al, 2011). CONCLUSIONS. 1. The variable effects of genetic load for left handedness may reflect underlying complex genetic variation in the basis for cerebral lateralization and specialization. 2. Since FS+ right handers comprise almost half of the population, there may be considerable normal variation in details of the "normal" neurological organization for language and how that organization constrains attested language universals.

B2 The role of familial sinistrality on hemispheric differences in syntactic processing across the lifespan

Michelle Leckey[1], Chia-Lin Lee[2], Kara D. Federmeier[1]; [1]University of Illinois at Urbana-Champaign, [2]National Taiwan University

The capabilities of the right hemisphere (RH) for syntactic processing remain poorly understood. In a series of studies, we have used event-related potentials (ERPs) in tandem with visual half-field presentation techniques to provide a multidimensional account of the processing biases of each hemisphere. Furthermore, based on prior work showing that structural and functional lateralization is affected by whether right-handed participants have left-handed relatives (Bever et al., 1989; Hancock & Bever, 2013; Tzourio-Mazoyer, et al., 2010; Tzourio-Mazoyer, et al., 2010), we compared participant samples grouped according to the presence (FS+) or absence (FS-) of familial sinistrality. The first experiment (Lee & Federmeier, in press) presented young adults with two-word phrases and examined the response to violations (e.g., the teach). The findings were strikingly different between the groups. The FS+ group showed a typical P600 response to the syntactic violations with presentation to both the left hemisphere (LH) and the right (RH). However, the FS- group elicited a strongly lateralized response, eliciting a P600 only with LH-biased presentation. With RH-biased presentation, this group instead elicited an N400 effect, suggesting that the RH appreciated that the words were less expected following the incorrect cue but did not treat this as a syntactic violation. In follow-up work, similarly lateralized patterns were found in Chinese for FS- young adults reading referential violations. Further work has shown that this result is not simply due to an inability of the RH of FS- participants to produce a P600 response. When a young adult FS- group was presented with morphological violations, they showed a bilateral P600 response. Thus the RH of FS- participants can appreciate some forms of syntactic violations, perhaps especially those that are lexically marked, as opposed to purely combinatorial. We have hypothesized that the differences

seen between the two groups are the result of differing levels of callosal inhibition, with FS- participants having a more distinct functional separation of the hemispheres. If so, given evidence that a reduction in callosal inhibition explains the documented reduction in laterality over the course of normal aging (Buckner & Logan, 2002; Reuter-Lorenz, 2002), we would expect the asymmetric pattern in the FS- group to shift with age -- and this was indeed found to be the case. When an older adult FS- sample was presented with the same phrase structure violations as in the original experiment, we observed a bilateral P600, similar to that seen in the young FS+ sample. As a set, these experiments show that the RH is capable of some forms of syntactic processing in all individuals, but that its specific capabilities vary with genetic factors related to handedness. In turn, these individual differences -- and their changes over the lifespan -- emphasize that even small anatomical and physiological differences, such as those that have been documented across the hemispheres and in FS+ versus FS- individuals, can have dramatic effects on the large-scale dynamic functioning of the language processing system.

Lexical Semantics

B3 Early and late neurological responses to preconscious form and semantic information in lexical category decision

Dane Bell[1], Kenneth Forster[1], Thomas G. Bever[1]; [1]University of Arizona

Some theories of lexical access (e.g. Coltheart et al., 2001) propose that sensory input in reading passes activation up to more abstract processing levels, e.g. lexical semantics, without the exhaustive search, activation thresholds, or deadlines required by staged accounts (Forster, 1976; Morton, 1969) in a process called cascaded activation (McClelland, 1979). The cascade model is based on neurological models of preconscious accumulating activation (ibid.), in which monitoring units aggregate activation and compete before an overt response. Accordingly, immediate imaging patterns of brain activation during lexical recognition can enrich data bearing on the cascade model by presenting time course information. The cascade model predicts that each word briefly activates all of the words sharing letters with it. For example, 'bottle' has letters in common with 'beetle', so it should activate the semantic category of INSECT more than 'glare'. To test this prediction, we presented subjects with masked primes that were form neighbors of target categories in a semantic categorization task. We analyzed the N400 and P200 components, the first reflecting semantic expectation (Kutas & Hillyard, 1984) and the latter reflecting perceptual expectation (Federmeier and Kutas, 2002). 45 right-handed, English-speaking subjects read singly presented English words (such as MELBOURNE or ROACH) and responded manually, differentiating target category words (e.g. CITY NAME) and non-target words (INSECT). A 50ms masked English word preceded the target word, similar either to a member of the target category ('membrane', similar to 'Melbourne') or an opposing category ('rough" similar to "roach"). EEGs were collected with a 65-electrode cap. Subjects responded significantly faster when the prime was similar to a word in the same category as the target, a difference that accompanied an N400 in the left hemisphere electrodes., In the second half of the experimental sequence, a P200 effect emerged, while the N400 prime similarity effect decreased. The emergence of the P200 effect is accompanied by a decrease in response latency. The N400 to the out-of-category targets is consistent with subjects' monitoring for the target category only. The emergence of the P200 effect to primes similar to the target category reflects acquiring implicit priming of the members of the target category that results in the preconscious cascade effect starting earlier. References Coltheart, M., Rastle, K., Perry, C., Langdon, R., & Ziegler, J. (2001). DRC: a dual route cascaded model of visual word recognition and reading aloud. Psychological review, 108(1), 204-256. Federmeier, K. D., & Kutas, M. (2002). Picture the difference: electrophysiological investigations of picture processing in the two cerebral hemispheres. Neuropsychologia, 40, 730-747. Forster, K. I. (1976). Accessing the mental lexicon. In R.J.Wales & E.Walker (Eds.), New Approaches to Language Mechanisms. (pp. 257-287). Amsterdam: North-Holland. Kutas, M. & Hillyard, S. A. (1984). Brain potentials reflect word expectancy and semantic association during reading. Nature, 307, 161-163. McClelland, J. L. (1979). On the time relations of mental processes: An examination of systems of processes in cascade. Psychological Review, 86, 287-330. Morton, J. (1969). Interaction of Information in word recognition. Psychological Review, 76,

Auditory Perception, Speech Perception, Audiovisual Integration

B4 A common variant of the CNTNAP2 gene is associated with structural variation in the dorsal visual stream and language-related regions of the right hemisphere.

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The CNTNAP2 gene encodes a cell-adhesion molecule that influences the properties of neural networks and the morphology and density of neurons and glial cells. Common polymorphisms of CNTNAP2 have been associated with quantitative variation in language-related phenotypes in neurodevelopmental disorders and the healthy population. In-depth phenotypic studies of people carrying rare mutations clearly support the relevance of CNTNAP2 for neurobiology of language and communication. A handful of studies have reported association of common CNTNAP2 polymorphisms with brain imaging phenotypes in small sample sizes (50-

300 subjects), but none of these studies have yet been independently replicated and they must thus be treated with caution. The current study tested for replication of associations between a common CNTNAP2 polymorphism (rs7794745) and variation in structural measures of grey matter as assessed with voxel based morphometry, previously reported by Tan and colleagues 2010 [1]. The Tan et al. (2010) study on 314 healthy subjects reported association of nine regions. We tested for replication within this restricted set of regions in a much larger sample of more than 2000 healthy subjects. We replicate (pFWE-corr = 0.01, Bonferroni-corrected for nine comparisons) the finding that T allele carriers show reduced grey matter volume in left superior occipital gyrus in the dorsal visual stream. This stream has been implicated in a number of developmental disorders and it is particularly susceptible to damage during early development [2], when genetic influences are greatest. In follow-up whole-brain analyses, we consistently observed association of the T allele with reduced grey matter in the left superior occipital gyrus, as well as in two novel regions: the right superior temporal gyrus and the right middle frontal gyrus. The strongest association on the cluster level (pFWE-corr = 0.025) was found for the right superior temporal gyrus, a core speech processing region within the superior temporal lobe. Activation of this region has shown association with the same CNTNAP2 SNP during sentence processing, using FMRI in a healthy population [3]. It has recently been noted that a segment along the superior temporal sulcus, overlapping with our locus of association, is deeper in the right than the left hemisphere in humans, but not in chimpanzees. This asymmetry is likely formed under strong genetic influence, since it appears already during mid-gestation [4]. Association of rs7794745 alleles with grey matter in right temporal and frontal gyri however needs to be replicated, in a future independent sample. Overall, our study gives an example of how standards of brain imaging genetics of language and communication can be raised in terms of the sample sizes studied and the approach to replication of novel findings. With improved standards, this field promises to generate robust knowledge concerning the genetic biases on language-related phenotypes, thus providing a molecular window into the neurobiology of language and communication. References [1] Tan et al. (2010). NeuroImage, 53(3): 1030-1042 [2] Braddick et al. (2003). Neuropsychologia, 41(13), 1769-1784. [3] Whalley et al. (2011). Am J Med Gen B (Neuropsych Genet), 156B(8), 941-948. [4] Leroy et al. (2015). PNAS, 112(4), 1208-1213.

B5 Assessing pre-natal rhythm-based discrimination of language by fetal magnetocardiography (fMCG)

Utako Minai[1], Kathleen Gustafson[2], Robert Fiorentino[1], Allard Jongman[1], Joan Sereno[1]; [1]Department of Linguistics, University of Kansas, [2]Hoglund Brain Imaging Center, University of Kansas Medical Center

Previous studies have shown that infants can discriminate spoken languages based on their rhythmic characteristics as early as a few days after birth (e.g., Mehler et al., 1986). Given that rhythmic properties of language have acoustic signatures that can be transmitted to the fetus, this raises the question of whether rhythm-based language discrimination ability is evident pre-natally. Kisilevsky et al. (2009), using fetal ultrasound, reported changes in fetal heart rate when presented first with spoken English, and then with a second language they held to be rhythmically different (Chinese), suggesting pre-natal sensitivity to rhythm. However, given methodological concerns, including that they presented English speech by one speaker and Chinese speech by another speaker, the interpretation of the fetal response reported in Kisilevsky et al. (2009) remains somewhat unclear. The current study assessed fetal discrimination of two uncontroversially rhythmically different languages (English and Japanese) using speech stimuli recorded by the same bilingual speaker, and measured changes in fetal heart rate to linguistic stimuli using fetal magnetocardiography (fMCG) for the first time. The stimuli included two-minute passages recorded both in English and Japanese read by the same female bilingual speaker. The rhythmic differences between the two languages were confirmed by acoustic analysis of the speech stimuli. Twenty-four mother-fetus pairs (mean gestational age=35.5 weeks; mean maternal age=29.4 years) participated in the fMCG experiment. fMCG was recorded while the participants were presented first with Passage 1, a passage in English, and then, following an eighteen-minute inter-passage interval, with Passage 2, either a different passage in English (English-English Condition: N=12), or a passage in Japanese (English-Japanese Condition: N=12). The fetal magnetocardiogram was reconstructed following Independent Components Analysis (ICA) decomposition of the fMCG recording. We calculated mean beats-per-minute (BPM) for a 30-second baseline interval directly preceding each Passage, and for the first 30-seconds within each Passage. We then subtracted the mean BPM of the 30-second baseline interval directly preceding each, from that of the first 30-second interval of each, yielding a BPM-Change value for each Passage. We conducted a mixed ANOVA with Condition (English-English vs. English-Japanese) as a between-subject factor, and Passage BPM-Change Value (BPM-Change for Passage 1 vs. BPM-Change for Passage 2) as a within-subject factor. The results revealed a significant interaction between Condition and Passage BPM-Change Value ($F(1,22) = 6.365$, $p < .02$); post-hoc t-tests confirmed a significantly larger BPM-Change for Passage 2 compared to Passage 1 for the English-Japanese Condition ($p < .007$), while there was no significant difference between the Passages for the English-English Condition ($p > .599$). Our results suggest that pre-natal infants are able to discriminate languages based on their rhythmic properties, as evidenced by their change in fetal heart rate when the language switched from English

to Japanese, as compared to when the switch was to an acoustically different passage of English. These findings provide the first evidence for fetal language discrimination as assessed by fetal biomagnetometry, and are consistent with the hypothesis that rhythm constitutes a pre-natally available building block in language acquisition.

B6 How does musical experience affect auditory perception? *Saloni Krishnan[1], Samuel Evans[1], Cesar Lima[1], Sinead Chen[1], Stella Guldner[1], Sophie Scott[1]; [1]Institute of Cognitive Neuroscience, UCL*

Multiple fMRI studies have shown that motor areas are activated even when passively listening to speech or music. Yet, it is unclear whether this activation is shaped by an individual's previous auditory-motor learning. Here, we study musicians to explore whether distinct motor experiences lead to separable profiles of neural activation when listening to music. We scanned guitarists (N=20) and non-musicians (N=20) in a 1.5T scanner (sparse acquisition, TR = 9.5s; TA = 3.4s) as they listened to excerpts of guitar music and beatboxing. These two types of stimuli were chosen for the specific motor expertise they require - while playing the guitar involves skilled hand movements, beatboxing involves complex manipulation of the vocal tract. The guitar pieces were recorded by an expert guitarist in studio conditions, beatboxing pieces were produced by an expert beatboxer and recorded in an anechoic chamber. Both sets of music included technically demanding pieces, ranging from moderate to extreme difficulty. Stimuli in both the beatboxing and the guitar condition ranged between 3-5 seconds, the two sets of musical stimuli did not differ in duration. Participants were explicitly instructed not to move and cameras positioned over the mouth and hand were used to assess compliance. In addition to the scans assessing listening to music, we also assessed generalisability of expertise, by including a run where participants listened to non-musical sounds that were produced using hands/ mouth. Finally, localisers were used to identify regions associated with phonation and respiration as well as with movement of the hand and the mouth. Results revealed expertise-related activation in guitarists. Relative to non-musicians, guitarists showed strong activation in bilateral precentral gyri, inferior frontal gyri and left intraparietal sulcus when listening to guitar music (over both silence and beatboxing). These findings clearly indicate that auditory-motor experience influences neural activation for listening. We are now extending this study to beatboxers (current N = 8) to explore whether the neural markers of expertise during listening generalise over these different auditory-motor experiences. Our focus on these two groups of musical performers distinguishes us from previous studies that have explored functional neural plasticity in musicians, which have focused almost exclusively on classical musicians (often grouping musicians with different instrumental expertise). We plan to interpret these results in light of the differences in musical production of the two types of music (voice vs. instrumental), the musical experience and training of the two musician groups, and generalisability across music and non-musical sounds.

B7 Corticocollicular influences on subcortical encoding of speech sounds *Han-Gyol Yi[1], Zilong Xie[1], Rachel Reetzke[1], Bharath Chandrasekaran[1]; [1]The University of Texas at Austin, Austin, TX, USA*

Corticofugal pathways extending from the primary auditory cortex (A1) to the inferior colliculus (IC) have been posited to underlie experience-dependent modulation of subcortical encoding of speech sounds. A1-IC white matter connectivity can be characterized in vivo using the diffusion tensor imaging (DTI) technique, but no direct link between A1-IC connectivity and subcortical encoding has been established. To address this issue, young adult native English listeners (N = 24) were recruited to undergo DTI acquisition. White matter connectivity between the inferior colliculus and subregions of the primary auditory cortex (Te1.0, 1.1, and 1.2) was identified using probabilistic tractography. Tracts identified between the IC and the pyramidal Te1.1 were more robust than those identified between the IC and the granular Te1.0 that receives direct input from the medial geniculate body of the thalamus. Participants from the same group underwent a subcortical electroencephalography (EEG) session where the frequency following responses to two English vowels (/a/ and /u/) produced by two native English speakers were collected. Consistency of subcortical encoding was assessed using a machine learning approach, where an observer-independent classifier based on the support vector machine algorithm was trained to differentiate responses to the two vowels across the two speakers on a single-trial basis, and then tested on an independent set of trials. Across the participants, the classifier performed significantly above the chance level (50%), 95% CI [62.9%, 78.4%]. Participants whose EEG responses yielded higher classifier accuracy exhibited better performance in a subsequent speech perception in noise task ($p = 0.00056$; logistic mixed effects modeling), indicating that the consistency of subcortical encoding as assessed using the machine learning approach was associated with expertise in speech processing. Furthermore, white matter connectivity between the IC and the pyramidal Te1.1 was more robust in participants with more reliable subcortical encoding. These results suggest that the consistency of subcortical encoding of speech sounds is linked to structural connectivity between the IC and the subregion of the A1 that does not extensively receive direct input from the medial geniculate body, implying the existence of corticocollicular influences on subcortical encoding of speech sounds.

B8 Corticostriatal white matter connectivity predicts speech category learning success *Han-Gyol Yi[1], Seth R. Koslov[1], W. Todd Maddox[1], Bharath Chandrasekaran[1]; [1]The University of Texas at Austin, Austin, TX, USA*

The putamen has been posited to be involved in categorization, which involves learning associations between perceptual regions and novel categorical representations based on the reward value in feedback. In the non-human primate brain, the auditory temporal cortex sends extensive output to the putamen, and the spatial organization of the pathways varies with structural heterogeneity along the Sylvian sulcus. The functional significance of the auditory corticostriatal connectivity has not been fully explored in humans. Recently, we have found that the functional activation of the putamen is sensitive to positive feedback during speech category learning. Moreover, the degree of sensitivity of the putamen to the valence of feedback predicts learning success (Yi, Maddox, Mumford, & Chandrasekaran, 2014, Cerebral Cortex). We hypothesize that such individual variability in the functional recruitment of the putamen during speech category learning is partly due to the extent of structural connectivity between the putamen and the primary auditory cortex. To test this idea, we recruited another group of native monolingual speakers of English (N = 24; ages 18 to 35) to be trained on identification of Mandarin Chinese lexical tone categories. The participants were presented with monosyllabic exemplars of Mandarin tones as fMRI data were collected. After the presentation of each stimulus, participants were instructed to identify the tone by pressing one of the four buttons. Positive or negative feedback was presented on a trial-by-trial basis depending on whether the tone was correctly categorized. The stimulus-to-feedback and feedback-to-stimulus intervals were jittered to allow separable estimation of hemodynamic responses to each event. Overall tone identification accuracy varied across participants from 14.2% to 80.4%, with mean performance of 35.0% (SD = 15.4%). The functional neuroimaging results revealed that higher learning performance was associated with greater activation in the right putamen during positive feedback relative to negative feedback, p = 0.0496 (linear mixed effects modeling). However, no comparable relationship was found in the left putamen, p = 0.964. Following training, the participants underwent a diffusion tensor imaging (DTI) scan. Probabilistic tractography was applied to the DTI data to identify white matter tracts extending between the primary auditory cortex and the putamen in each hemisphere. In both hemispheres, successful learning was associated with greater connectivity between the primary auditory cortex and the putamen. These results suggest that speech category learning involves functional recruitment of the putamen, which maps perceptual input received via the primary auditory cortex onto categorical representations.

B9 Exploring multivoxel classification in individual statistical analysis: an application to word level cortical representations of speech *Joao Correia[1], Bernadette Jansma[1], Giancarlo Valente[1], Milene Bonte[1]; [1]Maastricht University, Department of Cognitive Neuroscience, Faculty of Psychology and Neuroscience, The Netherlands*

Multivoxel classification approaches play an important role in fMRI research. In speech processing, their higher sensitivitity to find distinctions between subtle experimental conditions has allowed unravelling neural activity patterns that encode the phonological form (Formisano et al., Science, 2008; Killian-Hutten et al., Journal of Neuroscience, 2011; Evans et al., Cerebral Cortex, 2015) and semantic/conceptual representation (Simanova et al., Cerebral Cortex, 2014; Correia et al., Journal of Neuroscience, 2014) of speech items. Multivoxel classification is commonly paired with voxel selection procedures such as the searchlight method (Kriegeskorte et al., PNAS, 2006). This method uses local patterns of fMRI activations to classify experimental conditions within subjects. Group results are usually assessed using second-level statistical analysis of classification performance at each searchlight location across all subjects. However, especially for higher order functions, variability of information content across individual subjects may hinder the consistency of group results (Etzel et al., Neuroimage, 2013). Specifically, during speech comprehension, variability of subjects' reliance on the dorsal and ventral speech processing regions may relate to the strategy adopted and/or automaticity of processing (Hickok and Poeppel, Nature Neuroscience reviews, 2007). Here, by employing parallelized computational methods that allow performing searchlight in a fast manner, we investigate the discrimination of spoken words at the individual subject level using non-parametric permutation testing (1000 label permutations). In comparison to group-level statistical maps, subject-specific statistical maps provide an individual description of the brain networks recruited. Additionally, as subjects (native Dutch, advanced English learners, N=10) listened to both a selection of four Dutch and four English words of equivalent translational concepts from the semantic sub-category of 'clothes', we were able to investigate different aspects of information representation, namely the discrimination of Dutch words, the discrimination of English words, as well as, their across-language similarities. The functional significance of the regions/networks recruited by different subsets of subjects will be further investigated using correlations to behavioural measures, such as reaction times and accuracy rates in the identification of catch words (7% of trials not included in the analysis), as well as, English proficiency measures (Lextale proficiency test). Importantly, the analyses described in this study are exploratory and aim to contribute to the design of future multivariate classification experiments that plan to combine the advantages brought by multivoxel classification with the atractive perspective of individual statistical analysis.

B10 Bilingual hearing in noise: Strengths and weaknesses *Jennifer Krizman[1], Ann R. Bradlow[1], Silvia Siu-Yin Lam[1], Nina Kraus[1]; [1]Northwestern University*

Bilinguals, relative to monolinguals, are poorer at understanding speech spoken in suboptimal listening conditions. It has been hypothesized that this bilingual disadvantage results from an accumulation of difficulties at multiple levels of processing (i.e., sensory, cognitive, linguistic) and manifests, in part, as difficulty using the contextual cues (e.g., using other words in the sentence to identify an unknown word) of a speech stream when it occurs under degraded listening conditions. The aim of this study was to investigate potential sensory, cognitive, and linguistic sources of the bilingual speech-in-noise disadvantage. To do so, we tested monolingual-English adolescents and Spanish-English bilingual adolescents, aged 13-15 years recruited from 3 inner-city high schools in Chicago, on tests of sentence-in-noise, word-in-noise, and tone-in-noise perception. These measures vary in their balance of cognitive, sensory, and linguistic processing loads as a result of the different amounts of contextual cues present in each task's auditory target. While all tests require cognitive and sensory processing important for perception in noise, tone perception tests require no linguistic processing to identify the target tone, word perception tests require some linguistic processing to identify the target word, and sentence perception tests require the greatest amount of linguistic processing as well as the ability to use contextual cues to comprehend the target utterance. We found that differences between bilinguals and monolinguals in perceiving degraded auditory stimuli varied with the amount of linguistic information available in the stimulus. Specifically, while the groups performed similarly on the word-in-noise test, we observed a bilingual disadvantage for sentence-in-noise perception and monolingual disadvantage on the non-linguistic tone-in-noise test. These results replicate, in an adolescent population, poorer bilingual performance relative to monolinguals on tasks of speech in noise performance, especially when contextually-relevant cues are present. Moreover, outcomes from this study also suggest that bilingual enhancements in cognitive and sensory processing may boost performance on non-linguistic perception-in-noise tasks. Taken together, these results highlight the interplay of cognitive, linguistic, and sensory processing for perceiving degraded auditory stimuli and how these processes are selectively shaped by linguistic experience.

B11 Understanding speech perception in noise through the lens of socioeconomic status *Silvia Siu-Yin Lam[1], Jennifer Krizman[1], Nina Kraus[1]; [1]Northwestern University*

Youth from low socioeconomic standing (SES) tend to hear fewer and simpler words from their caregivers than higher-SES children. This impoverished linguistic environment is presumed to result in underdeveloped and weaker language skills for low-SES children. We hypothesized that linguistic experience, in addition to influencing language outcomes, also impacts how well an individual can understand speech spoken in suboptimal listening conditions. We predicted that SES-based differences in language experience would result in differences in speech in noise (SIN) abilities between low- and high-SES youth. Specifically, we assessed whether adolescents from low-SES families would perform more poorly than their high-SES peers on speech-in-noise perception and if differences in language skill between these groups could explain differences in SIN performance. We tested 145 adolescents (73 female, M = 14.5 years old) from low (N = 60) and high (N = 85) SES, as indexed by maternal education, on language measures, including vocabulary knowledge, spelling, real-word and non-word reading, and phonological processing. We also tested the adolescents on other measures known to be important for speech in noise, including processing speed, auditory working memory, and non-linguistic auditory processing (i.e., tone discrimination; backward masking). Lastly, we tested their perception of sentences presented in background babble. Comparing the low- and high-SES groups on these measures, we found that the high-SES group outperformed the low-SES group on every measure except processing speed. Then using a series of regression analyses, we examined how SIN performance in each group relied on the linguistic, cognitive, and auditory processing measures. In the high SES group, vocabulary knowledge, auditory working memory, phonological memory, spelling, and real-word and non-word reading accounted for their speech perception in noise abilities. Similar to the high SES group, vocabulary knowledge and phonological memory explained SIN performance in low SES adolescents. However, for the low-SES group auditory processing, but not measures of spelling and reading, explained SIN performance. These findings demonstrate the importance of language skills on speech perception in noise. Importantly, results indicate that language development, including development of reading skills, bootstraps perception of speech in noise and highlight the pervasive influence of childhood language experience on communication abilities.

B12 Biological markers of reading ability in the adult auditory system *Erika Skoe[1], Lisa Brody[1], Rachel M. Theodore[1]; [1]University of Connecticut*

Learning to read proceeds fluidly for most individuals, yet others face difficulty mapping letters on the page to the linguistic units necessary for accessing meaning, a challenge that can persist into adulthood. Behavioral markers of reading disorders include difficulties in verbal processing speed, verbal memory, and phonological processing. Phonological processing has been found to be a strong predictor of reading ability, not just in poor readers, but also across a spectrum of reading abilities. Research on the auditory system has shown that phonological processing relies critically on the brain's ability to transcribe sounds and sound features into a neural code. Through simple, non-invasive procedures, it is possible to tap into this transcription process by placing a small

set of sensors on the scalp that measure the neuroelectric activity produced in the auditory brainstem in response to sound stimulation. Previous work in preschool and school-age children has demonstrated that auditory brainstem responses (ABRs) are linked to performance on phonological processing tasks. Children classified as poor readers have been found to have abnormal latencies and more variable ABRs compared to their typically-developing counterparts, suggestive of auditory brainstem immaturity in the poor readers. However, it is currently unknown whether these same relationships occur in adults. Our study seeks to fill this gap. In the current study, ABRs were recorded to click and speech stimuli at varying presentation rates in a population of college students with diverse reading levels. All participants are native, monolingual speakers of American English with no history of a hearing or neurological disorder. Participants were evaluated using a standardized assessment battery that measures nonverbal intelligence, working memory, reading comprehension, and phonological processing. Scores on the battery were used to categorize participants into 'below average' and 'above average readers'. Our initial findings indicate that ABR latencies vary as a function of reading level in adults, especially when the sound stimuli are presented at a slow rate that mimics the syllable rate of speech. Specifically, below average readers have earlier latencies at the slow, but not faster rates of presentation, compared to age-matched adults classified as above average readers. This finding is concordant with the theory that reading impairments are linked to atypical perception and encoding of the speech syllable. Drawing on recent work on the developmental trajectory of the brainstem, which revealed that ABR latencies are earlier in school age children compared to adults, we interpret the finding of earlier latencies in below average readers as potentially indicative of delayed and/or prematurely halted auditory development. These data add to the body of evidence indicating that impaired/immature neural encoding of auditory signals may impinge upon the successful development of sound-based skills (i.e., phonological skills) that underlie reading, even into adulthood.

B13 Neural Encoding of Talker-Specific Phonetic Variation

Emily Myers[1], Rachel Theodore[1], Sahil Luthra[2]; [1]University of Connecticut, [2]Brown University

Each talker has a unique vocal signature that includes non-linguistic as well as linguistic properties of the signal. While listeners can take advantage of more global properties of the acoustic signal such as pitch or timbre to identify a talker's voice, evidence suggests that listeners are also sensitive to subtle differences in the way that different talkers pronounce the sounds of speech. For instance, work by Theodore & Miller (2009) demonstrated that listeners who heard a talker who pronounced voiceless stops with a relatively longer voice onset time (VOT) were later able to identify long-VOT productions as more characteristic of that talker's voice. Given that both the longer and shorter VOT variants are considered unambiguous exemplars of the voiceless stop category, this suggests that listeners treat variability within the phonetic category differently depending on the characteristics of the talker. Of interest is whether sensitivity to talker-specific phonetic variation is evident early in the processing stream, for instance in regions already shown to be sensitive to phonetic category structure such as the temporal lobes. In the current study, listeners were exposed to two talkers whose speech for voiceless stops was altered such that one talker had consistently shorter VOTs where the other had consistently longer VOTs. After training, participants performed a phonetic categorization task on both long and short-VOT variants of each talker's voiceless stops (and voiced stops) while BOLD signal was measured using fMRI. Sensitivity to talker-specific phonetic variation (talker-incongruent vs. talker-incongruent stimuli) was observed in right temporoparietal regions that overlap with regions that have previously shown to be modulated in response to lexically-guided perceptual learning (Myers & Mesite, 2014). This pattern suggests that adaptation to talker-specific phonetic variation may engage a right-lateralized network that encodes both linguistic and non-linguistic properties of the talker's voice.

B14 Speech detail that is available three months after birth is ignored when the very first words are recognized

Claudia Teickner[1,2], Angelika Becker[2], Claudia Friedrich[1,2]; [1]University of Tuebingen, [2]University of Hamburg

Our previous work on early language acquisition showed that (i) at three months after birth, infant speech processing is precise enough to recognize speech sound variation, even if this variation only affects a single feature of one phoneme, like the place of articulation (e.g., na vs. ma) or the stress of a syllable. Testing infants consecutively, we found that (ii) at six months after birth, their speech processing seems rather holistic than as detailed as with three months, as they did not recognize single feature or syllable stress variation anymore (Becker, Schild, & Friedrich, 2014; Teickner, Becker, Schild, & Friedrich, 2014). We concluded that the very first word recognition processes at around six months after birth (Bergelson & Swingley, 2013) appear to tolerate variation in phonetic detail and in stress. In the current study, we further investigated the coherency of this sensitivity deficiency within a unified design. We recorded the event-related potentials (ERPs) of 3- and 6-month-olds while presenting them with single syllables (primes) followed by dysillabic German words with stress on the first syllable (targets) that were taken from an early words screening inventory (German version of the McArthur Communicative Developmental Inventories) and from parental questionnaires. Three types of phoneme overlap were presented in prime target pairs: complete overlap (e.g., ma-Mama), partial overlap (e.g., na-Mama) or no overlap (vo-

Mama). These three conditions were presented two times, either featuring stressed or unstressed primes. Replicating the results of our previous studies, we found that (i) speech processing at three months after birth is detailed whereas (ii) with six months it is rather holistic regarding both phonetic detail and syllable stress. Taken together, these results again suggest that the very first representations of words around half a year after birth are rather holistic than detailed.

B15 Exploring STG lateralization and musical experience: Coordinate-based meta-analyses

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INTRODUCTION: Prior investigations of speech processing lateralization provide unclear and contradictory results, especially in the left and right superior temporal gyri (STG). While some groups suggest a left-lateralization (Scott et al., 2000), others suggest a more bilaterally distributed pattern of activation (Hickock & Poeppel, 2007). While this lateralization variance could be driven by differences in task-difficulty (Hickock & Poeppel, 2007), type of baseline (Narain et al., 2003), and spectrotemporal composition of the stimuli (Zatorre & Belin, 2001), these imaging studies do not account for distinction between musicians and nonmusicians. Trained musicians (relative to nonmusicians) have shown increased grey matter density in the STG bilaterally (Bermudez et al., 2009), as well as increased activation in these regions for music processing studies (Ohnishi et al., 2001; Oechslin et al., 2010). The present study, now including those distinctions, identified that musicians had a significantly bilateral STG activation for speech processing. METHODS: Four coordinate-based analyses of functional neuroimaging data (i.e., fMRI/PET) were conducted using activation likelihood estimation (ALE) (Turkeltaub et al., 2012). Inclusion criteria for the contrasts required that the study (i) reported subjects' musical background, (ii) reported contrasts involved in speech or music processing, (iii) reported coordinates for the whole brain in a stereotactic system (MNI/ Talairach), (iv) reported coordinates separately for musicians and nonmusicians, and (v) recruited healthy right-handed subjects. In total, 37 auditory processing studies (5 PET, 32 fMRI) satisfied all of the criteria, with 19 studies that specifically reported targets for musicians and 18 that reported targets for nonmusicians. For completeness, contrasts were further examined in terms of task difficulty, baseline complexity, and spectrotemporal composition. RESULTS: ALE maps ($p<.001$, $k=200$) revealed differences in voxel extent (mm3) and patterns of lateralization for language and music contrasts between musicians and nonmusicians. For speech processing, the ALE maps revealed a largely bilateral STG response for musicians, with only slight left-lateralization (LH>RH=192mm3), while nonmusicians had a highly left-lateralized STG response (LH>RH = 432mm3) with no significant right hemispheric STG activation. For music processing, both groups showed engagement of the STG bilaterally, with a strongly right-lateralized response for nonmusicians (RH>LH=3320mm3) and a comparatively more bilateral response for musicians (LH>RH=400mm3). Crucially, these patterns—for both speech and music processing—could not be explained by the other lateralization factors previously mentioned. CONCLUSION: The present study provides evidence that musical training drives a more bilateral STG response for speech processing—a finding that accounts for previously unexplained variation observed in the literature. While further research is needed, such work has implications for addressing auditory processing disorders with musical training.

B16 Neural Mechanisms of Perceptual Learning of Synthetic Speech

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Adult listeners rapidly adapt to hard to understand synthetic speech in a single training session, generalizing reliably to untrained words. The present study investigated the neural changes that take place following perceptual learning, focusing on changes in attention and post-perceptual processing. We investigated the temporal dynamics of neural activity associated with this perceptual learning by measuring high-density scalp EEG. Our previous behavioral research has suggested that training serves to shift attention to source-specific acoustic cues in a context-sensitive manner. Our previous EEG research (Heald et al., 2013) reported early changes in attention following training, indicated by reductions in the N1 component of the ERP to spoken words and reductions in the N1/P2 complex for correctly identified words. Listeners were tested and trained on synthetic speech (Rsynth, a Klatt based synthesizer) generated by rule, containing degraded and sometimes misleading acoustic cues. Training consisted of identification of single spoken words followed by a paired presentation of the spoken word with its printed form. We measured single word ERPs to 100 words at pretest before training and to 100 words at posttest after training with 128 electrodes (EGI system). Testing consisted of word identification without feedback. As in our prior studies, listeners showed significant changes in intelligibility from pretest to posttest. Examination of scalp-field differences using all sensors showed both significant global field power differences at times that are typically associated with N1, P2 and N400 components of the ERP to spoken words after training compared to pretest ERPs. Moreover, the distribution of brain electrical activity as measured in the ERP topographic map showed reliable changes in scalp distribution from pretest to posttest at time points related to the N1 and P2. We carried out source localization to investigate possible mechanisms underlying these changes in the scalp distribution of EEG over the course of listening to a difficult-to-understand spoken words before and after perceptual learning. Some theories of speech

perception might postulate that learning should produce changes within a static network of brain regions, such as reductions in the N1 that might reflect reduced demands on attention following training. The pattern of change suggests that perceptual learning changes the dynamics of network activity, particularly in the temporal relationship of anterior and posterior processing. Taken together our results suggest a specific form of change in neural processing underlying the generalized perceptual learning of speech.

B17 Different mismatch responses to lexical tone and consonant in Mandarin-speaking phonological deficit preschoolers and control children

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It has been widely accepted the important role of phonological awareness in reading acquisition for all languages. In tonal languages such as Mandarin Chinese, lexical tone is an additional important phonological cue. The present study investigated whether 6-year-old children with poor phonological skills had impaired cortical basis for detecting different speech sound features, in comparison to children with normal phonological skills. Here, using passive oddball paradigm, we recorded auditory mismatch responses to lexical tone and consonant from 63 preschool children, 25 of which had poor phonological skills. The results showed that the control and phonological deficits (PD) children processed the speech sound changes differentially as indicated by a mismatch negativity (MMN) and late discriminative negativity (LDN). The consonant deviants elicited MMN both in PD group and control group, but only elicited LDN in control group. Conversely, the lexical tone deviants elicited LDN both in PD group and control group, but only elicited MMN in control group. The amplitudes of lexical tone at the MMN and LDN time window correlated with character recognition. These results suggests the view that the impaired cortical basis for detecting different speech sound features occurred before the onset of formal reading instruction. MMN and LDN for these sound features might be used for identifying phonological impairment before school age.

B19 The auditory-brainstem response to continuous speech is modulated by the speech envelope and can inform on language processing and attention to speech

Tobias Reichenbach[1], Chananel Braiman[2], Chagit Reichenbach[2,3], Nicholas Schiff[2], A. J. Hudspeth[3]; [1]Imperial College London, [2]Weill Cornell Medical College, [3]Rockefeller University

Speech evokes a complex auditory brainstem response that encodes many aspects of the acoustic stimulus. In particular, the brainstem's response can track the fundamental frequency of speech that typically varies between 100 Hz and 300 Hz. Because the brainstem also receives extensive efferent feedback from the auditory cortex, the brainstem may engage in the processing of speech as well as in attention to one of multiple speakers. Recent research on the potential modulation of the auditory-brainstem response to short speech signals such as vowels by attention or speech intelligibility has, however, yielded inconclusive results. This may be partly due to the small signal-to-noise ratio of the brainstem's response, which necessitates many repetitions of short speech signals to which the brain may then adapt. In this study we have investigated the response of the auditory brainstem to continuous speech. Continuous speech does not require repetition. Moreover, continuous speech allows to correlate the brainstem response to the envelope of the speech signal. This may be important since it has recently been shown that cortical oscillations can entrain to the envelope, and since this entrainment may serve as a mechanism for language processing. We have recorded the response of the auditory brainstem to three-minute continuous speech signals in ten healthy volunteers. We have used the computer-linguistic program PRAAT to construct monotone speech, that is, speech in which the fundamental frequency and its higher harmonics remains constant over time. To avoid stimulation artifacts, we have further high-pass filtered the speech such that the fundamental frequency itself is absent from the speech signal. Our recordings showed that the auditory brainstem responds strongly at the fundamental frequency of the monotone speech. We further found that the amplitude modulation of the auditory-brainstem response is correlated to the speech envelope. The envelope correlation evidenced a characteristic delay of the brainstem response of about 9 ms. Importantly, the amplitude of the correlation at this delay has a much larger signal-to-noise ratio than the simple Fourier amplitude of the brainstem's response. Motivated by these results, we then performed two experiments to assess the modulation of this brainstem response by cognitive processes. First, we compared the brainstem response to intelligible, forward speech to that to unintelligible, time-reversed speech. For all subjects, we found that the envelope-modulated brainstem response at the fundamental frequency was significantly larger for reversed than for forward speech. Second, we investigated how the brainstem response is modulated by attention. We found that the envelope-modulated brainstem response at the fundamental frequency was, for every subject, significantly larger when attending to the speech signal then when ignoring it by reading a text. These results evidence a modulation of the auditory-brainstem response by higher cognitive functions. Importantly, we observed these consistent differences only when we accounted for the envelope modulation of the brainstem response. The complex brainstem response to continuous speech, and its resulting modulation by the speech envelope, may thus be a powerful tool for probing the role of the auditory brainstem and efferent feedback in language processing.

B20 Topographic representation of frequency-selective attention in human auditory cortex *Frederic Dick[1], Matt Lehet[2], Lori Holt[2]; [1]Birkbeck/UCL Centre for NeuroImaging, [2]Carnegie Mellon University*

Humans and other mammals are very sensitive to changes in the salience, task-relevance, and composition of the acoustic dimensions of complex and ecologically important sounds. Listeners appear to be able to shift attention across multiple simultaneously-present acoustic dimensions to home in on the ones that are diagnostic in guiding behavior. In particular, psychoacoustic experiments have shown that both endogenously and exogenously cued attention to a particular frequency or spectral band can enhance detection of auditory targets and sharpen sensitivity to multiple features within the attended band. Electrophysiological work in non-human animals has begun to uncover the mechanics of this process (Fritz et al., 2007; 2010) while a pair of fMRI studies in humans (da Costa et al., 2013; Paltoglou et al., 2009) have shown that attention to high or low frequency bands drives responses across auditory cortex in a way that is predicted by tonotopic mapping in the same participants. However, it is unclear how fine-grained this mapping is, how it differs across auditory fields, how it relates to the underlying myeloarchitecture of auditory cortex, and how other cortical regions drive or modulate 'attention-o-tonotopic' maps. In the current study, we use a novel fMRI paradigm to drive sustained attention to multiple frequency bands; in the same participants, we obtained quantitative MR data (to estimate cortical myelination) along with tonotopic mapping in order to localize auditory areas (Dick et al., 2012). Across participants, we found that multiple auditory fields showed 'attention-o-tonotopic' mapping that was closely aligned with tonotopic maps (which can be quite differently organized across participants and even over hemispheres). We also characterized the relationship of attention-o-tonotopic fields to putative the cortical myeloarchitectonic maps, both in the auditory core as well as non-core fields, and found interesting and reliable (cross-scan) patterns of individual variation. These results have implications for understanding how human listeners direct attention to behaviorally-relevant auditory dimensions in listening to complex sounds like speech and music and provide groundwork for understanding how experience may modulate these maps.

B21 A new framework to investigate hemispheric asymmetries in speech *Adeen Flinker[1], David Poeppel[1,2]; [1]New York University, [2]Max Planck Institute for Empirical Aesthetics*

The left and right hemispheres have been argued to have different sensitivities to temporal and spectral auditory information, but the underlying cortical mechanisms remain unknown. Two related models posit that asymmetries arise from a relative difference in temporal integration windows (i.e. AST, Poeppel 2003) or a difference in spectral versus temporal resolution (i.e. Zatorre et al. 2002). Here we examine a unifying scheme based on the modulation power spectrum (MPS) of speech, providing a novel framework to parametrically manipulate speech stimuli and test psychophysical and neurophysiological responses. In contrast with a spectrogram, which represents the signal's amplitude across time and frequency, the MPS is a second order representation that assesses how the time-frequency power is modulated across the spectral and temporal axes. We propose that the two hemispheres integrate different ranges of spectral and temporal modulations. In order to address this hypothesis, we implemented a new filtering technique and varied the degree of spectral and temporal modulations in the signal to produce new sentences materials. We characterized the modulation space as a function of intelligibility as well as pitch (here: gender) identification. Neurophysiological responses (MEG power 0.1-8 Hz) across sensors correlated significantly with the temporal and spectral modulation space. The spatial distribution of sensors was more left lateralized for the temporal modulation axis and more right lateralized for the spectral modulation axis. Behaviorally, the fine-graded parametric steps reveal a sharp intelligibility cutoff, a right ear dichotic advantage as well as an influence of spectral modulation on pitch perception.

B22 Investigating the factors that impact upon intelligibility processing when using TMS to target the auditory cortex. *Dan Kennedy-Higgins[1], Joseph T. Devlin[2], Helen E. Nuttall[1], Patti Adank[1]; [1]Department of Speech, Hearing and Phonetic Sciences, University College London, [2]Department of Experimental Psychology, University College London*

There is debate in speech perception research concerning the degree of laterality within the network. Correlational techniques, including fMRI and EEG have identified several key regions for processing intelligible speech, but the causal role of these regions in intelligibility processing is unclear. Transcranial magnetic stimulation (TMS) affords the ability to transiently disrupt cortical processing in a healthy human population, providing an opportunity to establish causal links between brain and behaviour. We investigated three factors that potentially influence the impact of TMS on speech intelligibility processing: online vs offline TMS, stimulation intensity, and location of the control site. The performance of 64 healthy native British English speakers was measured on a speech recognition threshold (SRT) test. The SRT represents the minimum signal-to-noise level (in dB) at which an individual can perceive 50% of the auditory speech material. Performance was assessed without TMS and after stimulation of the left superior temporal sulcus (STS), right STS and a control area. Vertex was used as the control site in experiments 1 and 2, occipital pole (OP) in experiment 3 and lateral occipital complex (LOC) in experiment 4. Experiment 1 found a significant impairment of performance on the

SRT test using 10Hz online rTMS when applied to either the left or right STS but no effect after vertex (control site) stimulation. Experiments 2 and 3 employed a 1Hz offline rTMS procedure. In experiment 2, the TMS intensity was set at a predefined 40% of overall maximum stimulator output level. In experiment three the intensity was defined by each individual subjects' active motor threshold (56% average). Experiment 2 showed a significant difference between SRTs following left STS stimulation vs. no TMS baseline; while no significant differences were found in experiment three. Finally in experiment 4 we used a stimulation frequency of 10Hz but adopted an offline rTMS design. Results of this experiment replicate those of experiment one and two with a significant impairment in performance after left STS stimulation compared to LOC (control site) stimulation. The results from this series of experiments suggest that with the right paradigm, TMS is capable of impairing speech perception abilities and holds promise to provide answers to questions raised in the current debate on the neural architecture of speech processing.

B23 A causal inference model for the McGurk effect *John Magnotti[1], Michael Beauchamp[1]; [1]Baylor College of Medicine*

During speech perception, humans integrate auditory information from the voice with visual information from the face. A striking example of this integration is the McGurk effect: when presented with particular pairs of incongruent auditory and visual speech syllables, individuals report hearing a third, unique syllable. Many explanations of the McGurk effect have centered on optimal integration, positing that auditory and visual cues are integrated according to their reliabilities. A problem for these integration models is the inability to predict when integration should not occur. For example, when speech cues have large asynchronies, they should not be combined, because they were likely generated from different causes. Rather than always integrating, the optimal observer should first perform causal inference to determine the likelihood that the two cues are coming from the same source. Previous work on this causal inference judgment has focused on causal judgments of asynchronous congruent audiovisual speech and spatially disparate beep/flash pairs. Modeling causal inference of the McGurk effect has remained difficult because the exact nature of the disparity involves a complex relationship between the auditory and visual cues, rather than two samples from a common domain (e.g., the auditory cue onset and the visual cue onset can be directly compared). We describe a generative model of multisensory speech perception that includes the critical step of determining the likelihood that the voice and face information have a common cause. The model is based on a principled analysis of how an observer should solve the causal inference problem using the both the disparity and reliability of the auditory and visual speech cues. The causal inference model has the power to explain both the integration that occurs during the McGurk effect and makes specific predictions about when this integration should break down—as the asynchrony increases, the model predicts the smooth transition to reporting only the auditory speech cue. The model also makes a testable, counter-intuitive claim: individuals with excellent visual speech recognition should be less likely to infer a common cause for stimuli with moderate asynchrony, as compared to individuals with poor visual speech recognition. A major benefit of causal inference type models is richer characterization of the McGurk effect in particular and speech perception more generally. Parameters from our causal inference model are directly interpretable in terms of stimulus and subject properties, allowing the model to capture both stimulus differences (e.g., talker effects) and listener differences (why some people get the effect but not others). The framework is general enough to handle the conditions of no disparity (full integration), high disparity (complete segregation), and conditions in between (weighted average of the integration and segregation models).

B24 Auditory temporal windows revealed by locally reversing Mandarin speech *Xiangbin Teng[1], Ning Mei[1], Xing Tian[3,4], David Poeppel[1,2]; [1]Department of Psychology, New York University, New York, NY, [2]Max Planck Institute, Frankfurt, Germany, [3]New York University, Shanghai, [4]NYU-ECNU Institute of Brain and Cognitive Science at NYU Shanghai*

Speech perception relies on the extraction of invariant linguistic information from speech signals with stochastic characteristics in time. To tolerate the temporal variations in speech, the auditory system analyzes signals across temporal windows of different durations, so the signals of appropriate length can be integrated and linguistic information of the corresponding timescale extracted faithfully. One way to probe this windowing analysis is to perturb the temporal structure of the speech signal. One technique involves reversing speech segments of different sizes and examining auditory performance. The present study employed segments of Mandarin speech varying between 30 to 300 ms in duration. We reversed the original speech signal, amplitude envelopes, and fine structure separately. Participants listened to ten Mandarin sentences at each reversed segment length. We fit intelligibility scores to psychometric function curves. We observed that speech intelligibility dropped below fifty percent when (1) the segment size used to reverse the original speech signal exceeded ~ 67 ms, and (2) the segment size used to reverse the envelope exceeded ~ 98 ms. Reversing the fine structure had no effect on intelligibility. The results further show that speech perception was not affected when the length of the reversed speech segment was less than ~ 40 ms or when the length of reversed envelope segment was less than ~ 60 ms. We provide an account of the current results addressing how a tone language can be effectively used to test the temporal analysis of different aspects of speech.

B25 A new acoustic space for hemispheric asymmetries investigated by dichotic listening

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Speech signals carry acoustic cues underpinning both the content of the message as well as speaker identity. In order to identify time-frequency features that are critical to these cues, we used a new speech filtering technique (Chi et al., 1999; Elliot & Theunissen, 2009) that decomposes speech along the temporal (time) and spectral (frequency) modulation domains. Sentences were degraded along both axes and filtered at critical lowpass modulations (temporal – 2 to 8 Hz, spectral – 0.16 to 1.12 cycles/octave) in fine-graded parametric steps. This approach provides a detailed resolution of psychophysical responses to intelligibility and gender identification. We found that filtering in both temporal and spectral domains affects intelligibility, while only the spectral axis affects gender identification. In order to investigate hemispheric asymmetries in the context of this new acoustic characterization, we employed a novel dichotic listening paradigm based on the filtered sentences. Psychophysical results showed a significant right ear advantage for the temporal modulation axis and a left ear advantage for the spectral modulation axis, providing evidence for an asymmetrical integration of spectral and temporal modulation cues.

B26 Effects of extended training on an incidental auditory category learning task

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Understanding auditory category learning informs the mechanisms available to phonetic category acquisition. Recent research has examined the ability of participants to learn complex, nonspeech auditory categories (Gabay, Dick, Zevin & Holt, 2015) and non-native Mandarin tone categories (Liu, 2014) during incidental training that involves auditory sound-category mappings that indirectly facilitate goal-directed performance in a non-auditory task. Participants—who are unaware of the importance of the auditory stimuli and the fact that the auditory categories perfectly predict the location of an upcoming visual stimulus in a visual detection task—learn the auditory categories and generalize to novel exemplars. Other perceptual category learning research has emphasized the significance of stimulus input distributions in engaging different category learning systems (Ashby & Maddox, 2011). An explicit system learns stimulus distributions differentiated by simple rules via explicit strategies and involves the head of the caudate nucleus in the striatum, as well as prefrontal cortex. The implicit system, in contrast, learns distributions requiring integration of dimensions via a slower procedural-learning process that engages the body and tail of the caudate as well as the putamen. This approach has recently been applied to speech category learning (Chandrasekaran, Yi, & Maddox, 2013). However, it is unknown whether there is a distinction between rule-based versus information-integration distributions for categories learned incidentally; prior studies have typically used explicit categorization training task with overt category decisions and trial-by-trial feedback. There is growing evidence that explicit and incidental learning paradigms draw upon neural substrates with distinctive computational specialties (e.g. Doya, 1999; Lim, Fiez, Wheeler, & Holt, 2013; Tricomi, Delgado, McCandliss, McClelland, & Fiez, 2006), so this is an important unresolved issue. In the current study, we examined learning of rule-based and information-integration nonspeech sound distributions across a two-day, spaced training regime or within a single session, with the number of overall training trials equated. When learning information-integration category distributions, participants in the extended training condition exhibited more robust evidence of categorization in the incidental task than those who trained in a single session. This difference was not observed among participants learning rule-based category distributions. In addition, there was an overall benefit of spaced training on generalization of categorization to novel sounds. This benefit was more pronounced for information-integration category learning. The results suggest that incidental auditory category learning of categories requiring integration of information across dimensions (like phonetic categories) can be enhanced with spaced training.

B27 Visual and Temporal Influences on Multimodal Speech Integration

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Speech perception is often bimodal: Perceivers use auditory and visual cues simultaneously to understand a speech signal when communicating. A neural model of audio-visual integration by Bhat et al. (2015) postulates that the integration of auditory and visual speech into a single percept involves a reweighting mechanism that shifts auditory processing from low-level to high-level auditory networks (e.g., from primary auditory cortex to middle temporal gyrus and Wernicke's area) as informativeness of the signal increases to better facilitate integration. The current study (N=40) behaviorally tested this claim by manipulating visual informativeness and measuring perceivers' audiovisual onset asynchrony (AVOA) tolerance for eight consonant-vowel syllables (/ga/, /sa/, /la/, /da/, /fa/, /ba/, /ra/, and /wa/, in order from least to most visually salient). Visemes varied in visual salience as defined by their place of articulation, number of visual cues, and uniqueness, with the prediction that increased visual salience will induce reweighting towards high-level auditory networks, thus increasing cohesion of the signals and increasing AVOA tolerance. AVOA threshold was estimated using a staircase method and averaging the last four reversals in the participants' responses. The

results patterned in the direction opposite of Bhat et al.'s model predictions: As the visual salience of the viseme increased, the AVOA threshold decreased, indicating an increased sensitivity to the temporal relationship between signals. Results also suggested that the duration of the viseme influenced AVOA tolerance, with thresholds increasing as articulatory duration increased. Follow-up experiments explored this relationship further by varying CV duration (short, normal, long) along with visual salience and estimating AVOA thresholds using the same adaptive paradigm. Stimuli were created by manipulating the duration artificially in the first experiment (N = 24) and with natural productions in the second experiment (N = 18). Durational predictions suggested that shorter visemes will decrease the temporal window of integration by speeding integrative processes, thus decreasing AVOA tolerance compared to longer visemes. Results showed that in addition to replicating the results of the first experiment, AVOA threshold increased as duration of the viseme increased, demonstrating an independent contribution of temporal properties of the stimulus on AVOA tolerance. An alternative theoretical explanation to Bhat et. al's model is offered in which visual informativeness and duration engage low-level visual attention mechanisms that highlight the temporal mismatch of the visual and auditory signal onsets, therefore decreasing AVOA tolerance. Complementary neuroimaging experiments are planned to test this proposal.

B28 Efficient classification of the temporal and spectral modulations essential for speech intelligibility

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Speech has characteristic patterns of energy fluctuation across both time and frequency. These fluctuations, known as temporal and spectral modulations, carry information necessary for effective speech reception. Temporal and spectral modulations can be captured jointly in the modulation power spectrum (MPS), which provides a phase-invariant representation of the modulation content of speech. The MPS is obtained from the 2D Fourier transform of the log-spectrogram. The magnitude of each pixel in the MPS gives modulation energy at a unique combination of temporal and spectral modulation rate (Hz, cycles/kHz). This representation is highly informative because it summarizes the subspace of modulations occupied by speech, and because modulation power in the joint representation can deviate from the pattern obtained from spectral and temporal envelopes considered individually. In the current study, we combined filtering techniques recently developed for the MPS domain with the classification procedure known as "Bubbles" to identify spectral and temporal modulations essential for speech intelligibility. Ten normal-hearing subjects performed a sentence reception task in which speech was degraded by filtering the MPS. On each trial, the MPS was rendered opaque and only randomly chosen regions were made available to the listener. These glimpsing regions – randomly placed Gaussian apertures known as bubbles – allowed certain spectral and temporal modulations through while removing others. The number of bubbles was varied adaptively to drive performance (number of keywords identified) to a threshold level (50% correct). Trials with more bubbles had a greater proportion of the original MPS intact, increasing the likelihood of effective speech reception. Critically, variability in the pattern (location within the MPS) of the bubbles across trials provided the basis for classification analysis. For each subject, trial-to-trial behavior was reverse correlated with random, trial-to-trial bubble patterns to produce a classification image (CImg) showing the regions of the MPS that reliably yielded effective speech reception when glimpsed through bubbles. A group CImg was formed by summing the individual-subject CImgs, and pixels that contributed significantly to intelligibility were identified by permutation testing ($p < 0.05$, 1000 null CImgs formed by shuffling subject responses). A core region of the MPS comprising low temporal (< 15 Hz) and spectral (< 3 cyc/kHz) modulation rates contributed significantly to intelligibility. The classified region was low-pass in the spectral modulation domain (3dB-down cutoff = 1.5 cyc/kHz) and bandpass in the temporal modulation domain (peak = 3.7 Hz). To test the reliability of the classification procedure, the experiment was repeated with a new group of five normal-hearing subjects using 2x-time-compressed sentences (implemented in Praat). The time-compression procedure effectively doubled the temporal modulation rates present in the stimuli. The region of the MPS classified in the follow-up experiment was shifted up by ~1/2 octave in the temporal modulation domain, demonstrating the sensitivity of the bubbles technique. However, the shift did not strictly follow changes in modulation energy induced by time compression, indicating some limitation either on subject strategies or on the neural representation of speech.

B29 Integration of temporally asynchronous speech cues investigated with eye-tracking and electrocorticography: Brain and behavior do not always timelock to the signal.

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A critical problem in speech perception derives from the fact that acoustic cues unfold over time. Even cues to a single phoneme do not arrive simultaneously. For example, fricatives like "s" and "sh" require information in both the frication noise and the subsequent formant transitions. One could envision two strategies for integrating asynchronous cues. Under one view, cues may be held in a memory buffer until enough information arrives to identify the phoneme. At this point, lexical items are activated. Alternatively, listeners could activate lexical items continuously as soon as any information arrives, updating activation as later cues arrive. We tested these

strategies with eye-tracking and electrocorticography. Research using eye-movements has shown that listeners make early commitments to potential lexical items before all information for a phoneme arrives, supporting continuous activation (McMurray, Clayards, et al., 2008; Toscano & McMurray, 2012; Reinisch & Sjerps, 2013). We investigated this with fricatives (/s/, /□/), where the asynchronous cues (frication spectrum and formant transitions) are highly acoustically distinct. We used eye-tracking in the visual world paradigm to assess lexical activation time-locked to the arrival of manipulated cues. Eye-movements to lexical competitors were not affected by frication spectrum until the end of the frication (the onset of the vowel). In a follow-up experiment we artificially lengthened or shortened the fricatives to see if the onset of the vowel is critical for the release of this buffer, or if listeners are just slow to process frication. We found evidence for the former, suggesting voicing may cue buffer release. These findings support a buffer strategy for fricative processing, one not seen in other speech sounds. Coarticulatory information in the fricative also gives listeners clues to the upcoming vowel (Yeni–Komshian & Soli, 1981). We next asked if anticipatory coarticulatory information is used with the same buffering strategy. Fricative-initial words were spliced so that coarticulation matched or mismatched an upcoming vowel. Unexpectedly, listeners showed evidence of a buffer for fricative identification, but used coarticulatory information significantly earlier to predict the upcoming vowel. This suggests that coarticulatory information in the fricative (cueing later material) is used immediately even though the fricative identity is processed later. To test the cortical instantiation of this system, we examined intracranial recordings from three adults undergoing monitoring for seizure localization. Participants heard consonant-vowel syllables beginning with /s/ or /□/ in a passive listening task. An SVM classifier analysis was conducted at 25 ms intervals using local field potentials and high gamma band activity recorded from Heschl's gyrus and superior temporal gyrus (STG). Patterned activity in Heschl's gyrus was sufficient to correctly classify the fricative throughout the frication. However, in all three subjects, areas of STG did not show above-average accuracy until the onset of the vowel, suggesting Heschl's gyrus may serve as the buffer. These results suggest that the auditory system has adopted complex solutions to the problem of integrating asynchronous cues. Even for a single phoneme, some cues are buffered (possibly in Heschl's gyrus), while other cues are integrated immediately.

Language Development, Plasticity, Multilingualism

B30 Bilingual language control in perception vs. action: MEG reveals reactive control mechanisms in anterior cingulate cortex and domain-general proactive control in dorsolateral prefrontal cortex

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Introduction: Language-switching is central to bilingual individuals' everyday experience, yet the neural foundations underlying this process remain largely uncharacterized. Is bilingual language control a subdomain of general executive control (Abutalebi et al., 2008) or is it supported by language-specific mechanisms (Calabria et al., 2011)? This fundamental question interacts with another unaddressed basic question of the neurobiology of bilingualism: Does language-switching in comprehension involve similar neural mechanisms as during production? We addressed both questions within the same experiment by asking subjects to either produce or comprehend number words while the language switched between Arabic and English, and by comparing these results to similar tasks where instead of language-switching, the semantic category of the comprehended or produced word was changing. Methods: 19 Arabic-English bilinguals performed four maximally parallel switching tasks varying in modality (production/comprehension) and switch type (language-switching/category-switching), yielding a 2 x 2 design. In both production tasks, participants named playing-cards for which the color of the suit cued output selection. In language-switching, participants named the numerosity depicted by the card, red suits standing for Arabic and blacks for English. In category-switching, performed in Arabic, red indicated numerosity naming and black suit naming. In the language-switching version of the comprehension tasks, subjects listened to number words in Arabic or English and subsequently indicated whether a visually presented number matched the auditory input. In the category-switching variant, subjects heard number or color words in Arabic and indicated whether a visually presented colored number matched what they had heard. Magnetoencephalography was recorded during all tasks, with analyses focusing on prefrontal and cingulate cortices (PFC/ACC respectively), previously implicated for language selection and switching (Abutalebi & Green, 2007) as well as for general domain cognitive control (Braver, 2012; Hikosaka & Isoda, 2010). In production, we only analyzed data that preceded the motion artifacts created by articulations. Results: The comparison between language-switching in production vs. comprehension elicited significant interactions at 300-700ms in the left ACC and in the PFC bilaterally, the former showing an increase for switch over non-switch trials in comprehension and the latter in production. Additionally, contrasting language-switching vs. category-switching revealed that the PFC production effect generalizes to category-switching while the ACC comprehension effect did not. Conclusion: This study demonstrates, for the first time, that the brain areas responsible for language-switching in production and comprehension dissociate even for identical lexical material: while producing switches recruited the dlPFC bilaterally, comprehending them engaged the left ACC,

suggesting that the recruited cognitive control may adapt as a function of the domain of the switch. Further, these results conform to extant models of cognitive control (Braver, 2012) suggesting that whether the switch is proactive (in production) or reactive (in comprehension) could influence to a great extent the neural involvement during language switching. Finally, our findings suggest that language-switching is a subdomain of general executive control in production, an active task, whereas during more passive comprehension, language and category-switching appeared to elicit no overlap.

B31 Neural underpinnings of language switching in trilinguals: an MEG study *Suzanne Hut[1], Päivi Helenius[2], Alina Leminen[1,3], Jyrki Mäkelä[4], Minna Lehtonen[1,5]; [1]Cognitive Brain Research Unit, Institute of Behavioural Sciences, University of Helsinki, Finland, [2]Brain Research Unit, O.V. Lounasmaa Laboratory, and Aalto Neuroimaging, Aalto University, Espoo, Finland, [3]Center of Functionally Integrative Neuroscience, Department of Clinical Medicine, Aarhus University, Denmark, [4]BioMag Laboratory, HUS Medical Imaging Center, Helsinki University Central Hospital, Helsinki, Finland, [5]5Department of Psychology and Logopedics, Åbo Akademi University, Turku, Finland*

In today's increasingly multilingual world, many people learn to speak two or even more languages reasonably fluently. Amongst these multilinguals are also those that grew up as bilingual speakers, and then mastered a third language after childhood. How does the brain process and control languages that are learned at a different age, even if proficiency in all these languages is high? Early acquired dominant languages are likely to have higher activation levels than less dominant languages, however, it is still largely unknown how the activation levels of these different languages are controlled, and how interference from an irrelevant language is prevented. Previous research on language switching reported asymmetrical switching costs, where switches to the dominant language result in larger switching costs than switches to a second language (L2) (see Bobb and Wodniecka, 2013 for an overview). This suggests that languages with higher base activation levels need to be inhibited more strongly that a less dominant, second language. A recent magnetoencephalography (MEG) study by Pellikka et al (2015) found an asymmetric switching effect in the N400m response during a semantic categorization task, suggesting that the dominant language requires more suppression when it occurs in a context of predominantly L2 words. The current MEG study takes this one step further by focusing on trilingual language switching, in order to investigate the control mechanisms between early acquired languages, and a non-dominant language learned at a later age. In the experiment, early Finnish-Swedish bilinguals who mastered English after childhood (N=18), were presented with spoken words in each of the three languages, while MEG was simultaneously recorded. The words in each language were presented in a pseudorandom order with an ISI (inter-stimulus interval) of 1600ms, i.e. three or four words in one language were directly followed by three or four words in another language. During the experiment, the participants performed a simple semantic categorisation (animate/inanimate) task. Data on six different switching directions were obtained: 1)Finnish to English, 2)Finnish to Swedish, 3)Swedish to English, 4)Swedish to Finnish, 5)English to Finnish, and 6)English to Swedish. For all words, prominent activation was detected bilaterally in the temporal cortex. Preliminary results showed significantly larger brain responses in the 300-500ms time window during switches from English to Finnish as compared to non-switched Finnish words, and a similar trend is visible for switches from English to Swedish. However, switches between the early acquired languages Finnish and Swedish did not show any significant effects. The switching effects were particularly pronounced in the right hemisphere, whereas no lateralisation effects were found during the presentation of non-switched words in any of the languages. These findings point to asymmetric switching costs, where switches to one of the native languages are more costly than switches to a later learned language. In line with previous findings, these preliminary results suggest that more dominant languages are suppressed during the use of a non-native language. However, the mechanisms of control between two native languages seem to differ to that to some extent, as they do not require similar suppression.

B32 ERPs reveal mechanisms of language control during L2 speech planning: Inhibitory processes observed on the Go *Rhonda McClain[1], Eleonora Rossi[1], Judith F. Kroll[1]; [1]The Pennsylvania State University*

When bilinguals prepare to speak, words from both languages are active and potentially competing for selection. Inhibition of the dominant or first language (L1) has been hypothesized to resolve cross-language competition. At the same time, the two languages interact seamlessly during code-switching, suggesting that mechanisms of language control are engaged flexibly during bilingual production. Flexibility in the recruitment of different cognitive control resources may be the source of bilingual cognitive advantages (e.g., Morales et al., 2015). However, there is little evidence that directly links inhibition during speech planning to the observed cognitive advantages. Additionally, little is known about how inhibitory control is engaged by second language (L2) learners. Learners may have a particular need to inhibit the more dominant L1 to speak a weaker L2. Learners may also need to develop mechanisms of recovery from inhibition in order speak the L1 after speaking the L2. Therefore, we hypothesized that L2 learners would demonstrate online modulation of inhibition as a consequence of speaking two languages. We examined these issues by using ERPs to catch inhibition on the fly. In the present study, participants named pictures in blocks that required

standard picture naming and later named pictures in a Go/No-go fashion. A language switching manipulation was used to determine whether there were inhibitory effects during learners' speech planning. Switches between languages occurred over blocks, rather than on a trial-by-trial basis. L2 learners (N=18) first named pictures in the L1, then L2. Later, they named pictures again in the L1, but in Go/No-go fashion. Monolinguals (N=18) named in L1 only during the standard picture naming blocks and later Go/No-go blocks. We predicted that if learners inhibit L1 as a consequence of speaking L2, learners and monolinguals would be differentially affected by the requirement to speak the L1 in later blocks. Literal repetitions of pictures from the standard naming blocks were included in the later Go/No-go blocks to assess the consequences of language inhibition (e.g., Misra et al., 2012). Based on previous research, we predicted that No-go trials should elicit greater positivity than Go trials in the P300. However, we predicted that if learners engaged inhibition in order to speak the L2, they would show enhanced P300 amplitudes on No-go trials compared to monolinguals. Overall, the ERP patterns demonstrated increased P300 for Go trials relative to No-go trials for both groups, suggesting that Go/No-go naming affected both groups similarly. However, when L2 learners named pictures that were repeated, the Go P300 amplitude was larger than when completely new pictures were named. When monolinguals named repetitions, there was no difference in the P300 amplitude between new and repeated pictures. The increased P300 for repetitions suggests that there was inhibition of pictures previously named in the L2. These results suggest that there are inhibitory consequences of speaking the L2 on the L1 for learners. In addition, the results suggests that there are overlapping mechanisms of language control and domain-general inhibition.

B33 Bilingualism delays manifestation of Alzheimer's disease

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Objectives: The current study investigated the effects of bilingualism on the clinical manifestation and diagnosis of Alzheimer's disease (AD) in a European, homogeneous sample of patients. Methods: We assessed all new incoming possible AD patients in two university hospitals within a specified timeframe. In total, 69 monolinguals and 65 bilinguals diagnosed with probable AD were compared for onset of clinical manifestation and diagnosis of the disease. The influence of gender, education, occupation, and other potentially interacting variables was also examined. Results: The results of our linear regression model indicated a significant delay for bilinguals of 4.6 years in AD manifestation and 4.8 years in AD diagnosis. This bilingual effect occurred independently of other potential confounding factors such as gender, education, and occupation. Conclusions: Our study strengthens the claim that bilingualism contributes to cognitive reserve and postpones the symptoms of dementia. It is the first study to show that such a bilingual AD delay in non-immigrants living in an L1 dominant culture, using a systematic sample of all incoming suspected AD patients, coming from a homogeneous population with regard to ethnicity, culture, environment, and patterns of language use. These findings have considerable implications for the cognitive wellbeing of AD patients, and for health care costs.

B34 Cortical Maturation Accompanying Individual Differences in Longitudinal Development of Children's Reading Ability

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Acquisition of proficient reading skills in early childhood is crucial to later success in critical thinking and communication, and provides an important foundation for higher learning. The identification of cognitive and neuroanatomical markers associated with longitudinal growth in children's reading abilities is therefore key to understanding the developmental trajectory of these important skills. Previous attempts to relate brain structure and function to reading competency have focused on a single time point; thus, little is known about the brain bases of individual children's longitudinal development of reading abilities. Using a longitudinal design combined with multimodal brain imaging, we investigated how individual differences in reading skill acquisition correspond to maturation in brain networks supporting proficient reading. Cognitive measures and high-resolution whole-brain structural images were obtained at two time points (time 1 = 8.2 ± 0.9 years, time 2 = 10.6 ± 1.7 years) from thirty-seven children. Vertex-wise analysis of cortical thickness revealed a positive relationship between changes in cortical thickness and changes in reading ability in the bilateral posterior cingulate cortex, an area implicated in episodic memory and emotional salience. A negative relationship was identified between changes in cortical thickness and changes in reading ability in a network of regions associated with semantic memory and recollection (left anterior temporal lobe, right middle temporal gyrus, right parahippocampal gyrus, and right precuneus), language processing (right supramarginal gyrus and right angular gyrus), and visual processing within the ventral visual stream (right inferior temporal gyrus, right ventral temporal-occipital cortex, and right middle occipital lobe). Results suggest that structural maturation in networks involved in language processing and memory over time affect the development of reading abilities in early childhood. These findings provide an unprecedented greater understanding of how the developing brain changes in response to reading acquisition and mastery.

B35 Salience network manages language production of bilinguals through interaction with target brain regions

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Bilinguals control language processing by directing relevant information to the neural substrate engaged by currently used language. Recent evidence showed the dorsal anterior cingulate cortex (dACC) may take on this function of language control, consistent with its core position in the salience network (SN). The SN is proposed to direct relevant information to target brain regions and assist the processing. The core regions of SN also include the bilateral anterior insula, which often shows greater activation when the language tasks engage more demand of control. The question arises how the dACC and anterior insula of bilinguals function to manage language processing in the framework of SN in order to select target language for production. The present study explored this issue by investigating the activation and functional connectivity (FC) of SN with language regions with and without time lag. Bimodal bilinguals were recruited in this study for the reason that their two languages are in different modalities and can be separated in respect of the underlying neural substrate and FC with SN. We adopted a delayed picture naming task, in which a picture was presented first, then a cue after several seconds (2, 4, 6s), indicating which language to name. The dACC and left anterior insula were activated during preparation, while the putamen and language-specific regions activated during production. We further investigated the simultaneous and time-lagged FC between the SN and language regions in two other naming tasks. The dACC and insula, but not the putamen, were found to simultaneously interact with target language region more in that language than the other one (e.g. the left PCG for sign language than spoken language). The granger causality analyses showed that the dACC and insula time-lagged influence the target language regions, suggesting their role in assisting the lexical processing of target language. Taken together, these results inform us about the way that the dACC and anterior insula interacted with other language regions. It also sheds some lights on the significant role of SN in language processing and control.

B36 Behavioral and neural effects of language anticipation during bilingual word production

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Previous research has suggested that informative semantic category cues may facilitate the processing of upcoming linguistic information (e.g. Cristescu & Nobre, 2008; Kanske, Plitschka, & Kotz, 2011). However, little is known about processing of the cues themselves or about the effects of cues on bilingual language processing. The pre-activation of language membership information in particular may have important implications for our understanding of bilingual language control. The present study compared the nature of semantic category and language membership pre-activation and the subsequent consequences on target word processing. Spanish-English bilinguals learned to associate symbols with a particular type of information about an upcoming word (English, Spanish, animal, tool, or no information). Either a language membership cue (Language Task block) or a semantic category cue (Semantic Task block) was presented two seconds prior to each of 576 words, which participants named aloud as quickly as possible. Naming times were recorded, and event-related potentials (ERPs) were time-locked to cues and to target words. Participants named words 25 ms faster when given a language membership cue compared to a null cue but no such behavioral difference was found in the Semantic Task. ERPs 300-400 ms post-cue onset revealed that participants processed informational cues differently than null cues in the Semantic Task, but no difference was found in the Language Task. In contrast to predictions based on prior studies, ERPs to target words preceded by informational and null cues were not significantly different. However, language switches in the Semantic Task and the null cue trials in the Language Task elicited a larger P2 than language non-switches 150-250 ms post-target onset. The direction of this effect was reversed when language membership cues preceded targets. Additionally, Spanish words elicited a larger frontal negativity than English words in the 300-500 ms time window when no language membership cues were given; the presentation of language membership cues eliminated this difference. Behavioral results in the Language Task and ERP results for the cues in the Semantic Task confirmed that participants processed the cues and used them to pre-activate information about upcoming words as intended. Yet the lack of an ERP difference between informational and null cues on target words suggests that the results of prior studies may have arisen due to costs associated with mispreparation for an upcoming target (invalidly cued) rather than benefits of preactivation of correct information about an upcoming target (validly cued). Even so, we found other behavioral and ERP evidence that language membership cues did affect the processing of target words. These cues may have hastened production in the target language by allowing participants to pre-activate grapheme to phoneme conversion rules specific to each language. Furthermore, information about the upcoming language may have enhanced bilingual language control by reducing the neural costs of language switching and of processing the non-dominant language.

B37 Evidence against the phenomenon of hemispheric lateralization in categorical perception

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The Sapir-Whorf Hypothesis is a classic theory suggesting that the language we speak impacts how we perceive the world, proposing that language experience shapes even "low-level" perception. Recent research on the Sapir-Whorf hypothesis has focused on hemispheric lateralization in categorical (object) perception, finding that people process categories differently in the left and right cerebral hemispheres (LH and RH), theoretically because the LH dominates language processing. Studies have shown that reaction times (RTs) to target stimuli are faster when targets come from a different lexical category than distractors (e.g., cats versus dogs), but significantly more so when targets appear in the right visual field (RVF), which feeds into the LH. We sought to further examine these lateralized perceptual processes, by both replicating and extending the original studies (by Gilbert et al., 2006; 2008). The aim of Experiment 1 was to expand upon Gilbert's findings by carefully comparing the perception of famous and unknown faces, separately in different visual fields. Whereas language is LH-dominant, face perception involves several bilateral brain regions. Visual perception of unknown faces shows RH dominance, but famous faces activate semantic and lexical information in the LH, resulting in greater bilateral brain activation. We hypothesized that we would find evidence for categorical perception for famous faces, lateralized to the LH/RVF, because in addition to being processed as faces, they would be processed as lexical categories. The experimental paradigm involved a forced-choice computer task using RTs. Participants saw a four faces arranged in a square, all of them the exact same face except for one (the target). The target was either from the same general category as the distractors (i.e., either a famous target among famous distractors or an unknown target among unknown distractors) or the target and distractors were from opposite categories (either a famous target among unknown distractors, or vise-versa). The stimulus display only appeared for 200 ms, to discourage saccades. Participants indicated by keyboard press whether the target face was located on the right or left half of the screen. A similar paradigm has been used (by Gilbert et al., 2006; 2008) to show hemispheric lateralization both in the categorical perception of colors and animal shapes. In addition to the extension described in Experiment 1, we simultaneously performed replications of the original experiments conducted by Gilbert and colleagues in 2006 and 2008. These experiments involved a stimulus display of 12 images arranged in a circle, with 11 identical distractors and one unique target. As in Experiment 1, participants indicated via keyboard press whether the target (displayed for 200 ms) appeared on the left or right half of the screen. Gilbert's 2006 experiment involved color squares along the green-blue spectrum, and Gilbert's 2008 experiment involved cats and dogs as the lexical categories. Across all four experiments, however, we could neither extend nor replicate the original findings, despite conducting direct replications. We address several potential problems with the original research by Gilbert and colleagues, including asymmetries in the stimulus materials and data-trimming procedures that may have encouraged false-positive findings.

B38 The impact of timing on lexical-semantic prediction in L1 and L2

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Much previous work suggests that predictive processing mechanisms facilitate language comprehension in native speakers, and more recent work indicates that this is less true for non-native speakers operating in their second language (L2). However, it is unknown whether this discrepancy is because processing in a second language is qualitatively different (i.e. not employing prediction), or simply because additional factors modulate the predictions that L2 speakers generate. In the current ERP study we explore the possibility that non-native speakers are slower to generate predictions than native speakers by manipulating the amount of time available between a visually presented predictive context word and target word. Participants were presented with English adjective-noun phrases in which the probability of the noun given the adjective was either high (mashed potato) or low (shredded potato) as assessed through corpus counts. Low probability adjectives did not strongly predict any other noun. In one block of the experiment, the stimulus onset asynchrony (SOA) between the adjective and noun was short (200ms), and in the other it was long (800ms), with the order of blocks counterbalanced across participants. Participants performed a memory recognition task at the end of each block to encourage attention to stimuli. Here we report data from an initial set of 20 speakers of English as a first language (L1) and 18 L2 participants. L2 participants had limited exposure to English before the age of 10. Their English proficiency was assessed via self-report. We hypothesized that L1 participants would demonstrate effects of prediction on N400 amplitude at both short and long SOAs, but that L2 participants would demonstrate such effects only at long SOAs. However, results from the initial dataset show a different pattern. Both groups demonstrated a small, but reliable N400 effect of predictability at the short SOA. At the long SOA, the L1 group showed a much larger N400 effect than the L2 group, although both were reliable. Additionally, the L2 group showed a late frontal positivity for the low probability nouns at the long SOA. No such effect was observed in the L1 group. These data by themselves do not clearly support the hypothesis that prediction is slower or absent in non-native speakers, but they do suggest interesting similarities and differences in predictive processing for L1 and L2 speakers. We speculate that the equivalent N400 effects across groups at the short SOA may reflect both groups' sensitivity to low-level transitional probabilities, and that the relatively smaller

N400 effects for the L2 population at the long SOA may be due to their reduced ability to rapidly access deeper lexical-semantic representations used to generate stronger lexical predictions. Furthermore, our findings may suggest that in the L2, interpretive reanalysis mechanisms are associated with predictive processing, as late frontal positivities have been observed in L1 speakers for plausible but surprising continuations and are thought to reflect such mechanisms. The current study thus provides insights into the neural bases of predictive processing in L2 and shows some evidence for a qualitative distinction between L1 and L2 speakers.

B39 Mapping the body into the brain: Neural representation of novel words learned through gestures and their impact on memory

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Vocabulary learning in a foreign language can be enhanced if learners enrich novel words with self-performed gestures. Different accounts explain the enhancing effect of gestures on verbal memory. However, a full picture of how words learned with iconic gestures are functionally represented in the brain is lacking. In this study, subjects learned foreign language words with iconic and semantically unrelated gestures. Iconic gestures lead to significant better memory results. After behavioral training, in the fMRI-scanner, subjects discriminated audio-visually between words they had previously learned with gestures and unknown words. In contrast analysis between baseline, i.e. silence and words learned with iconic gestures, the words are functionally represented by extended experience dependent neural networks. They include the language network, sensori-motor areas, the basalganglia, and the cerebellum. These networks mirror the sensorimotor input provided during encoding. Furthermore, the contrast analysis additionally reveals the involvement of memory networks. Our results are in line with a number of studies that describe word and language acquisition as an embodied experience. On the base of their complexity and relating to connectionist models of memory, multi-sensory networks account for better information retention.

B40 Atypical language lateralization in congenital blindness

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Introduction: One of the earliest discoveries about the neural basis of language is that it is left-lateralized. Imaging and lesion studies demonstrate that language is left-lateralized in approximately 95% of right-handed adults. This consistency suggests that language lateralization is determined largely by genetics (Annett, 1998). On the other hand, there is also some evidence that experience can modify language lateralization. Native signers recruit right-hemisphere language homologues during sign language processing, perhaps due to the spatial nature of sign language (Bavelier et al., 1998). We asked whether language lateralization is altered by blindness. In blind individuals, the language network undergoes dramatic reorganization--perisylvian areas are supplemented by visual cortex. Is this change accompanied by a change in language laterality? Methods: Congenitally blind and sighted adults took part in two functional magnetic resonance imaging (fMRI) experiments of sentence comprehension. In experiment 1, participants heard pairs of sentences and decided whether they had the same meaning. Sentence pairs contained identical content words but one sentence was in active voice, the other in passive voice. In a control task, participants judged the equivalence of the variable X across a pair of math equations. In experiment 2, participants listened to sentences and answered yes/no questions about them. In a control task, participants performed a working memory task with sequences of nonwords. After standard fMRI preprocessing, a general linear model was used to analyze BOLD activity as a function of condition for each subject. We calculated laterality indices (LIs) for each participant, based on the sentence > math (Exp 1) and sentence > nonword (Exp 2) contrasts using the formula: [L-R]/[L+R]. L and R denote the number of voxels above the Z=3.1 (P<0.001) threshold, in left and right hemisphere respectively. We computed LIs separately for (a) the entire cortex, excluding the occipital lobe (b) 5 perisylvian regions of interest within the language network, and (c) occipital cortex. Results: Blind participants' whole-brain language responses were not strongly lateralized in either experiment (one-sample t-tests, Exp 1 P=0.5, Exp 2 P=0.06). By contrast, sighted participants displayed typical left-lateralization (Exp 1 P<0.001, Exp 2 P<0.001). Reduced left-lateralization in blindness was consistent across the distinct regions of the language network (group-by-ROI ANOVAs, Exp 1: main effect of group P<0.001, group-by-ROI interaction P=0.63; Exp 2: main effect of group P=0.006, group-by-ROI interaction P=0.26). Occipital laterality was highly correlated with the lateralization of the combined frontal, temporal, and parietal lobes (Exp 1: P<0.001; Exp 2: P<0.001). Crucially, the amount of occipital cortex recruited for language did not predict laterality anywhere in the brain (P>0.65). Conclusion: Language is less left-lateralized in individuals who are blind from birth. This pattern of atypical lateralization is consistent across the perisylvian language network, as well as in language-responsive areas in the occipital lobe. Our results suggest that language lateralization is altered by experience. We will discuss how visuo-spatial input may play a role in the left-lateralization of language.

B41 Delayed language development in young children raised in institutional care is manifested in the atypical N400 component

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Institutional care for children left without parental care is associated with early deprivation due to such factors as inconsistent and unresponsive caregiving, and focus on children's medical rather than psychosocial well-being (Petersburg-USA Orphanage Research Team, 2008). Empirical evidence points to delays that children receiving institutional care (IG) exhibit with respect to physical growth, cognitive development, and social-emotional functioning. However, despite the growing recognition of the importance of early linguistic input and communicative environments for language development, language has been rarely investigated in IG children. Studies of 3 to 11 year-old children (Loman et al., 2009; Windsor et al., 2011) found lower language development in both spoken and written modalities in the IG group. The current study investigated the neurophysiological rather than behavioral indices of early language development in infants and children aged 13 to 47 months in institutional care and raised by biological families in Saint-Petersburg, Russia. EEG data was collected from 42 children. After the exclusion of children who did not provide enough data due to fussiness or were excluded for other reasons (e.g., known severe neurological or genomic conditions), the effective sample included 30 children - 17 IG children (9 males, M age 27.88 months, SD=10.07) raised in institutional care facilities and their 13 (5 males, M=31.54, SD=9.74) age peers raised in biological families (BF). A picture-word paradigm was used to elicit the N400 component. Children sat on their caregiver's lap and were presented with a colorful picture and an auditory word that matched the picture or mismatched it in three possible ways (unrelated real word, phonotactically legal Russian pseudoword, or illegal pseudoword), for a total of 40 blocks. EEG was recorded using a high-density 64-electrode actiCHamp EEG acquisition setup and processed offline in Brain Vision Analyzer. Average amplitude has been extracted for the 350-550ms time window (where the visual analysis suggested the presence of a central/left-lateralized N400 in the whole sample). We found a robust N4 in the BF (one-sample t-test = -2.49, p = .028) but not the IG group (one-sample t-test = 2.07, p = .055). The size of the N4 correlated with age (r = -.51, p = .004) in the whole sample. Analyses of the N4 amplitudes indicated that children in the IG group had a markedly reduced left-lateralized N400 than children in the BF group in the left central (FC3+) electrode cluster (t = 3.36, p = .002), with a large effect size (Cohen's d = -1.21). Preliminary analyses suggest that children in the IG group show reduced sensitivity to phonotactics, and overall atypical topography of neural responses to spoken (pseudo)words. These results suggest that children receiving institutional care are delayed in their linguistic development, and that this delay manifests in the atypical patterns of neural responses to spoken words. We also suggest that N4 can be used as an endophenotype for early linguistic development in special, as well as typical populations. This research was supported by the Government of the Russian Federation (grant No 14.Z50.31.0027; E.L.G., Principal Investigator).

B42 The relationship between inter-hemispheric resting-state connections and language development in the first year of life

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The infant brain is organized into structural and functional networks. During the first months of life, the language/auditory network experiences the fastest growth (Dubois et al., 2014, Gao et al., 2014). Also, it has been previously proposed that frontal and temporal functional networks play a relevant role in speech perception development already at 4 months of age (Homae et al., 2010). Because it has been previously observed that different brain regions are involved during speech processing across monolingual and bilingual 4-month-old infants (Molnar et al., 2013), it is a possibility that bilingual exposure, as a long-term environmental factor, affects the developing language neural circuitry. Here, first we measured functional connectivity at rest as reflected by synchronized spontaneous activity of spatially distant areas in the human infant brain. Specifically, we used a 52-channel near-infrared spectroscopy system to measure spontaneous brain activity in 20 4-month-old Spanish monolingual and 20 Basque-Spanish bilingual infants. Correlation coefficients for the time course of the hemoglobin signal were determined to construct the connectivity matrices of each infant participant. Network metrics of intra-hemispheric and inter-hemispheric connectivity were evaluated to reveal potential differences in the connectivity patterns between groups. Overall, the findings suggest that early and continued exposure to a bilingual environment affects the configuration and the development of resting state functional brain networks. In particular, the resting state networks of 4-month-old infants revealed stronger inter-hemispheric connections in bilinguals than in monolinguals. Later, between 10 and 12 months of age, we measured the receptive vocabulary size of the same 40 infants using the McArthur Communicative Development Inventory developed for Basque and Spanish. The vocabulary size was determined for Spanish in monolinguals. The receptive vocabulary size was estimated across both Basque and Spanish (bilingual lexicon) but also for each language separately in bilinguals (Basque lexicon vs. Spanish lexicon). The individual vocabulary size scores then were correlated with the inter-hemispheric connection strength (between temporal and frontal regions) observed at 4 months of age in each infant. Results will be discussed within the current frameworks of monolingual and bilingual language development.

Language Disorders

B43 Cohesion of cortical language networks in the alpha EEG band during word processing is predicted by a common polymorphism in the SETBP1 gene

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The genetic underpinnings of developmental language disorders (DLD) are unknown, in part due to the behavioral heterogeneity of its manifestations. To address this issue, we sampled from a unique geographically isolated population called AZ (Rakhlin et al., 2013). The increased (i.e., ~30%) prevalence of DLD in AZ suggests that it might be controlled by a restricted set of genetic factors. A recent genome-wide association study of DLD in AZ revealed a significant gene-level association of syntactic complexity and the SETBP1 gene. In the current study, we aimed at replicating this association using language-related EEG endophenotypes. Thirty nine children aged 7.17 to 15.83 years (M = 10.54, SD = 2.34; 23 with and 16 without DLD; all children satisfied a set of exclusionary criteria) participated in the study. Children viewed pictures and listened to spoken words in a picture-word matching paradigm. We analyzed the data from the condition that produced large and robust DLD vs. TD group differences in the amplitude of the N400 component in this sample (Kornilov et al., 2015). In this initial phonological overlap condition, the target word was replaced with a word semantically unrelated to the target, but overlapping with it in the initial phonemes (e.g., hear /tors/ "trunk" – see tort "cake"). We used a 64-electrode BioSemi ActiveTwo system to record the EEG signal at 1024 Hz. Data processing was carried out using Brain Vision Analyzer. The DNA was extracted from peripheral blood or saliva samples and genotyped using either HumanCoreExome or HumanCNV 370k-Duo Illumina's microarray panels. EEG data were segmented into 800ms (100ms pre-stimulus interval; all children provided at least 10 epochs) epochs time-locked to the onset of the word. We then estimated coherence for 18 bilateral pre-defined language ROIs in the intracortical space using eLORETA in six EEG frequency bands. Pairwise lagged intracortical coherences were converted into graphs using ROIs as nodes and coherences as edges. The resulting networks were characterized with respect to a set of graph theory indices, including path length and cohesion (number of edges that need to be removed to make the graph not strongly connected). An association analysis of the five SNPs revealed that rs8085464, a single nucleotide polymorphism in the intronic region of SETBP1 gene explained 27% of variance in intracortical network cohesion (pBonferroni = .0254) in the alpha EEG band, with the minor allele being associated with higher network cohesion, which in turn was linked to poorer language. The results suggest that SETBP1 plays a role in language development, and are further discussed in the context of brain lateralization, optimality of the topographic organization of language processing in the developing brain, and recent studies of the role of alpha EEG in lexical processing. This research was supported by National Institutes of Health Grant R01 DC007665 (E.L.G., Principal Investigator), National Science Foundation Grant CAREER 0748684 (J.S.M., Principal Investigator), National Science Foundation IGERT Training Grant 114399 (J.S.M., Principal Investigator), and the Government of the Russian Federation (grant No 14.Z50.31.0027; E.L.G., Principal Investigator).

B44 Neurodevelopmental Trajectory of Syntactic Processing Related to Recovery or Persistence in Children Who Stutter

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Introduction: Developmental stuttering is a multifactorial, neurodevelopmental speech-language disorder, characterized by involuntary disfluencies during speech production (Smith, 1999). Stuttering typically emerges around 33 months of age – a period of rapid syntactic development. In a recent study from the longitudinal Purdue Stuttering Project, ERP patterns mediating syntactic processing distinguished stuttering recovery versus persistence in 6- to 7-year-old children who stutter (CWS) (Usler & Weber-Fox, 2015). Syntactic (phrase structure) violations within Jabberwocky sentences elicited robust P600s in children who had recovered from stuttering and children who do not stutter (CWNS) over posterior medial-lateral electrode sites, consistent with high proficiency in syntactic processing (Pakulak & Neville, 2010). In contrast, the ERPs of children with persistent stuttering displayed an opposite pattern – an N400-like component over centro-posterior electrode sites. We concluded that childhood persistent stuttering was associated with a reliance on immature semantically-based strategies for processing syntax. In a follow-up longitudinal analysis, we analyzed the ERPs elicited by the same subjects two years previously (4- to 5-years-old), an age close to the onset of stuttering. Methods: All native-English-speaking participants were evaluated based on the criteria established by Yairi and Ambrose (1999) to determine if they demonstrated stuttering. Group means for CWS and CWNS had comparable age, socioeconomic status, and nonverbal reasoning abilities. An inclusionary criterion for language proficiencies, including SPELT-3 (Dawn, Stout, & Eyer, 2003) and TACL-3 (Carrow-Woolfolk, 1999) testing, was utilized to ensure that all participants exhibited language abilities within the normal range. During the ERP task, participants watched cartoon videos and heard concurrent Jabberwocky sentences embedded with syntactic (phrase structure) violations. Every violation sentence had a corresponding control sentence. Eye blinks and other movement artifacts were removed from the EEG signals using ICA and automatic artifact rejection algorithms.

From this data, mean amplitudes of two well-known ERP components, the N400 and P600, were measured. Results: Results confirmed our hypothesis of differences in ERP elicitation between 4- to 5-year-old CWS and CWNS. Furthermore, we observed group differences at this young age between children who would later persist in stuttering versus those who eventually recovered. Phrase structure violations elicited an early negativity/P600 pattern in typically developing CWNS. For CWS who eventually recovered, violations elicited an N400-like component. ERP differences between canonical and violations were not robust in CWS who eventually persisted. Summary: By looking longitudinally to determine how neural correlates for syntactic processing change over development, we can shed light on the neurodevelopmental trajectories of language development that likely play a role in the onset and chronicity of stuttering. Our evidence indicates that soon after the onset of the disorder, children who stutter exhibit maturational lags in syntactic development. Recovery from stuttering in later childhood, on the other hand, is associated with overcoming this immaturity in syntactic processing. (NIH-NIDCD DC00559).

B45 Temporal Endogenous Attention Modulates Rule Learning in Children with Specific Language Impairment

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Given that speech is a sequence of sounds that unfolds in time, the orienting of our attentional resources to speech in the temporal domain is necessary to predict forthcoming information. In this study, we investigated the involvement of temporal endogenous orienting of attention (the voluntary directing of attention to a point in time) for the acquisition of rules in language. Many rules in language require keeping track of non-adjacent predictive information while ignoring irrelevant intervening elements (e.g. is reading, is playing). In order to study the role of temporal endogenous attention mechanisms in language rule learning, we tested children diagnosed with Specific Language Impairment (SLI) with and without inattention. The goal of our study was to test both (i) the effects of attentional disorders on language deficits and (ii) the role of endogenous temporal orienting in language rule learning. Children with SLI (n = 18) and typically developing children (TD, n = 18) performed two experiments: a temporal endogenous orienting task and an auditory non-adjacent dependency artificial language learning task. Since attention-deficit/hyperactivity disorder (ADHD) frequently co-occurs with language impairments, scores from the ADHD-IV questionnaire were also obtained for all participants. In the temporal orienting task, participants performed a simple-RT detection task, containing trials matching or mismatching the temporal expectancy (early/late) for the target appearance based on the (short/long) cued interval. In the non-adjacent rule learning task, participants were exposed to one of two artificial languages with utterances of the form [aXb or cXd] or [aXd or cXb]. At test, participants were presented with grammatical and ungrammatical utterances and asked to indicate whether or not each utterance was from the previously-exposed language. For both tasks, results showed no significant differences in performance between groups. However, when dividing children with SLI based on their attention deficits (AD) scores, we observed that task-performance of the SLI group with AD significantly differed from the SLI group without AD as well as from the TD children. Both ADHD scores and temporal endogenous orienting of attention scores correlated with rule extraction performance in SLI (but not in TD). These findings suggest that (i) attention deficits in SLI – but not SLI per se – have an impact on the acquisition of non-adjacent dependencies in language, and (ii) endogenous temporal orienting relates to rule learning abilities in SLI. This study has implications not only for our understanding of the cognitive processes underlying language learning, but also for the assessment of childhood disorders in attention and/or language, especially since early identification of cognitive deficits is crucial for successful intervention.

B46 The relationship between novel word learning and anomia treatment success

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INTRODUCTION. Successful anomia treatment may depend, in part, on learning mechanisms. However, few studies have explicitly evaluated novel word learning in individuals with aphasia and investigations into the relationship between word learning ability and anomia therapy success are lacking. The aims of the present study were to evaluate the ability of adults with post-stroke aphasia to learn novel words associated with unfamiliar objects and to establish the relationship between learning ability and anomia treatment outcomes. METHODS. 30 adults (6F, 34M; mean age 59.2 years) with chronic, post-stroke aphasia (mean time post onset 38.3 months) were recruited to the study. Prior to treatment, participants underwent an assessment of language, which included the Comprehensive Aphasia Test and three baseline confrontation naming probes in order to develop sets of treated and untreated items. We also administered a novel word learning paradigm, whereby participants learnt novel names associated with unfamiliar objects and were then tested on recall and recognition. Participants completed 48 hours of Aphasia Language Impairment and Functioning Therapy (Aphasia LIFT) over a 3 week (intensive) or 8 week (distributed) schedule. Therapy primarily targeted the remediation of word retrieval deficits, so naming of treated and untreated items immediately post-therapy and at 1 month follow-up was used to determine therapeutic response. RESULTS. Twenty-eight participants

completed the Aphasia LIFT program. Performance on recall (expressive) and recognition (receptive) tasks demonstrated that participants were able to acquire novel words; however, performance was variable and was influenced by participants' aphasia severity and age. Four out of 30 participants demonstrated a significant increase in expressive recall of novel word stimuli post-training and 19 out of 30 participants demonstrated above chance performance on the novel word recognition task. There was a moderate, positive correlation between novel word learning ability and therapy gains for treated items at post-therapy, $r(28) = .458$, $p = .014$. In contrast, participants' novel word learning performance did not predict therapy gains for treated items at 1 month follow-up or for untreated items at either time point. Therapy intensity and time post onset did not influence treatment outcomes. DISCUSSION. This is the first study to directly examine the relationship between novel word learning and therapy outcomes for anomia rehabilitation in adults with aphasia. Importantly, we found that novel word learning performance was associated with therapy outcomes for treated items at post-therapy. We propose that verbal learning ability may be a contributing factor to the initial acquisition of treatment gains in anomia rehabilitation. Assessment of an individual's word learning skills may help to identify individuals' potential for improvement and assist in predicting anomia treatment response.

B47 Hippocampal Contributions to Language Development: Evidence of Poor Hippocampus-dependent Declarative Memory in Developmental Language Impairment (DLI)

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Growing research has shown that the same hippocampus-dependent processes supporting the formation and flexible use of relational representations in declarative memory also support certain aspects of language use and processing (Duff & Brown-Schmidt, 2012). Although developmental language impairment (DLI) has been primarily linked to deficits in procedural memory, several key findings suggest that hippocampus-dependent declarative memory may also be disrupted in DLI. For example: 1) adults with DLI have abnormal hippocampal volume (Lee et al., 2013) suggesting the neural correlates of DLI may not be limited to the striatal procedural memory system; 2) in addition to grammatical difficulty, individuals with DLI also have deficits in word learning and online sentential processing, abilities involving the hippocampus (Duff & Brown-Schmidt, 2012); 2) recent work showed striatal and hippocampal contributions to procedural learning (Albouy et al., 2008), indicating a possible role of the hippocampus in explaining procedural learning deficits in DLI. To test the hypothesis that the hippocampus-dependent memory system is disrupted in DLI, we recruited a group of adults with DLI (n=8) and a healthy demographically matched comparison group (n=8) and assessed their hippocampus-dependent declarative memory in a battery of standardized tests and experimental tasks sensitive to hippocampal processes/function. These measures include: 1) Wechsler Memory Scale (WMS)-IV: a general measure of declarative memory across time (immediate, delayed) and domains (visual, auditory). Individuals with hippocampal dysfunction typically perform poorly; 2) an eye-tracking task of on-line pronoun interpretation: participants view a scene while listening to a short discourse introducing two characters, and their eye movements are monitored to assess discourse integration and maintenance. Previous work in individuals with hippocampal dysfunction showed disrupted use of order of mention information linked to hippocampal processes of temporal binding and online maintenance (Kurczek et al., 2013); and 3) the spatial reconstruction task: participants study a spatial arrangement of five novel stimuli and reconstruct the array after a 4-second delay. Swap errors on this task (i.e., reversing relative positions of item pairs) are suggested as a highly sensitive index of deficits in hippocampal binding (Watson et al., 2013). On the WMS-IV, the DLI group performed significantly worse than the comparison group on the Immediate and Delayed Memory Indexes, a result largely driven by poorer performance on auditory tasks (e.g., verbal paired association) than on visual tasks. In the eye-tracking task of on-line pronoun interpretation, the DLI group preformed similarly to the comparison group but showed a slightly weaker use of order of mention information than the comparison group. In the spatial reconstruction task, the DLI group made significantly more swap errors than the comparison group. These preliminary findings provide initial support for our hypothesis of disrupted hippocampus-dependent declarative memory in DLI. These results suggest that, along with deficits in procedural memory, disruptions in the hippocampus-dependent memory system may also contribute to the language profile of DLI. Further investigation of hippocampal contributions to language development is warranted. DLI may provide a good model for examining the interaction of memory systems and its impact on individual differences in language development.

B48 Effective connectivity of the naming network in post-stroke chronic aphasia

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Intact language processing for picture naming involves recruitment of regions involved with access of lexical concepts (LMTG), word form encoding (e.g., LpSTG), and word syllabification (LIFG) (Indefrey & Levelt, 2004). Lesions secondary to left-hemisphere stroke force reorganization of this system; activation in patients has been noted in the aforementioned areas, right-hemisphere homologues, and/or additional left-hemisphere regions (e.g., LMFG) (Turkeltaub et al., 2011). However, while several studies of task-based effective connectivity of normal language processing exist (e.g., Abel et al., 2011), little is known about the functional reorganization of

language networks in patients with stroke-induced aphasia. Therefore, we used fMRI and Dynamic Causal Modeling (DCM) to investigate reorganized language systems in patients with chronic aphasia versus networks of healthy controls. Ten patients and eight age-matched controls completed an event-related picture-naming task with experimental (i.e., orally naming pictured items) and control conditions (i.e., stating "skip" to scrambled pictures). T1 images were acquired with the following parameters: 176 sagittal slices, 1x1x1mm voxels, TR=2300ms. BOLD data were collected with the following parameters: 40 axial slices, 2x2x3mm voxels, TR=2570ms. Functional images were co-registered to structural images and normalized to MNI space. Manually-drawn lesion masks from each patient's structural image were used during normalization to minimize deformities (Brett et al., 2001). DCM model space included three regions crucial for picture naming (i.e., LIFG, LMFG, LMTG). For each patient, the amount of spared tissue per region was calculated using MarsBaR. If activation was not seen in a region with less than 75% spared tissue, the statistical threshold was reduced to extract noisy signal as a VOI (Seghier et al., 2014). Random-effects individual and group-level Bayesian Model Selection (BMS) was applied. All controls had activation in each region for the contrast of interest (pictures – scrambled), p<.001. Seven patients had activation in all three regions. Noisy-signal VOIs were created for two additional participants based on the criterion described above (i.e., P2: 53.48% LIFG spared; P4: 16.13% LMTG spared); one participant had greater than 75% spared tissue in LMFG but no activation and was excluded from the final analysis. Group-level BMS for controls revealed the best-fit model was LMTG–LIFG–LMFG (xp=.1701). Conversely, group-level BMS revealed that the best-fit models for patients were LIFG–LMFG (xp=.3318) and LIFG–LMTG (xp=.3201). In summary, these results demonstrate that differences exist between intact and damaged, reorganized language networks. The control results (i.e., input to LMTG, modulation to other regions) align with the word production literature as the semantic system must first be engaged (by LMTG) prior to subsequent processes such as syllabification (by LIFG). In light of patients' impaired naming skills, the patient group results support previous connectivity studies (e.g., Kiran et al., 2015) that propose that LIFG subsumes the role of other left-hemisphere language regions after stroke. It has also been proposed that LIFG plays a critical role in semantic executive control, including efforts at correct selection of spoken word targets (e.g., Whitney et al., 2012). These results provide preliminary insight into how brain connectivity is altered for patients with aphasia during oral naming.

B49 Bilingualism and language networks in the semantic variant of primary progressive aphasia. *Ismael Luis Calandri[1], María Alejandra Amengual[1], Mauricio Farez[1], Hernán Chavez[1], Cecilia Rollán[1], María Cristina Medina[1], Liliana Sabe[1], Silvia Vazquez[1], Ricardo Allegri[1]; [1]Institue of Neurological Research Dr Raúl Carrea, FLENI, Argentina*

Background: Accumulating research shows that bilingualism influences the development, efficiency, and decline of crucial cognitive abilities, and it has been associated with neuroplasticity, cognitive training and cognitive reserve The aim of this work is compare using DTI-based tractography, language-related white matter tracts in bilingual and monolingual patients with Semantic variant of Primary Progressive Aphasia (Sv-PPA). Assessing patients with Sv-PPA, offers the opportunity to evaluate the influence of bilingualism in a model of selective damage of the semantic system. Materials and Methods: We used DTI-based tractography in 6 patients with Sv-PPA to evaluate inferior longitudinal fasciculus (ILF), superior longitudinal fasciculus, and uncinate fasciculus (UF) bilaterally, and compared fractional anisotropy (FA) and mean difussivity (MD) between bilinguals and monolinguals. Bilingualism was assessed through number of spoken languages and proficiency. Results: The sample included 6 patients divided in two groups: bilinguals (n=3) and monolinguals (n=3). Statistical analysis showed significant differences between groups only when comparing FA values in the right UF ($p < 0.037$). Diffusivity values did not differ. Conclusions: Results indicated significantly higher microstructural integrity in the bilingual group in the right UF, compared to their monolingual peers, showing higher FA. The UF has been proposed to play a role in lexical retrieval, semantic association and aspects of naming that require connections from temporal to frontal areas. Previous research consistently showed its selective damage in Sv-PPA. The management of multilingual semantic knowledge could determine an improvement in the conditions of the tract and strengthen it against degeneration, but further research is needed to address this item.

Lexical Semantics

B50 Semantic features and concepts in the left and right angular gyrus *Megan Reilly[1], Natalya Machado[1], David Badre[1,2], Sheila Blumstein[1,2]; [1]Cognitive, Linguistic and Psychological Sciences, Brown University, [2]Brown Institute for Brain Science*

Recent models of semantic memory propose that the semantic representation of a concept is based, in part, on a network of features. In this view, a feature may be distinctive for a concept (a zebra has stripes) or it may be shared across many concepts in a category (a zebra has four legs). Our current understanding of shared and distinctive features relies on the patient literature: semantic dementia (SD) patients tend to show deficits for distinctive features earlier in disease than for shared features, and this pattern varies across categories, such that the shared features of living things are more resistant to damage than the features of nonliving things. However, the pattern of

processing these features and categories in healthy adults has not been systematically studied. Although patients tend to have damage to the left temporal lobe, the angular gyrus (AG) is often implicated in semantic processing and its contribution to processing shared and distinctive features is unknown. Additionally, the left hemisphere is generally considered to be dominant for processing language, but there is evidence that the right hemisphere plays some role in semantic processing, although it is less efficient than the left at processing fine-grained semantic relationships, i.e., distinctive features. Thus, the current study aimed to examine shared versus distinctive feature processing across living and nonliving categories in healthy adults, with the goal of both comparing the left and right hemispheres and investigating the specific role of the angular gyrus. Two experiments used functional magnetic resonance imaging (fMRI) and transcranial magnetic stimulation (TMS). In a feature verification task, participants responded yes or no to the appropriateness of a concept (living or nonliving) paired with a semantic feature (shared or distinctive). During fMRI (n=16), the left AG showed greater deactivation for nonliving concepts than for living concepts, but no differences between shared and distinctive features. The right AG, on the other hand, showed greater deactivation for distinctive features than for shared features, but was not sensitive to semantic category. The neuroimaging results suggest that the two hemispheres process semantic information at different levels of specificity: the left AG is sensitive to integrating concepts into categories, while the right is sensitive to shared vs. distinctive features. Pilot results of a repetitive TMS experiment (n=6) show that stimulation of the right AG results in slower responses specifically for the shared features of living things. These results suggest that the right hemisphere plays a necessary role in semantic processing, specifically for features which are consistently co-activated across a broad set of concepts. This study also informs patient research: the shared features of living things are typically highly preserved in SD patients, suggesting that the right AG's role in semantic processing is robust to damage to the left-hemisphere semantic network. This highlights the possible need for cognitive models of semantic memory to account for two different patterns of semantic processing.

B51 Surrounding linguistic context influences the role of neural oscillations underlying word learning

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INTRODUCTION. Adults acquire most of their vocabulary by learning from context, or using surrounding linguistic information to identify a word's meaning. Most EEG research examining word learning from context has focused primarily on the word being learned without taking into consideration the contribution of surrounding linguistic context. The current study used time frequency analysis of the EEG to examine differences in neural processing when the surrounding linguistic context sets up word learning versus when it does not. METHODS. Ten adult participants read sentence triplets presented word-by-word. Sentences were 7 words long and the target novel word appeared in the sentence-final position. In the Meaning Plus (M+) condition the three sentences in each triplet increasingly supported the novel word's meaning with the third sentence providing a great deal of contextual support for the novel word's meaning. The Meaning Minus (M-) condition also contained sentence triplets but each sentence provided little contextual support, making it difficult to derive meaning. After each sentence triplet, participants were asked to identify the novel word's meaning, if possible. ANALYSIS. EEG data were epoched from 500 msec before to 7000 msec after initial word onset. Time frequency analysis was used to quantify event-related spectral perturbations. Epoched data were Fourier-transformed, magnitude-squared, and normalized to obtain the power spectral density. Data were averaged across trials and subjects, and computed using the log power values minus the baseline. Within EEGLAB, an interactive Matlab toolbox, we performed random permutation statistical analysis of the EEG data, computing p-values for both the time and frequency points for each comparison of interest. The study design was a 2 Condition (M+, M-) x 3 Sentence (1,2,3) ANOVA in each of the frequency bands of interest: theta (4-8 Hz), alpha (8-12 Hz), lower beta (12-20 Hz) and upper beta (20-30 Hz). RESULTS. No significant effects were identified in the alpha and lower beta frequencies. Following evidence associating alpha with attention and lower beta with syntactic integration, the lack of effects in our data indicate that participants utilized attention and syntactic integration equivalently across all sentences in both conditions. For all sentences and both conditions, theta increased when each word appeared on the screen, interpreted as evidencing lexical-semantic processing of each word. Additionally, for the third sentence, the M- condition exhibited increased theta compared to the M+ condition, suggesting greater effort in lexical-semantic processing while trying to identify the novel word's meaning in the M- condition. For upper beta, a significant effect was found in the M+ condition, driven by an upper beta increase across the entirety of the third sentence. This was interpreted as increased memory demands as participants verified the meaning of the novel word. CONCLUSIONS. Findings indicate that as adults attempt to learn a new word's meaning, they engage attention (alpha) and syntactic integration (lower beta) equivalently, regardless of whether the context supports learning. When the linguistic context is non-supportive, they rely more on lexical-semantic processing (theta), whereas memory (upper beta) is utilized more within a supportive context.

B52 Cross-modal representation of spoken and written word meaning in anterodorsal pars triangularis

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INTRODUCTION: For years the commonalities underlying the semantic processing of different input-modalities have been studied by means of univariate analysis but nowadays Representation Similarity Analysis (RSA) provides a new opportunity to better understand the nature of such common processing. In two event-related fMRI experiments we searched for regions with activity patterns reflecting a cross-modal semantic similarity effect between written and spoken word modality. The first experiment aimed at defining a set of regions activated during a property verification task with written or spoken words as input. The second experiment aimed at determining, within this set of regions, whether the semantic similarity between pairs of words is reflected cross-modally in the activity pattern despite differences in word format. METHODS: 18 and 20 healthy subjects participated in the first and second experiment respectively. 24 concrete nouns were used which refer to animals. Based on a feature generation experiment conducted by De Deyne et al. (2008), the pairwise semantic cosine similarity was calculated for each pair of items (semantic cossimilarity matrix). During fMRI subjects performed a property verification task in spoken and written modality. The fMRI data of the first experiment were modelled using a General Linear Model (GLM). Clusters showing a significant main effect of task in the first experiment were used as VOI in the second experiment. The cosine similarity matrix based on fMRI data of the second experiment was generated by calculating the pairwise cosine similarity between every pair of trials (fMRI cossimilarity matrix). Four fMRI cossimilarity matrices were calculated based on the input-modality of the trials: written and spoken words pooled cossimilarity matrix, written cossimilarity matrix, spoken cossimilarity matrix and cross-modal cossimilarity matrix. Finally we conducted the RSA between the semantic cossimilarity matrix and each fMRI cossimilarity matrix. RESULTS: The main effect of task (uncorrected $p<0.001$ combined with a cluster-level corrected $p<0.05$) yielded 7 clusters: left ventral occipitotemporal transition zone (vOT), left ventromedial temporal cortex, retrosplenial cortex, pars orbitalis bilaterally, left anterodorsal pars triangularis and the frontal pole. The left anterodorsal pars triangularis showed a significant effect of semantic similarity cross-modally: activity patterns were more similar for word pairs that were more semantically similar, even though the words were presented in two different modalities (Cosine Similarity (CS) = 0.029, P = 0.0004). When the RSA was conducted between the semantic cossimilarity matrix and the written cossimilarity matrix, 3 clusters showed a significant semantic similarity effect: vOT (CS = 0.933, P = 0.008), left ventromedial temporal cortex (CS = 0.879, P=0.008) and left pars orbitalis (CS = 0.138, P = 0.027). CONCLUSIONS: The cross-modal effect is in line with a role of anterodorsal pars triangularis in amodal semantic processing.

B53 Differences in resolving within-language lexical competition for monolingual and bilingual speakers – electrophysiological evidence

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We have found evidence that bilingual speakers might be better than monolinguals at inhibiting lexical competitors within a language during word production (Zhou & Krott, in preparation), in line with the hypothesis that bilinguals are better at response conflict resolution (e.g. Bialystok, Craik, Klein, & Viswanathan, 2004). Here we sought evidence for such enhanced performance in speakers' brain responses. We tested 40 monolingual and bilingual English speakers, matched for age, education and intelligence, in a semantic blocking experiment (Kroll and Stewart, 1994). Participants overtly named pictures in a homogeneous condition, where pictures were from the same semantic category (e.g. tie, skirt, boot and coat), and in a heterogeneous condition, where pictures were from different semantic categories (e.g. tie, snake, brush and chair). Speakers are typically slower when naming pictures in the homogeneous condition, likely due to stronger lexical competition among items with shared semantic features (but see Oppenheim, Dell, & Schwartz, 2010 for an alternative explanation). We examined three ERP markers for the semantic interference effect: an early marker around 200 ms which has been related to lexical selection (Aristei, Melinger, & Rahman, 2011; Janssen, Carreiras, & Barber, 2011), a late marker around 400 ms which has been related to response monitoring (Maess, Friederici, Damian, Meyer, & Levelt, 2002), and an ERN-like marker immediately after response which has been related to conflict monitoring (Ganushchak & Schiller, 2008). We adopted an ICA procedure (Porcaro, Medaglia & Krott, 2015) to remove ocular and speech artefacts from the EEG. We conducted stimulus-locked and response-locked ERP analyses. Cluster-based permutation tests were used to statistically test differences in ERP responses between experimental conditions for each participant group separately. In contrast to our previous finding, behavioral results showed no group differences. However, brain responses showed that semantic context affected the two participant groups in largely different ways. Both groups were similar in that they showed reduced positive activity in posterior regions with a peak at 220 ms in the homogeneous condition compared with the heterogeneous condition. This is in line with increased processing demands in the competitive context due to lexical competition. The two

groups differed in that only monolingual speakers showed a significant reduced positive response around 400 - 450 ms and a long-lasting widely distributed negative shift in the homogeneous condition starting about 100 ms after response onset. Thus, monolingual speakers appeared to be more affected by the competitive context during response monitoring, arguably due to competition not being resolved completely during the lexical selection stage. Furthermore, only bilingual speakers showed increased negativity at fronto-centrally sites around 180 ms for the homogeneous condition, in line with an increased activation of frontal control networks in this group. Our results support the notion that monolingual speakers resolve lexical competition less effectively. In line with suggestions based on bilinguals' performance in non-linguistic conflict tasks (Kroll & Bialystok, 2013), we propose that bilinguals recruit top-down control more strongly, which enables them to resolve lexical competition more efficiently than monolingual speakers.

B54 Sometimes it takes three to tango: The figurative chef, recipe, and ingredients in the neural architecture of colour knowledge

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Introduction. Knowledge about perceptual attributes of objects is a crucial cognitive faculty that influences how we perceive and act on the world. Some prominent hypotheses emphasise the role of sensorimotor cortices as embodied foundation for perceptual knowledge. Beyond the cortical realms for perception and action, however, we still have poor understanding about other neural mechanisms recruited in this neural architecture. Methods. Using fMRI, we discovered a tripartite neurocognitive structure involving the inferior frontal gyrus (IFG), ventral anterior temporal lobe (vATL), and a visually-based ventral occipitotemporal cluster (vOT) that underpin our conceptual knowledge about the conceptual association between objects and their canonical colours. Specifically, we measured brain activity using functional magnetic resonance imaging (fMRI) while participants made judgements based on concepts about typical object colour or amodal semantic association. Results. In the ventral temporal cortex (VTC), we found a gradient-like organisation of neural responses along the caudal-to-rostral axis, with the most posterior VTC (lingual and posterior fusiform gyri) more sensitive to modality-based colour knowledge, the most anterior VTC (temporal pole) more responsive to amodal semantic knowledge, and intermediate sections indifferent to the two. This 'modal vs. amodal' gradient was mirrored along the medial-to-lateral axis of VTC, with the medial bank preferring modality-related processing while the lateral bank preferring amodal processing. Interestingly, both colour and amodal semantic knowledge elicited robust activation of the vATL, peaking at the anterior fusiform gyrus, a site considered as the pan-modality 'hub' for semantic processing. Analysis of functional connectivity (psychophysiological interaction, PPI) further showed that, compared to retrieval of amodal semantic knowledge, colour knowledge resulted in significantly greater functional coupling between the IFG and V4, two crucial areas suggested as the executive control centre and embodied substrate of colour knowledge, respectively. When using a more liberal threshold, we also saw greater functional coupling between the ATL and IFG during colour than amodal knowledge. Finally, using dynamic causal modelling (DCM), we demonstrate the facilitatory and inhibitory modulations within this tripartite network and how the interaction betwen brain regions is constrained by the representational references of the VTC. Conclusion. Our finding suggests a possible triangulation of the neurocomputation that underlies colour knowledge – to access conceptual attributes about object colour, the IFG cherry-picks task-relevant information from the 'directory' of semantic features stored in the vATL and retrieve the 'raw material' from V4 that codes bodily chromatic representation.

B55 Using lexical semantic ambiguity to distinguish information-specific from domain-general processing

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Word recognition usually involves processing word meanings, yet it is unclear whether the neural basis of meaning search and retrieval is distinct from semantic feature storage. We elicited word recognition using lexical decision: participants indicated whether a letter string was a word. Words varied in meaning relatedness: words with multiple unrelated meanings (bank) are thought to elicit greater semantic search and retrieval processes compared to words with related meanings (paper). This was crossed with imageability: highly imageable words have richer semantic feature representations compared to less imageable words. A second hypothesis was neural effects of these variables would differ depending on similarity of the nonword background to the words. Foils were either pronounceable nonwords (pseudowords, PW, brab) or pseudohomophones (PH, karv). Words and nonwords may differently engage task-positive or default-mode networks, depending on level of stimulus discriminability. With PW foils, low- vs. high-imageability words activated areas found in meta-analyses to be associated with semantics, including bilateral posterior cingulate (PC), dorso-medial prefrontal cortex, and left middle temporal gyrus. A very different pattern was seen for this contrast with PH foils: activation was limited to left orbital inferior frontal gyrus, and right inferior temporal gyrus. Relatedness showed no activation against a PW background, but low- vs. high-relatedness words with PH foils showed activation in left angular gyrus (AG). Thus, imageability is associated with activation in semantic areas when lexical decisions can be made using semantic information alone, but relatedness is associated with activation in semantic regions when lexical decisions require more detailed search. The

lexicality contrast (words - nonwords) showed activation for words in task-positive network areas: inferior frontal junction, intraparietal sulcus, and ventral occipitotemporal sulcus (vOT); whereas nonwords activated resting-state or putative semantic regions such as AG and PC. An interaction of lexicality with nonword type was significant, including left AG and PC for (words - PW) > (words - PH), and the opposite pattern in vOT. That is, lexicality contrasts with more semantic content but also more difficult discrimination led to less activation in AG and PC, and more activation in vOT. This supports the second hypothesis: areas previously interpreted as supporting semantic processing are instead responding to domain-general processing demands. Overall, this study clarifies conditions where information-specific and domain general effects co-occur.

B56 Separate brain networks dynamically represent perceptual and categorical information of object concepts in the human brain

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Semantic memory stores multiple aspects of conceptual information associated with real-world objects (e.g., apple), including object categories (fruit) and their sensorimotor features (red, round, and juicy). These information are overlapped and shared across related concepts, forming a sophisticated hierarchical conceptual network, ranging from object-specific features to more abstract semantic categories. However, despite evidence from behavioral studies, little is known about how human brain dynamically represents such conceptual hierarchy. In the present study, we used functional magnetic resonance imaging (fMRI) techniques combined with multivariate representational similarity analysis (RSA) to investigate how the brain represents the conceptual hierarchy at each end of the hierarchical structure, namely object-categorical and object-specific feature information. Eighteen participants were recruited for the experiment. They were presented written names of 90 objects in 12 object categories in two different task contexts during fMRI scanning. In one task, participants were asked to judge whether the current object (e.g., apple) and the previous one (e.g., orange) were in the same object category (1-back category judgement task). In the second task, participants judged whether the current object (e.g., orange) and the previous one (e.g., banana) had similar colors or perceptual contours (1-back perceptual judgment task). This selective attention paradigm allowed us to examine how categorical and perceptual information was selectively activated by object names. In this way, we also limited the perceptual differences of different objects if they were presented in pictures. To use whole-brain searchlight RSA analysis, we constructed five cross-item dissimilarity matrix models, ranging from visual perceptual models to more abstract category models, so as to investigate whether spatial activation pattern of a particular brain region could significantly explain these models in above two task contexts. The RSA results showed that abstract category information and object-specific conceptual features were associated with two relative separate brain networks. A distributed fronto-tempo-parietal network that was previously argued in meta-analysis (e.g., Binder et al. 2009) as the semantic system, was shown to be significantly correlated with abstract category models only in the category judgment task but not in the perceptual judgment task. However, a different network, including bilateral anterior temporal lobe and sensorimotor regions, was significantly fitted the conceptual feature model during the perceptual judgement task but not in the category judgment task. By contrast, such selective attentional modulation effect was not observed in the primary visual cortex and the posterior inferior temporal areas that encode visual features of word forms prior to semantic retrieval. These results suggested that human brain can dynamically wrap semantic representation space to efficiently achieve task goals. Together, these results further our understanding of the segregation and organization of the human semantic system. Importantly, we refined the functional roles of sub-regions with this system, and demonstrated its dynamic and flexible mechanism for conceptual information representation.

B57 An ERP investigation of the role of prediction and individual differences in semantic priming

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A number of ERP studies have shown N400 amplitude reductions as a function of contextual support; however, the extent to which this reflects prediction remains an issue (e.g., DeLong et al., 2005). Under the prediction account, N400 amplitude reduction is at least in part the result of predicting particular upcoming material, a process which requires attentional control and may show individual variation. Moreover, it has been argued that these predictive effects are not limited to sentence contexts, but also extend to word-pair semantic priming (Hutchison, 2007; Lau et al., 2013). In a behavioral study, Hutchison (2007) probed for prediction effects by presenting color-and-verbal cues indicating the likelihood of encountering a related prime-target pair prior to each trial (green text stating '80% Related' or red text stating '80% Unrelated'). They found greater priming effects for the highly-related cue than for the highly-unrelated cue trials, an effect limited to individuals with high attentional control (measured by a composite score comprising operation span, Stroop, and antisaccade measures). Lau et al. (2013) manipulated predictive validity by constructing separate blocks with few related pairs and many related pairs, presented in that order; they found greater N400 reduction for related prime-target pairs for the high-relatedness than for the low-relatedness block. Although some studies have also found anterior positivities argued to reflect unfulfilled

predictions (Van Petten & Luka, 2012), this effect was not found for the targets in Lau et al. (2013). The current study further investigates the role of prediction and individual differences in word-pair semantic priming using color-and-verbal relatedness-proportion cues (80% Related; 20% Related), following Hutchison (2007), and a battery of individual difference measures. N=17 native English-speaking adults completed the ERP study and a set of tasks assessing aspects of attentional control (Counting Span working memory task and Stroop task) and phonemic/semantic fluency (FAS task). In the ERP study, participants read 480 prime-target pairs, and were asked to press a button when an animal word appeared. The stimuli included 160 targets and 320 fillers used to ensure that the 80% and 20% cues accurately represented the relatedness-proportion in the experiment. Each target was paired with one of four primes: related prime with '80% Related' cue, related prime with '20% Related' cue, unrelated prime with '80% Related' cue and unrelated prime with '20% Related' cue. Results show an overall effect of relatedness: related targets yielded smaller N400s than unrelated targets. This effect was modulated by relatedness-proportion, with a greater N400 reduction effect for the '80% Related' than for the '20% Related' condition. An anterior positivity also emerged for the unrelated targets in the high-relatedness condition. This positivity, which was significantly larger in the '80% Unrelated' than the '20% Unrelated' condition in left anterior (and marginal in right anterior), may reflect the cost of disconfirmed predictions within the highly-related condition. Finally, accuracy on the Stroop task was significantly correlated with the relatedness effect in anterior regions. These findings converge with Lau et al. (2013) and Hutchison (2007) in demonstrating the role of prediction in word-pair semantic priming.

B58 Is upper better than lower? ERP correlates of letter degradation in visual word recognition

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Recent research has shown that the upper part of words enjoys an advantage over the lower part of words in visual word recognition and reading. For instance, Perea et al. (2012, QJEP) found that the magnitude of masked repetition priming was only slightly greater when the primes were presented intact than when the primes only preserved the upper part; in contrast, the repetition priming effect was substantially smaller when the primes only preserved the lower part. In addition, Perea (2012, PBR) found that, during sentence reading, there is a substantially larger reading cost—relative to the sentences with intact words—when deleting the upper part of words than when deleting the lower part of the words. To examine in further detail the role of the upper part of words during reading, we conducted an ERP experiment in which the participants' responses (both behavioral and EEG) were recorded in a lexical decision task that included intact stimuli vs. degraded stimuli (only the upper part of the words/pseudowords were presented). The words and pseudowords were composed of unambiguous letters in their upper part (e.g., stimuli composed of letters such as "i" or "j" we not included). We also manipulated a marker of word identification: lexical frequency (high- vs. low-frequency words), as our aim was to track the time course of amodal completion of the upper part of words. The behavioral results revealed additive effects of lexical frequency and degradation (i.e., longer response times to low- than to high frequency words; longer latencies to degraded than to intact words). The ERP results displayed a different pattern for the degraded and intact stimuli in the early (perceptual) stages of processing (before 300 ms aprox)—note that the letter degradation transformed the linguistic stimuli into pseudo-orthographic stimuli. The ERP components related to early visual features and/or category processing (N/P170, P300) were sensitive to visual degradation, with larger amplitudes for the degraded than for the intact stimuli. This pattern was observed across words (high/low frequency) and pseudowords, and culminated as a difference in latency in the N400 peak between the intact and degraded versions of the stimuli (shorter for intact stimuli). With respect to the time course of lexical frequency, we found an earlier lexical frequency effect for the degraded (starting around 300ms) than for the intact words (starting around 400ms). This interaction is consistent with a process of normalization during amodal completion that is sensitive to higher-level (lexical) feedback.

B59 The bilateral inferior parietal lobules in support of Chinese multi-character word recognition

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Introduction The majority of Chinese words are multi-character words. The Chinese multi-character word recognition is of great importance for Chinese reading and is highly related to a key step of Chinese text processing, i.e. word segmentation. In recent years, many neuroimaging studies investigated the functional anatomy of Chinese reading. However, most of these studies only focused on the character-level processing. To our knowledge, only two studies investigated Chinese multi-character word recognition and some confounding factors such as difficulty were poorly controlled in them.

Therefore, the functional anatomy of Chinese multi-character word recognition remains unclear. In the present study, we investigated the neural mechanisms underlying Chinese multi-character word recognition by exploring brain regions showing the transposed character effect, an effect that can reflect lexical processing and has not been investigated using functional MRI. To examine whether the brain regions showing the transposed character effect participant in word recognition, we further investigated two other effects reflecting lexical processing, i.e. the lexicality effect and the word frequency effect. Methods Using fMRI, brain activations evoked by two-character words, transposable nonwords, and nontransposable nonwords during lexical decision were compared. A transposable nonword is produced by transforming the positions of the characters of a real word (called the base word). It can automatically activate the representation of its base word. Therefore, the comparison between transposable and nontransposable nonword conditions (the transposed character effect) at least partially reveals the mechanisms underlying multi-character word recognition. In addition to the analysis of the transposed character effect, we further examined the lexicality effect (word vs. nonword) and the word frequency effect (high frequency word vs. low frequency word). Finally, the brain regions showing a conjunction of the three effects were obtained. Results The transposable nonwords evoked stronger activations than nontransposable nonwords did in the bilateral inferior parietal lobules (bIPLs). The involvement of the bIPLs in Chinese multi-character word recognition was further confirmed by the results a conjunction analysis of the contrasts "transposable nonword > nontransposable nonword", "word > nontransposable nonword", and "high-frequency word > low-frequency word". The conjunction of these three effects can hardly be explained by the known confounding factors such as difficulty. Conclusions Chinese multi-character word recognition is supported by the bIPLs. In terms of the existing knowledge about the bIPLs, our findings indicate that the access of semantic/phonological information of word representations and/or the semantic integration of the meanings of characters might play an important role in Chinese multi-character word recognition.

B60 Neural oscillations related to word learning from auditory context *Alyson D. Abel[1], Madalyn Long[1], Julia N. Price[1]; [1]San Diego State University*

INTRODUCTION. It is widely accepted that school-aged children and adults learn much of their new vocabulary by encountering novel words in written contexts; however, less is known about the process of learning vocabulary in auditory contexts. Learning new words by using only the surrounding linguistic contexts, whether written or auditory, is an incremental process, occurring through multiple exposures to the word. Previous research has identified changes in theta (4-8 Hz) and upper beta (20-30 Hz) during word learning from written context. This study extends that work, exploring potential changes in theta and upper beta associated with the process of word learning in an auditory context. METHODS. Six adult participants silently listened to naturally-paced sentence triplets. Sentences were 6-9 words in length with the target novel word appearing in the sentence-final position. In the Meaning Plus (M+) condition the three sentences in each triplet increasingly supported the novel word's meaning with the third sentence providing a great deal of contextual support. The Meaning Minus (M-) condition also contained sentence triplets but each sentence provided little contextual support, making it difficult to derive meaning. After each sentence triplet, participants were asked to identify the novel word's meaning, if possible. ANALYSIS. EEG data were epoched in a -500-1500 msec range around the target word. Time frequency analysis was used to quantify event-related spectral perturbations. Epoched data were Fourier-transformed, magnitude-squared, and normalized to obtain the power spectral density. Data were averaged across trials and subjects, and computed using the log power values minus the baseline. Within EEGLAB, an interactive Matlab toolbox, we performed random permutation statistical analysis of the EEG data, computing p-values for both the time and frequency points for each comparison of interest. The study design was a 2 Condition (M+, M-) x 3 Presentation (1,2,3) ANOVA in theta (4-8 Hz) and upper beta (20-30 Hz) between 350 and 550 msec post-target word onset. RESULTS. There was a significant condition x presentation interaction for theta driven by an increase in theta power at the second presentation in the M+ condition only. In considering the association between a theta power increase and semantic processing, this finding indicates greater semantic processing as the meaning of the word is likely being identified during the second presentation in the M+ condition, unlike the M- condition, in which the word's meaning was not available. Upper beta showed a significant decrease from the first to second presentation in both conditions. These beta decreases may relate to binding/memory processes; specifically, active maintenance of early-presented linguistic information in memory and the binding of this early information to later-presented linguistic information. CONCLUSIONS. The current auditory context demonstrated changes in theta and beta, consistent with a previous study investigating visual word learning; however, the pattern of findings differ. Specifically, upper beta power increased during the written task and decreased during the auditory task. This suggests that various cognitive processes may be differentially involved based on modality of the word learning context.

B61 A Brain-Based Componential Model of Semantic Representation Correctly Classifies Words into Superordinate Categories *Leonardo Fernandino[1], Colin Humphries[1], Lisa Conant[1], Rutvik Desai[2], Jeffrey Binder[1]; [1]Medical College of Wisconsin, [2]University of South Carolina*

In featural models of concept representation and categorization, concepts are typically described by a set of prototypical features, and category membership is usually determined by similarity in terms of feature matches and mismatches. However, the features on which these models are based are often complex concepts themselves, such as "grows on trees", or "is a mammal", which makes it difficult to relate the model to actual neurobiological processes. Here we investigate whether a model of concept categorization based on embodied, neurobiologically realistic features, rooted in known brain systems, succeeds in classifying words into superordinate categories. The model consists of 65 attributes related to sensory, motor, spatial, temporal, affective, social, and cognitive processes. A set of 302 English nouns, rated on each attribute on a 7-point Likert scale, and belonging to 10 mutually-exclusive categories, was used in the study: 30 animals, 17 food items, 43 human occupations, 20 musical instruments, 40 locations, 30 plants, 35 social situations/events, 27 tools, 20 vehicles, and 40 abstract concepts. Categorization was implemented through logistic regression, using all 65 attributes as predictors. Model training and testing followed a leave-one-word-out cross-validation procedure: for each category, the model was trained to distinguish between the target category and all other categories combined, using 301 words as input data, and then tested on the remaining word. Thus, for each word, the model generated a membership probability for each category, and assigned it to the category with the highest probability. The resulting classification had a perfect hit rate (1.0) for animals, human occupations, musical instruments, plants, tools, and vehicles. The other categories had the following hit rates: Food: .88, Location: .97, Social event: .97, Abstract: .97. Mean hit rate across categories was .98 (chance = .1), showing that a componential model based on embodied, brain-based features can classify common nouns into superordinate categories with high accuracy. To further explore the model and relate it to studies of category-specific semantic deficits in stroke patients, we investigated the effect of "lesioning" specific attributes of the model. To better assess classification performance of the "lesioned" models against the "intact" model, we computed Luce's choice indices for each word, which takes into account not only whether the word was correctly classified, but also the magnitude of the membership probability for the correct category relative to the membership probability for the other categories. Luce's choice indices for the intact model were as follows: Animal: .96, Food: .87, Human: .98, Musical instrument: 1.0, Location: .96, Plant: 1.0, Social event: .93, Tool: .92, Vehicle: .92, Abstract: .95. Mean across categories was .95. Lesioning specific attributes led to sharp drops in performance in particular categories, according to the attribute's relevance. For instance, when the attribute "motor hand actions" was lesioned, classification performance for tools dropped to .41, for musical instruments to .68, and for foods to .63, with negligible impact on the other categories. These results suggest that category-specific semantic impairments observed in stroke patients may be explained by embodied componential models.

Orthographic Processing, Writing, Spelling

B62 Peripheral Response to Foveal Word Stimuli in Retinotopically Mapped V1

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A tacit assumption underlying many neurological models of reading is that the early visual cortices extract simple visual features of written words which form the input to progressively more complex feature detectors in extrastriate regions, ultimately culminating in specialized orthographic detectors in the so-called "visual word form area." From here, the reading process begins as orthographic codes are linked to phonological and semantic representations in peri-Sylvian association cortices. According to this account, primary visual cortex (V1) is the beginning of a feed-forward processing chain that essentially recodes the visual stimulus from its initial retinotopic code into a more abstract orthographic code. A growing body of evidence, however, suggests that processing, even in the earliest visual areas, is better characterised as interactive, feedback rich, and subject to cortico-cortico influences from higher-order regions. V1 is known to receive vastly more feedback input than retinogeniculate afferents and this feedback connectivity originates not only in adjacent visual cortices but also in auditory association cortices. For instance, stronger connections from auditory cortex to V1 are found in peripheral than foveal and parafoveal regions. These findings raise the possibility that V1 does considerably more than passively represent foveal information during reading – a hypotheses we investigated here using fMRI. We obtained retinotopic maps of V1 in volunteers who subsequently performed reading tasks in the scanner. Words relative to rest produced activation in foveal regions of V1 consistent with location of word stimulus on retina. Strikingly, there was even greater activation in peripheral areas of V1, well outside the retinotopically-defined region of the stimulus. Word stimuli subtended a maximum visual angle of 1.7° and yet robustly engaged regions of V1 with eccentricity of >10° visual angle. In other words, there were two distinct activations within V1 – a foveal region consistent with the retinotopic presentation of the word and a more eccentric peripheral region far beyond that expected for the physical stimulus. One possible explanation is that the peripheral activation represents a form of audio-visual interaction, presumably due to the sound patterns of words. A second finding was that words with low lexical frequencies (e.g. "thaw") produced significantly greater V1 activation than high frequency words (e.g. "seat"). Because the stimuli were tightly controlled for visual and orthographic properties, it is unlikely this difference was due to purely bottom-

up aspects of the words. Instead, these findings suggest top-down contributions to V1 that in part reflect higher-order properties of the stimuli. These two findings are inconsistent with the notion that V1 simply encodes visual features of the word stimulus that become the input to more complex feature detectors in extrastriate regions. Rather, they suggest that even the earliest stage of cortical processing is influenced by top-down information processing dynamically encoding both visual and non-visual properties of the stimulus.

B63 Large-scale functional networks connect differently for processing words and symbol strings

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Large-scale cortical networks are thought to support the dynamic integration of information across functionally specialized brain regions. Here, we characterized cortico-cortical connectivity patterns underlying single word reading and visual recognition of symbol strings. We recorded magnetoencephalography (MEG) data from 15 participants performing a one-back task on written words or symbol strings (Vartiainen, Liljeström, Koskinen, Renvall, Salmelin, J Neurosci 31:1048-1058, 2011) and applied a frequency-specific spatial filtering technique with high temporal resolution (Laaksonen, Kujala, Salmelin, Neuroimage 42:207-217, 2008) to identify task-specific interactions between cortical regions. Modulations in coherence between cortical regions following stimulus presentation (50-800 ms) were determined by contrasting the spatial filtering results for words and symbols ($p<0.05$, FWE corrected) in pre-specified frequency bands between 3 and 90 Hz (similarly to Liljeström, Kujala, Stevenson, Salmelin, Hum Brain Mapp 36:1202-1216, 2015). Adjacency matrices with nodes based on an anatomical parcellation scheme were created for describing the observed interactions. Whole-cortex mapping of coherence revealed spectrally and spatially distinct connectivity patterns for words and symbols. For words, increased coherence was detected mainly in alpha (8-13 Hz) and high gamma (60-90 Hz) frequency bands, but for symbol strings in the low gamma (30-45 Hz) range. Word reading enhanced coherence in a left-lateralized network with nodes in classical language regions: left inferior frontal, middle/superior temporal, and occipito-temporal cortex. Symbol processing recruited a bilateral network that included fronto-parietal connections, typically associated with directing spatial attention and visual working memory. The left frontal cortex was a major part of both networks, but with different connectivity patterns for the two stimulus types. The spatial distribution of the network nodes agreed well with existing activation- and lesion-based views of language and visual recognition. The present study demonstrates the formation of task-relevant, frequency-resolved large-scale network patterns driven by input stimulus, and provides novel evidence that global functional networks are dynamically modulated by task or stimulus to support goal-directed behavior.

B64 The neural mechanisms of vertical reading fluency in competitive Scrabble players

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Introduction: Skilled readers are able to rapidly recognise words presented in a familiar horizontal format. However, presenting words in unfamiliar formats can significantly impede this proficiency. There is some evidence to suggest that efficiency of visual word recognition can be modulated by experience. One group that has extensive experience viewing words in unfamiliar formats is competitive Scrabble players, who have been found to be faster than controls at correctly identifying words presented vertically in a visual lexical decision task. The current study employed EEG to investigate the neural mechanisms underlying this vertical fluency in Scrabble players. We expected to find group differences in the N170 and P300 components for vertical words, associated with perceptual orthographic processing and visual attention respectively. Methods: Data from 19 competitive Scrabble players and 19 age-matched controls were analysed. All participants completed a visual lexical decision task during EEG recording, with stimuli presented in horizontal and vertical orientations. Response latencies of correct trials were analysed with a 2 (group) x 2 (orientation) repeated measures ANOVA. Four electrode clusters were analysed: A posterior cluster in each hemisphere, and a centro-parietal cluster in each hemisphere. Peak amplitude, latency, and area under the curve were analysed with 2 (group) x 2 (orientation) x 2 (hemisphere) repeated measures ANOVAs. Results: Behaviourally, controls were slower than Scrabble players to correctly respond to vertical words, with no difference between groups for horizontal words. For the N170 component, greater N170 amplitudes were found in the left hemisphere, and horizontal words peaked earlier than vertical words for both groups. Scrabble players had a greater area under the curve for vertical compared to horizontal words in both hemispheres, whereas controls showed no difference between word orientations. For the P300 component, controls had earlier peak amplitudes in the left hemisphere compared to Scrabble players, whereas Scrabble players had larger and more sustained amplitudes in the right hemisphere compared to controls. Discussion: Results for the N170 component suggest early recruitment of left hemisphere orthographic processing in response to linguistic stimuli, as well as faster engagement of perceptual encoding mechanisms for horizontal words compared to vertical words across groups. However, the more sustained N170 for vertical compared to horizontal words for Scrabble players suggests greater reliance on perceptual processing for vertically presented words. Results for the P300 suggest that Scrabble players also

engage right hemisphere attentional mechanisms during visual lexical decisions for both orientations. These results have implications for understanding the function of the visual word recognition system, as well as the cognitive and neural consequences of extensive training within this system.

B65 Examining the effective connectivity of the ventral occipito-temporal cortex during visual word processing with combined TMS-EEG

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Written language processing involves rapid extraction of different kinds of information, from low level visual features to high-level linguistic information. Neuroimaging studies have shown that a specific area, the left ventral occipito-temporal cortex (vOT), plays a crucial role in this complex activity. It is co-activated with several perceptive and linguistic-related areas during reading tasks. It remains unclear, however, if such correlations of neuronal activity reflect effective connectivity between vOT and the co-activated areas. Here, we used a combination of TMS and EEG to firstly investigate the temporal dynamics of EEG activity during word-reading and secondly to examine the effective connectivity between vOT and other areas recruited by the reading network at different functional states: states being modulated by the characteristic of a stimulus (colored dots vs. words) and the task performed by the participants (visual vs. linguistic). The rational is that stimulation of the neurons in the vOT should induce a current spread of neural activity toward anatomically connected areas, modulated by the stimuli and the tasks. Four Go/NoGo tasks (visual task on dots, visual, phonological and semantic tasks on words) were performed during EEG recording. In half of the trials, a TMS pulse was applied at the scalp position corresponding to the left vOT, 100ms after stimulus onset (based on a previous TMS study). vOT was identified in individual anatomical MRI of each subject using functional data (i.e. word-reading contrast in an fMRI experiment). Analyses of the stimulus-evoked response (only "NoTMS" trials) revealed a pronounced negative peak in the 150-200ms time-window at bilateral occipital electrodes during the three "word" conditions, which was largely reduced in the "color" condition. The amplitude of this N170 was not modulated by the task being performed (visual, phonologic or semantic), suggesting a mainly bottom-up response. Specificity to the linguistic tasks (vs. visual) seemed to emerge at right frontal-lateral electrodes in a later time-window (200-300ms), previously associated with pre-semantic orthographic or phonologic processing. In a second set of analyses, TMS-evoked potentials were computed for each subject and task by subtracting NoTMS responses from the TMS condition. An initial modulation of TMS-EPs, related to stimulus type (words vs. colored-dots), was found in the 200-250ms time-window at right lateral-posterior electrodes (i.e. inferior parietal region). A second effect on TMS-EPs, related to the task being performed (visual vs. linguistic), was found in the 350-400ms interval at central-posterior electrodes. In summary, we observed that TMS stimulation of the vOT induced currents that varied, firstly, in the parietal cortex of the controlateral hemisphere as a function of the stimulus being processed, and ,slightly later, in a bilateral posterior region as a function of the information being monitored by the subject (i.e. visual or linguistic). While further analyses of the data should help us interpret the observed task- vs. stimulus dependent TMS effects (e.g. current sources densities analyses), our results so far demonstrate that TMS can be used to probe the networks engaged during reading tasks and to show task-dependent changes in connectivity.

B66 Response Retrieval and Motor Planning During Typing

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Typing is becoming the main written modality. Until the advent of personal computers, typing skill was restricted to a small population of professional experts. Nowadays, many people acquire a high level of expertise through sustained practice rather than formal training. In spite of this prevalence, we do not know much about the neural processes underlying typing. Typing, as any language production modality, requires word retrieval from long term memory and relies on a distributed brain network of left hemisphere areas. However, the motor programs recruited to execute the response differ from those of speech or handwriting. Typing can be described as bi-manual sequence movement production, requiring precise coordination of both hands and their fingers. The constraints imposed by the recruitment of such motor effectors on earlier word retrieval processes remains to be assessed. We examined, in the temporal domain, the interplay between response retrieval and motor planning during typing. About 30 expert typists, all native speakers, were recruited. They had mostly informal but very extensive training. They were engaged in a picture naming task requiring retrieval of long-term linguistic knowledge; in addition, we manipulated the semantic context in which target words appeared to index the stage of word retrieval. Participants were instructed to type their responses, rather than speaking or writing, to elicit processes associated with keystroke representation; in addition, we controlled the side of the first keystroke of target words. We recorded high-density electroencephalograms (EEG) continuously from the presentation of a picture to the typing of its name, in a total of 500 trials per participant. We computed analysis on both potentials and time-frequency, time locked both to stimulus and response. We favored a

data-driven statistical analysis minimizing a prioris regarding time-windows and electrodes of interest. The analysis of the beta frequency band revealed a two-phase desynchronization (ERD), first left-lateralized and then bilateral. Potentials data preceding response execution revealed clear components over the motor cortices, of opposite signs between hemispheres; the contrast between such ipsi- and contralateral activity was independent of the hand typing the first key. In contrast, the first keystroke side produced significant differences early after stimulus presentation (~200 ms). Finally, the semantic manipulation did not reveal any significant effect. The two clearly distinct ERD phases are interpreted as a refection of retrieval and execution processes. The characteristic pattern seen over ipsi- and contralateral hemispheres in the potentials data is interpreted as activation and inhibition of the contra and ipsilateral motor cortices, respectively, due to its similarity to EEG data observed during single movement preparation. The early signature of response properties – i.e. an influence of keystroke side - in the potentials data can be linked to keystroke schemata, as postulated in cognitive theories. Indeed a specificity of typing is its reliance on keystroke representations that hold information about both letter identity and spatial characteristics of the key to strike. Overall, these results suggest an early retrieval of representations holding information about keystroke features, echoing in particular recent reports supporting early activation of phonology in speech production.

B67 Magnetoencephalography (MEG) evidence for the bidirectional mapping consistency between orthography and phonology in Chinese character recognition

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The orthographic consistency, defined as whether words have rimes that can be spelled in multiple ways, has shown a robust effect on spoken word recognition. By contrast, the effect is less reliable in visual modality. However, it is crucial to examine if the orthographic consistency effect could also be obtained in visual word recognition. It implies, when reading a word, the orthographic form not only actives its phonological form, the orthographic consistency associated with the phonological form would have an additional resonance effect on the visual word recognition. In Chinese, two types of orthographic consistency measures can be defined: one is homophone density and the other is the phonology-to-orthography (P-to-O) consistency (whether a set of homophones can be divided into subgroups based on their phonetic radicals). In this study, we aimed to employ magnetoencephalography (MEG) to investigate the temporal dynamics of two types of orthographic effects in Chinese visual word recognition, and how O-to-P consistency (whether a phonetic radical can be mapped onto different pronunciations) modulate those effects. Participants were asked to perform a homophone judgment task, the former stimuli were manipulated in three factors (homophone density, P-to-O consistency and O-to-P consistency) and two levels (high, low). The data revealed significant interactions between homophone density and O-to-P consistency in the left fusiform gyrus, which is responsible for visual-orthographic processing, at ~120 ms, and in the left insula and the left superior temporal gyrus, which are associated with phonological and semantic processing, from 160 ms to 200 ms. The activations were higher in reading high homophone density characters, especially for those with high O-to-P consistency. In the later time window of 300ms to 350ms, both types of orthographic consistency were found in visual cortex, including cuneus, precuneus, pericalcarine and lingual gyrus, where the high P-to-O consistent and high homophone density characters revealed greater activations. These effects were further modulated by the O-to-P consistency effect in the time window from 560 to 600ms: the activations were increased when reading high O-to-P consistent characters with high number of homophones and high P-to-O consistency. These results support the bi-directional interaction between the phonology and orthography in Chinese character recognition. In particular, the modulation effects were found in several brain regions related to visual processing in both the early and late time windows, suggesting that orthographic knowledge is automatically activated and modulated by bidirectional O-to-P consistency and P-to-O consistency.

B68 The neural underpinnings of reading skill in deaf adults

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Little is known about the neural adaptations that support skilled reading when the process of learning to read is altered by deafness rather than by a specific reading disability. We investigated word-level reading circuits in skilled deaf readers (N = 14; college level) and less skilled deaf readers (N = 14; mean reading age = 12 years) who were all highly proficient users of American Sign Language. During fMRI scanning, participants performed a semantic decision (concrete concept?), a phonological decision (two syllables?), and a false-font control task (string underlined?). For each task vs. the control task, less-skilled readers exhibited weaker and less extensive with-group neural activation compared to skilled readers, but direct contrasts revealed no significant group differences. However, at an uncorrected threshold, skilled readers exhibited greater activation in left inferior frontal gyrus (IFG) compared to less skilled readers for both tasks. There were no regions that were significantly more active for the less-skilled readers (even with liberal thresholds). Thus, we did not observe a distinct pattern of neural activation specific to less skilled deaf readers. Inspection of inter-individual variability revealed a high degree of heterogeneity in the location of activation across the less skilled readers, whereas for the skilled

readers, the spatial location of neural activity was highly consistent. Whole-brain correlation analyses across all participants revealed that for the semantic task, reading ability was positively correlated with neural activity in a region anterior to the visual word form area (VWFA) that is associated with the orthography-semantics interface (Purcell, Shea, & Rapp, 2014). We suggest that better deaf readers have stronger or more finely tuned links between orthographic and semantic word-level representations, leading to more consistent or extensive engagement of this interface for skilled readers. Accuracy on the semantic task was positively correlated with neural activity in the left anterior temporal lobe, a region linked to conceptual processing in hearing people (Patterson et al., 2007). This result suggests that when reading words, the neural substrate supporting conceptual processing is similar for deaf and hearing readers. Reading ability did not correlate with neural activity during the phonological task, consistent with recent work suggesting that for deaf individuals, phonological ability is only weakly predictive of reading skill (e.g., Mayberry et al., 2010). Accuracy on the phonological task was positively correlated with neural activity in left posterior IFG, a region linked to syllabification processes during speech production. Following MacSweeney et al. (2009), we hypothesize that deaf readers rely more on fine-grained articulatory coding than on auditory processes when reading. We found no correlation between reading skill and neural activity in the VWFA for either task, suggesting that a primary marker of disabled reading in hearing individuals, namely reduced activation in the VWFA in comparison to skilled readers, does not hold for deaf readers. Overall, highly skilled deaf readers robustly engaged the same reading circuit that has been identified for hearing readers, while less skilled deaf readers exhibited much weaker activation within this circuit.

Syntax, Morphology

B69 Delta-band oscillatory phase predicts formation of syntactic phrases: electroencephalography evidence from attachment ambiguities

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The number of words in most sentences exceeds working-memory capacity; hence, successful sentence comprehension requires that words form syntactic phrases. The syntactic phrases of a sentence can be inferred from the intonation phrases in speech. Delta-band oscillations in auditory cortex are known to track intonation phrases during speech perception, but the implications for the formation of syntactic phrases are unclear. In the current auditory electroencephalography study on sentence comprehension, we hypothesized that delta-band oscillations predict comprehenders' formation of syntactic phrases. Our sentence materials involved a low–high attachment ambiguity, where an identical word occurred either in the middle or at the offset of an intonation phrase, thereby either continuing or ending a syntactic phrase. We reasoned that delta-band oscillatory phase at the identical word should be predictive of whether participants decide to continue (deciding for low attachment) or terminate (deciding for high attachment) the current syntactic phrase with the critical word. We correlated single-trial delta-band oscillatory phase with participants' attachment choices, finding that delta-band oscillatory phase during the processing of an identical word predicts whether participants decide to continue or terminate the current syntactic phrase. Source localization suggests brain regions involved in auditory attention, pitch perception, and syntactic phrasing generate the scalp-level effect. Delta-band oscillations thus not only support the perceptual processing of intonation phrases, but also the cognitive formation of syntactic phrases during language comprehension: Rhythmic fluctuation of auditory attention with the delta-band oscillatory cycle may situate the formation of syntactic phrases into periods of maximal auditory attention.

B70 Do we pre-activate linguistic information when processing predictable morpho-syntactic regularities?

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Preceding sentential context generates expectations about the sentence elements that follow. Previous neuroimaging research has shown that the activation strength within the language-related cortical areas is inversely correlated with a word's contextual predictability at different stages of word processing (phonological, semantic, syntactic). These findings can be explained either by the integration cost - unpredicted words or word elements are harder to integrate into the emerging sentence meaning, or predictive coding - the prediction-error associated with unpredicted elements is greater. Both of these require the existence of a mechanism by which context generates constraints or explicit expectations about upcoming sentence elements either prior to or shortly after their perceptual onsets. Using a spatiotemporally resolved imaging method - the combination of electro- and magnetoencephalography (EMEG) - we searched for such mechanisms during the processing of error-free and unambiguous sentences. Such an approach ensures that observed effects are not masked by other intervening cognitive strategies of error-detection or re-analysis, as generated in previous research using

sentences containing violations. During the experiment subjects listened to Russian sentences with contextually predictable and unpredictable verb-agreement suffixes. For example, in the sentence /Sasha igrayet na pianino/ - 'Sasha plays piano' the suffix /ayet/ is unambiguously predicted by the subject Sasha. We can produce the same gramatically error free sentence with a different word order /Na pianino igrayet Sasha/ where the same agreement marker /ayet/ precedes the subject and is no longer predicted. We included two types of agreement suffixes - /ayet/ third person singular and /ayut/ third person plural. Firstly, we compared the source space activations related to predicted and unpredicted suffixes using both univariate and multivariate methods. All predicted suffixes generated greater signal amplitudes and produced characteristic activation patterns within the language-related bilateral temporal areas prior to the perceptual onset of the predicted suffix. For the predicted suffixes only, these activations were further modulated by the suffix type. Secondly, using multivariate representational similarity analysis (RSA) we have shown that the activation patterns related to singular and plural predicted suffixes started to diverge before the suffix onset. The spatial distribution of these effects within the posterior, middle and anterior temporal areas suggests that specific suffix-related information about both the phonological form and the grammatical meaning of the suffix may be predictively pre-activated. Interestingly, we did not observe increased activations for unpredicted suffixes after suffix onset, which we would expect, if they required greater integration cost or produced greater prediction-errors. These results, only made available through multivariate analysis of EMEG data in source space, give new insights into how highly predictable linguistic regularities are processed.

B71 Neural Correlates of Syntactic Movement *Eduardo Europa[1], Cynthia K. Thompson[1,2,3]; [1]Northwestern University, [2]Feinberg School of Medicine, [3]Cognitive Neurology and Alzheimer's Disease Center*

Syntactic movement is a psycholinguistic concept from Government and Binding Theory (Chomsky, 1981, 1986, 1995) referring to the displacement of sentence constituents to argument (NP-movement) or non-argument positions (Wh-movement) within sentences. Such displacement results in noncanonical sentences where the theme is encountered before the agent, which requires greater cognitive resources for comprehension, as compared to canonical sentences. Studies examining the neural mechanisms of complex, noncanonical sentence processing have shown that comprehension of sentences with Wh-movement (e.g., object-cleft sentences) and NP-movement (e.g., passive sentences) elicits activation in overlapping, but distinct left-lateralized networks, including the inferior frontal gyrus (IFG) and temporoparietal junction (Thompson et al., 2010; Mack et al., 2013). The purpose of the present study was to directly compare the neural correlates of these two movement types. Twelve right-handed native English speakers (6 females, mean age = 27.75 years, SD = 3.44) with normal or corrected-to-normal hearing and vision participated in the study. Participants were scanned with a 32-channel head coil in a 3T Siemens TRIO system at the Center of Translational Imaging at Northwestern University. Functional magnetic resonance imaging (fMRI) data were acquired during comprehension of noncanonical (e.g., passive and object-cleft) and canonical sentences (e.g., active and subject-cleft). Presented with black and white line drawings of two-participant semantically reversible actions, and auditory sentences, participants responded with a button press to indicate whether the sentences matched or mismatched the scene; mismatches involved role-reversals. There was also a control condition where participants were instructed to push a button after hearing reversed speech (i.e., time-reversed auditory sentence stimuli) and scrambled versions of the black and white line drawings. Participants were less accurate ($t(11)=2.81$, $p<0.05$) and required greater reaction time ($t(11)=3.13$, $p<0.005$) for passive compared to active sentences. Greater reaction time ($t(11)=5.20$, $p<0.001$) on object-cleft structures, compared to subject-cleft sentences, was also found, but no significant differences in accuracy were found for the two sentence types. In line with previous fMRI studies, a main effect of canonicity was found for noncanonical sentences in bilateral frontal and left inferior parietal cortices. Wh-movement (object-cleft>subject-cleft) over NP-movement (passive>active) resulted in activation in bilateral IFG and insula and left middle frontal gyrus; however no activation was found for NP-movement over Wh-movement. These findings are in line with both representational and processing accounts of the two sentence types. IFG activation for Wh-, but not NP-, movement may reflect syntactic movement operations, which are more complex for the former, requiring crossing of clausal boundaries, with movement to a higher clause (Caramazza & Zurif, 1976; Grodinsky, 1990). In addition, two co-referential relations are required for Wh-movement structures: (1) between the trace and the wh-element, and (2) between the wh-element and the direct object. Previous research also suggests that the IFG activation may be due to greater syntactic working memory demands required for processing Wh-movement structures (Fiebach, Schlesewsky, & Friederici, 2001). Further research is required to clarify the differences between the two movement types.

B72 The effect of degree of automaticity in processing hierarchical structure in arithmetic and language *Hyeon-Ae Jeon[1], Angela Friederici; [1]Max Planck Institute for Human Cognitive and Brain Sciences*

It has recently been suggested that a degree of automaticity in cognitive processing is a crucial factor in modulating the functional organization of the prefrontal cortex (PFC): the posterior-to-anterior gradient system for more controlled processes with a low degree of automaticity and the posterior-confined system for automatic processes with a

high degree of automaticity (Jeon and Friederici, 2015). The neural mechanism involved in processing arithmetic has been investigated along with mathematical proficiency. It has been suggested that people with high proficiency retrieve mathematical facts stored in memory quickly and effortlessly, whereas people with low proficiency derive answers from procedural knowledge that is slow and prone to error (Zamarian et al., 2009). Taking these observations together, we investigated the neural networks for hierarchical processing in language and arithmetic depending on individual levels of proficiency. We recruited two groups of participants: mathematicians with a high level of mathematical proficiency and non-mathematicians with a low level of mathematical proficiency. Participants went through hierarchical processing with center-embedded sentences in language and center-embedded calculations in arithmetic. Using functional magnetic resonance imaging, we observed a significant difference between groups when processing arithmetic. While a broad fronto-parietal network was being activated in non-mathematicians, focal activation in the left precentral gyrus and left superior parietal lobule were found in mathematicians. However, no group difference was found in language. To elucidate the effect of degree of automaticity on the functional segregation within the PFC, a correlation analysis was conducted between individual degree of automaticity and the percent BOLD signal change from peak activations within the PFC. As a result, significant activation in its posterior area (precentral gyrus) was observed for arithmetic in mathematicians, being positively correlated with the degree of automaticity. However, non-mathematicians recruited a wide posterior-to-anterior network, with peak activation in the anterior region (pars triangularis, BA45) showing a negative correlation with the degree of automaticity. For language, no group difference was found in the activation pattern within the PFC and the posterior region of the PFC (BA44) was positively correlated with the degree of automaticity in both groups. From the current data we discovered that the organizational principle of the degree of automaticity in the PFC can also be applied to the arithmetic domain, making a possible broad generalization of this organizational rule. Jeon, H.-A., & Friederici, A. D. (2015). Degree of automaticity and the prefrontal cortex. Trends in Cognitive Sciences, 19(5), 244-250. Zamarian, L., Ischebeck , A., & Delazer, M. (2009) Neuroscience of learning arithmetic—Evidence from brain imaging studies. Neuroscience and Biobehavioral Reviews, 33(6), 909-925.

B73 Syntactic LAN and P600 effects dissociate with experience to anomalous sentences

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Two types of ERP effects have been previously reported in response to syntactic anomalies, relative to well-formed sentences, during sentence comprehension. The most common effect is a central-parietal late positivity (P600). This effect is sometimes preceded by left anterior negativity (LAN). LAN-without-P600 is unusual in response to syntactic violations. The P600 effect has been associated with syntactic repair, and more recently with the difficult integration of morphosyntactic and semantic information. The LAN has also been associated with integration as well as working memory demands. Understanding of the processes reflected in these widely observed syntax-related ERP effects is challenged by the lack of clear distinction between the conditions that elicit them. Here, we found separable P600 and LAN effects elicited by the same stimuli, distinguished by the amount of experience participants had with anomalies across the study. Thirty-seven participants read 130 sentences appearing either in a syntactic violation or well-formed control form (e.g., "The thief was caught by FOR/THE police"). Target sentences were uniform in structure, consisting of a noun phrase, passive verb, and by-phrase, in which a preposition could replace the determiner to create an anomaly. Target sentences were interspersed with 270 filler sentences of varied structure and well-formedness. Words were presented RSVP (SOA = 550 ms; 100 ms ISI). Participants answered yes/no comprehension questions following one-third of the items. Continuous EEG was recorded from 64 Ag/Ag-Cl electrodes (Neuroscan QuikCaps), sampled at 1000Hz. After recording, data were down-sampled to 200 Hz, bandpass filtered (0.1 – 50 Hz), and analyzed in epochs spanning -200 ms – 1000 ms relative to word-onsets. In the grand-average data, syntactic anomaly ERPs were dominated by a LAN in the absence of a clear P600 effect. This effect pattern contradicted a clear P600-without-LAN pattern in a previous study with similar stimuli (Kim & Gilley, 2013) and is generally unusual for studies of syntactic anomaly. We speculated that the current results were influenced by learning over experience with these experimental stimuli, in part because we presented a larger than typical number of stimuli. Further analysis of the first and second halves of the study separately found that syntactic anomalies elicited a clear P600-without-LAN effect in the first half of the experiment and LAN-without-P600 pattern in the second half. This dissociation very clear but was masked in the grand-averaged data. The P600-to-LAN switch suggests a change in parsing strategies as the participants repeatedly encountered anomalous items throughout the experiment. At first readers might adopt a repair strategy (reflected in the P600) and then adapt to a more automatic parsing strategy (or lexical recognition/integration process; reflected in the LAN) as the anomaly context becomes more familiar. Previous reports of joint LAN-P600 effects may similarly reflect two separate stages of responding, rather than a single two-component response. We are currently conducting additional studies and analyses to better understand the typicality of this P600-to-LAN switch, and to better understand the LAN and P600 functionally by investigating the functional demands that lead to their dissociation over time within the current study.

B74 Expectation effects in syntactic processing – evidence from ambiguous sentence structures *Leon Kroczek[1], Thomas C. Gunter[1]; [1]Max Planck Institute for Human Cognitive and Brain Sciences*

Sentence comprehension is a rapid process that takes place within milliseconds after a linguistic input is presented. Generally, it has been hypothesized that the brain enables such efficiency by means of predictive processing. In language comprehension, expectation effects have been demonstrated mainly for the semantic domain. However, processing the syntactic structure of a sentence ("who is doing what to whom") is a crucial part in sentence comprehension. Accordingly, top-down expectations could also play an important role with regards to syntactic structure processing. In the current EEG study a speaker's voice (male, female) was coupled to the expectancy for a particular syntactic structure. Thus, one speaker produced complex Object-Subject-Verb (OSV) sentences with a higher probability than easy Subject-Object-Verb (SOV) sentences (the O-speaker) and vice versa for the other speaker (the S-speaker). Importantly, experimental sentences were ambiguous towards their syntactic structure up to the sentence final word. We hypothesized that speaker information would make the disambiguation easier. Preliminary analysis showed that participants were sensitive to a particular speaker identity as demonstrated by an increased positivity for the O-speaker compared to the S-speaker that was elicited at a time-point before the actual syntactic structure was disambiguated. ERPs time-locked to the disambiguating final word showed a main effect of structure, with complex OSV structures having a more positive waveform than easy SOV structures. Additionally, the probability of a structure also had an effect approximately 200 ms later in time. Sentences with a congruent speaker-structure pairing (S-speaker/SOV and O-speaker/OSV) showed a greater positivity than sentences with an incongruent speaker-structure pairing (S-speaker/OSV and O-speaker/OSV). These findings suggest that although the participants coupled the probability for a particular sentence structure to a particular speaker, this had no beneficial effect for syntax processing per se. Probably the ambiguity of the sentences led to these results.

B75 Differentiating Types of Grammatical Illusions: a Closer Look at Escher Sentences *Patrick Kelley[1], Karthik Durvasula[1], Alan Beretta[1]; [1]Michigan State University*

Grammatical illusions are sentences where the parser fails to recognize a grammatical constraint, eliciting a grammatical judgment from a reader when the sentence itself is ungrammatical (Phillips, Wagers, & Lau, 2011). One particular type of illusion, Escher Sentences (Eschers) can be subdivided into two types, Type I and Type II. Type I and Type II Eschers commonly elicit grammatical judgments from readers, but they suffer from two grammatical constraint violations with respect to comparisons: type vs. token and number. Type I Eschers contain both violations where Type II Eschers only contain a mismatch in type vs. token. Two experiments were conducted to determine acceptability differences between these two types and to probe for a difference at the neurophysiological level. Methods: Experiment 1 consisted of 55 native speakers of English that participated in a survey grading the acceptability of controls, fillers, and both types of Eschers using a scale rating of 1-7, where 1 was not an acceptable sentence of English, and 7 was completely acceptable. Experiment 2 consisted of a different group of 21 native speakers of English that participated in an EEG experiment where Type I and Type II sentences were randomly presented using an RSVP paradigm (SOA 600ms). Stimuli were presented one word at a time for 400ms with a 200ms ISI. Participants were tasked to rate the acceptability of each sentence using the same scale as the previous experiment. 32 electrodes were used with a 256Hz sampling rate, a filter of .01-40Hz, and mastoids were used as references. Results: in Experiment 1, there was a significant effect of the sentence type and acceptability judgments, and post-hoc tests indicated significant differences between Type I and Type II, Type I and Control, and Type II and Control. In Experiment 2, an ANOVA was performed with the factors Condition (2: Type I, Type II) X Anteriority (2: Anterior, Posterior) X Laterality (2: Left, Right) at the 500-800ms window. There was an interaction between Anteriority and condition, and post hoc tests indicated that Type I was significantly different than Type II in the Anterior region. Conclusion: behavioral results indicate a significant difference between Type I and Type II Eschers, where Type I sentences are markedly less acceptable than Type II. The ERP data is interpreted as a late frontal positivity, suggesting that Type I sentences have a greater violation in sentential expectancy than Type II (DeLong, Urbach, Groppe, & Kutas, 2011). This difference is attributed to the number of grammatical constraints violated by each type of Escher sentence. Overall, the data suggest that these illusory sentences differ in illusory strength, which is determined by the processing requirements of the grammatical constraints. These results begin to shed light on the understanding of how and why grammatical illusions can bypass the judgments of the parser.

Poster Session C

Friday, October 16, 10:00 am – 12:00 pm, French and Walton Rooms

Control, Selection, Working Memory

C1 Alpha power in young and older adults' attention at a cocktail party *Chad Rogers[1], Lisa Payne[2], Sujala Maharjan[2], Robert Sekuler[2], Arthur Wingfield[2]; [1]Washington University in St. Louis, [2]Brandeis University*

Auditory attention is critical for understanding a single talker in a multi-talker environment, such as a cocktail party (Cherry, 1953). For older adults, this type of listening is more difficult (e.g., Ezzatian et al., 2015), more exhausting (e.g., Kramer et al., 1997), and more poorly encoded to long-term memory (Tun, O'Kane, & Wingfield, 2002) than in young adults. Recent work using electroencephalography (EEG) has demonstrated a neural correlate of auditory attention in the directed dichotic listening task (DDLT), where listeners attend to one ear while ignoring the other (Kerlin et al., 2010; Frey et al., 2014). Differences between left and right hemispheres in alpha band power (8-13 Hz), localized to parietal cortex, indicate the direction to which attention is focused. In the current study, we used EEG and the DDLT to examine alpha lateralization and its relationship to short and long-term memory performance in young (n=15) and older (n=15) adults. The DDLT consisted of a cue arrow to attend to the left or right ear, followed by streams of four unrelated words presented to each ear, and finally a probe word presented to both ears. Participants immediately judged if the probe word was presented in the attended ear. Following the DDLT, participants' performed a delayed recognition task on all words presented. We found that older adults were less accurate on the DDLT than young adults, and were more likely to have intrusions from the unattended stream. EEG measures revealed when participants were instructed to attend to the right ear, they showed greater alpha power in parietal and right-temporal regions than when they attended to the left ear. All listeners showed this pattern, although it was more evident in the young adults. For delayed recognition, young adults recognized words from the attended stream, but were below chance for words from the unattended stream. Older adults did not show this differentiation; their later recognition for attended and unattended words was equivalent. In summary, we found a right-ear advantage in both oscillatory brain dynamics and behavior. Alpha lateralization indices only indicated greater activity when attending to the right than when attending to the left—no significant alpha clusters were greater when attending left than right. This was true for both young and older adults. Both groups were more accurate when attending right, and made more false alarms to a word from the unattended stream when attending left. We hypothesize that the right-ear bias during the DDLT reveals an interaction between spatial attention and the dominance of the left hemisphere for processing language.

C2 Wait for it: Predicted Error vs. Prediction Error in Language Processing

Phillip M. Alday[1], Jona Sassenhagen[2], Scott Coussens[1], Ina Bornkessel-Schlesewsky[1]; [1]University of South Australia, [2]Goethe University Frankfurt

The free-energy principle, as proposed by Friston (2005, 2009), provides a parsimonious account of cortical activity as an expectation-maximization process in a hierarchical model. In this framework, prediction is pre-activation; however, pre-activation is not necessarily restricted to simple Hebbian association, but is rather an integrative, partially pooled stochastic computation across multiple timescales, including an infinite past (a prior in the Bayesian framework or long-term memory in neurocognitive terms). The long-standing debate in the literature about whether the N400 reflects prediction or (associative) pre-activation is thus ill-posed (cf. Kutas and Federmeier 2011). Recent attempts to quantitatively model the N400 through information theoretic measures (e.g. surprisal, entropy, cf. Frank et al. 2015) capture a large part of this variation through conditional frequency distributions, but naive corpus measures fail to capture the effect of explicit markers of information content such as "surprisingly" or "importantly", whose conditional frequency is uniformly low. We examined the role of such explicit markers of high information content (unpredictability) in a 2x2 paradigm extending the classic N400 semantic violation paradigm by crossing "cueing" with "plausibility", e.g. "The [kind|strange] doctor gave his patient a red [lollipop|fork]". We used linear mixed-effects models to model the modulation of mean EEG amplitude in a time window 250-400ms post stimulus onset. A preliminary analysis (13 subjects) revealed a strong crossed interaction for plausibility and cueing, which absorbed the well-established main effect for plausibility. Conditional on cueing, we observed a simple effect for plausibility. Visual inspection of the ERP suggests a ranking of the four conditions in terms of N400 amplitude: uncued implausible > cued implausible > (misleadingly) cued plausible > uncued plausible. Model estimates support this ranking, but are not reliable based on estimates of error in this preliminary dataset. The strong interaction with cueing is not easily explained by traditional accounts based on associative pre-activation, but is easily accounted for by a hierarchical model. Global cues influence the structure of predictions and thus the brain is less committed to a particular associative expectation, which modulates the N400 for implausible completions. Invalid cueing (cued yet plausible) increases N400 amplitude compared to the baseline condition by preventing the brain from committing to a particular model. In Bayesian terms, cueing affects the specification of the prior and leads to a less-specific, broader posterior distribution. For the implausible completions, this reduces the mean error, but increases the mean error for the plausible completions. In conclusion, prediction is more than just pre-activation based on naive Hebbian conditional frequencies. Prediction arises from a hierarchical, generative model that pools both distributional information and information about expected distributions. A predicted error can reduce the prediction error because prediction overrides and overcomes frequency.

C3 ERP Effects for Prominence in Reference Resolution

James R. Monette[1], John E. Drury[1]; [1]Stony Brook University

[BACKGROUND] Previous ERP studies of anaphor processing have reported sustained anterior negativities (Nrefs) following anaphors in contexts with more than one potential antecedent (e.g., ''Bruce told Al that HE…"; Nieuwland & Van Berkum 2006). More recently it has become clear that these situations of referential ambiguity may also give rise to P600-type effects, with the observed pattern (i.e., Nref, P600, or both) depending on both presence/absence and type of behavioral task as well as individual differences in working memory span (Nieuwland & van Berkum 2008; Nieuwland 2014). However, electrophysiological investigations of reference resolution have not pursued potential differences within their referentially unambiguous control conditions, namely whether or not the subject or object of the matrix clause is taken to be the single available referent (ex. "John told Sarah that he…" vs. "John told Sarah that she…"). These antecedent positions differ in locality to the referent (object position > subject position) and in relative prominence (subject position > objection position), both of which have been shown to influence reference resolution in behavioral studies (Foraker & MclElree 2007, Felser 2014). [STUDY] The present ERP reading/judgment study examined responses to pronouns in contexts with 2, 1, or 0 available antecedents. Additionally, we divided the cases with only one available referent [1Ref] based on whether the first or second NP served as the antecedent. For example: [2Ref] "Mary told Jane that SHE…" [1Ref-NP1] "Mary told John that SHE…" [1Ref-NP2] "John told Mary that SHE…" [0Ref] "Mike told John that SHE…". Included also in this study were a range of violation types targeting, e.g., morpho-syntax ("could *walks…"), semantic anomaly ("ate the *cloud"), and logical-semantics/pragmatics ("There wasn't *John in the room"). [METHODS] Sentence presentation was standard RSVP, followed by acceptability judgments on a 1-4 scale. ERPs were time-locked to pronouns and were examined for 1200 ms epochs (100 ms baseline). Individual reading span scores were acquired for each participant prior to testing. [CONCLUSION] Preliminary data (N=13) suggest both Nref and P600 effects for both [2Ref] and [0Ref] compared to the [1Ref-NP1] cases (consistent with Nieuwland 2014). Comparison between the [1Ref-NP2] and [1Ref-NP1] cases showed a broadly distributed negativity for the [1Ref-NP2] condition that was present over anterior electrodes from 400-900ms and posterior electrodes from 500-1000ms. The anterior portion of the effect differed significantly in amplitude and scalp distribution from Nref effects observed in our 2Ref condition, suggesting that this profile is unique from those elicited in response to referential ambiguity. Likewise, the posterior portion of the effect differed in timing and distribution from N400 effects elicited elsewhere in the study. We interpret these results as evidence for a cognitive bias towards selecting more prominent antecedents, taking the effects observed for the [1Ref-NP2] condition to index an extra cognitive burden for coindexing the pronoun with a less preferred antecedent. We situate our discussion within the framework of Content Addressable Memory (CAM), and make a case for connecting prominence with focal attention.

C4 Dissociating the effects of genetics and bilingualism during cognitive control: fMRI evidence from Spanish-English bilinguals

Kelly A Vaughn[1], Aurora I Ramos-Nuñez[1], Maya R Greene[1], Arturo E Hernandez[1]; [1]University of Houston

Research suggests that bilingual language use requires the same control regions of the brain as non-verbal cognitive control, such as the anterior cingulate cortex (ACC) and the inferior frontal gryus (IFG) (see Abutalebi & Green, 2007). Activity in these brain regions is also associated with dopamine pathways, and may differ across individuals based on genetic factors. Individuals who carry the A1 allele of the ANKK1 gene have fewer dopamine receptors in fronto-striatal regions, and show less neural activity in inferior frontal regions during non-verbal cognitive control than individuals who do not carry this allele (Stelzel, Basten, Montag, Reuter, & Fiebach, 2010). No study to date has examined the relationship between A1 carrier status and neural activity during bilingual language control. Additionally, no study to date has connected the ANKK1 gene to activity during non-verbal cognitive control tasks in a Hispanic, bilingual population. This is important based on data from Hernandez, Greene, Vaughn, Francis, and Grigorenko (2015) indicating that Hispanic bilinguals carry the A1 allele at twice the rate of Caucasian monolinguals. The goal of the current study was to determine whether carriers of the A1 allele and non-carriers differ in neural activity during language control and non-verbal cognitive control tasks after controlling for bilingual language variables. Forty-four Spanish-English bilingual young adults (ages 18-35) who gave DNA samples performed the Simon task, the shape-color task, and a bilingual picture-naming task in the fMRI scanner. The genetic data was analyzed by collaborators at the EGLab for behavioral and molecular genetics at Yale University. AFNI software (Cox, 1996) was used to analyze the fMRI images during each task, and neural activity for each participant was calculated within two regions of interest (ROIs): the bilateral anterior cingulate cortex (ACC), and inferior frontal gyrus (IFG). Activity in these ROIs was used as the outcome variable for multiple regressions with age of English acquisition (AOA), English proficiency, Spanish proficiency, and A1 carrier status. For verbal cognitive control, measured by the picture-naming task, A1 carriers showed more activity in the bilateral IFG than non-carriers for English naming, but AOA and English proficiency were also significant predictors of activity in this region. For the shape-color task, A1 carriers activated the bilateral ACC less than non-carriers for switch > repeat contrast, while AOA and English proficiency predicted neural activity in the IFG for the switch > repeat contrast. During the Simon task, A1 carrier status did not significantly predict activity in either of the ROIs, but AOA, English proficiency, and

Spanish proficiency were related to activity in the left ACC for the incongruent > congruent condition. These results suggest that neural activity in cognitive control regions during language control and non-verbal control is related to genetics and bilingual language experiences. Future studies should seek to understand the complex, multivariate nature of cognitive control by including many environmental and genetic factors in the analyses.

C5 Lesions to lateral prefrontal cortex impair control over response selection in word production

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Speaking is an action that requires control, for example, to prevent interference from distracting or competing information present in the speaker's environment. The lateral prefrontal cortex (PFC) is thought to be involved in control over task performance, and the left inferior frontal gyrus (LIFG) in particular has been proposed as a key candidate in mediating selection among semantically related response competitors. Here, we examined the role of left PFC in the control over response selection in word production by testing six non-aphasic patients with focal lesions to the left PFC (mainly centred around the LIFG) on a control-demanding task. Patients and age-matched controls named pictures presented along with distractor words (picture-word interference). The picture-word interference task taps into control processes involved in word production by requiring that response selection of the picture name be made in the presence of incongruent, competing information from the distractor word. We varied the degree of competing information from distractors to increase the difficulty of response selection. Distractors were semantically related, phonologically related, unrelated to the picture name, or neutral (XXX). We analysed the behavioural responses using Bayesian estimation to provide a more reliable estimate of how groups differed in the conditions under analysis. Controls and patients did not differ in the number of errors they made but patients were overall slower in their responses. Both groups showed lexical interference, that is, slower picture naming responses with unrelated than with neutral distractors, an effect though to reflect response selection difficulty in the presence of competing linguistic information. Relative to controls, all six left PFC patients had disproportionally larger lexical interference effects. Moreover, controls showed a semantic interference effect, that is, slower responses with semantically related than with unrelated distractors. This effect is thought to reflect the difficulty in selecting the picture name amongst semantic competitors. By contrast, patients did not show a reliable semantic interference effect. Finally, phonological facilitation was observed in both groups, that is, faster picture naming responses with phonological than with unrelated distractors. However, the phonological facilitation effect was disproportionally larger in patients than in controls. These findings suggest that the lateral PFC is a necessary structure for providing control over response selection in word production, but may not always be critical in mediating selection among semantically related competing candidates.

C6 Electrophysiological Predictors of Successful Memory During Encoding of Sentential Information Vary Based on Constraint and Predictability

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A growing body of evidence has shown that language comprehenders can use contextual information to generate expectations about likely upcoming words. Confirmed predictions can ease word processing; for example, the N400 event-related potential (ERP) component is more positive for expected words in strongly compared to weakly constraining sentences, while unexpected words in either context elicit large N400s (Federmeier et al., 2007). Disconfirmed predictions entail additional processing, seen in the ERP as a later frontal positivity. However, the precise mechanisms underlying these effects are unknown. How are predictable and unpredictable words processed and incorporated into a message-level representation? We set to identify these mechanisms by looking at the downstream consequences of expectation on memory, as well as examine neural differences during sentence processing that are associated with successful recognition memory decisions. Participants read strongly and weakly constraining sentences with expected or unexpected endings ("The prisoners planned for their escape/party") and later were tested on their memory for the sentence-final words. Critically, the memory test contained lure words that had been predictable ("escape"), but were never read (subjects saw "party"). Behaviorally, participants displayed above chance discrimination, but were more likely to false alarm to the lures ("escape") than to totally new (unpredicted) items. This effect did not differ by contextual constraint. ERPs at test showed that expected items from strongly constrained sentences produced more positive N400s, but not LPCs, to old items compared to new items (old/new effects). By contrast, expected and unexpected items from weakly constraining sentences showed larger LPC old/new effects. Thus, despite equal performance across constraint, subjects used different strategies to successfully retrieve information. Weakly expected items require a more effortful episodic reconstruction, while strongly expected items recruit a faster semantic memory-based judgment. We then compared the differences between ERPs during encoding for items that were later correctly recognized to items that were incorrectly recognized. This revealed that words that were expected in strongly constraining sentences

that elicited a more positive N400 were more likely to be remembered. This N400 effect was similar for items in weakly constraining sentences, but showed a broader topography and was sustained over a longer period of time. These results suggest that correctly remembering information is facilitated when that information is more easily accessed from semantic memory during encoding when it is first encountered. This facilitation occurs more easily in strongly constraining sentences. Finally, we examined responses to sentence-final words for which the corresponding lure item was either successfully rejected or not. This allowed us to assess what leads to the successful rejection of a disconfirmed expectation. Strongly constraining and weakly constraining sentences differed: when lures were later falsely endorsed, ERPs from strongly constraining contexts show a punctate left frontal positivity, while ERPs from weakly constraining sentences show a more positive N400-like effect. Thus, the successful suppression of a strong versus a weak expectation seems to require the recruitment of different neural structures.

C7 Structural connections of the medial prefrontal cortex: Dividing motor, semantic and default mode networks

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INTRODUCTION The medial prefrontal cortex (mPFC) is implicated in multiple domains, including language and semantic cognition as well as the default mode network (DMN). However, whether sub-regions are variably related to different domains, is unknown. This is the first exploration of the structural connectivity across the entire mPFC as a way to inform function and to examine connectivity related to white matter tracts critical for language. METHODS Structural connectivity analyses were performed on diffusion-weighted MR images from 24 participants. Unconstrained probabilistic tractography was seeded from ROIs of Brodmann areas 6, 8, 9, 10 and 11 using the probabilistic index of connectivity (PICo) algorithm. In a follow up analysis, unconstrained tractography was computed for each voxel on the grey-white matter interface in ventromedial PFC (vmPFC; BA10 and 11). This allowed tractographic parcellation of the vmPFC using the PARCEllation of Neural Images using Pico method. RESULTS Differential connectivity was identified. BA6 connected to primary motor cortex and the corticospinal tract. BA11 connected to anterior temporal lobe (via the uncinate fasciculus) and primary visual and auditory regions (via the inferior fronto-occipital fasciculus). BA9, positioned between these extremes, showed local connectivity (frontal cortex and insula). BA8 and 10 had similar but reduced connectivity to BA6 and 11, respectively. In moving from BA6 to 11, a gradient of connectivity was demonstrated from motor through local to high-order cognition areas. However, mPFC subregions were not differentially connected to networks associated with distinct higher order functions (e.g., semantics and language vs. DMN). Therefore, a secondary analysis was conducted to parcellate the vmPFC (BA10 and 11) based on structural connectivity without user-defined ROIs. vmPFC voxels formed 2 clusters, with differential connectivity from basal BA11 (orbitofrontal cortex) and dorsal BA11 and BA10. The orbitofrontal cortex connected to temporal and occipital regions related to semantic and sensory processing, whereas more dorsal areas connected to DMN regions. SUMMARY Involvement of multiple mPFC subregions has been demonstrated for language and semantic tasks. The structural connectivity identified here suggests these subregions may have dissociable roles. Distinct areas of the mPFC are connected to regions involved in motor, semantic and default mode networks. A network of regions responsible for semantic cognition (including language processing) was shown to connect to an orbitofrontal region of mPFC. This was distinct from more dorsal regions of vmPFC, implicated in the DMN. The importance of the uncinate fasciculus and the inferior fronto-occipital fasciculus in connecting mPFC structures to sensory-specific and multimodal semantic and language regions was highlighted. The novel tractographic parcellation technique allowed an emergent division of regions with distinct functional roles.

C8 Distinct temporal and prefrontal contributions to word retrieval in picture naming

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Retrieving words as we speak is known to involve different regions of the temporal and prefrontal cortices. Recent studies are suggesting that temporal and prefrontal activity may reflect different aspects of word retrieval in picture naming, namely rapid bottom-up lexico-semantic activation and top-down control over response selection respectively. However, how cortical response strength relates to trial-by-trial performance in these regions during word retrieval is unknown. We hypothesized that more efficient processing in the temporal cortex reflected by higher cortical activation would lead to faster reaction

times in picture naming and would be associated with a reduced need of frontal top-down control. Conversely, we hypothesized that more difficult trials with longer reaction times would be associated with increased frontal top-down control activity. We recorded electrocorticography (ECoG) in 8 neurosurgical patients (6 with left, 2 with right hemisphere coverage, spanning the areas of interest) as they performed a picture naming task. We examined how high gamma activity (HG, 70 to 150 Hz, reflecting local cortical activity) in temporal and prefrontal cortices correlated with trial-by-trial naming latencies. We found that opposite correlation patterns between HG power and naming latencies dominated the frontal versus temporal regions engaged in picture naming. In the left and right temporal cortices, faster trials were generally associated with more HG: 75% (stimulus-locked) and 79 % (response-locked) of electrodes showing negative HG-RT correlations were in temporal cortex. In the left prefrontal cortex, slower trials were generally associated with more HG: 100% (stimulus-locked) and 72 % (response-locked) of electrodes showing positive HG-RT correlations were in prefrontal cortex. Our results suggest a dynamic interplay between temporal and prefrontal regions during word retrieval in picture naming. Performance appears to be optimized when temporal cortical activation is high, similarly as reported in perceptual regions in non-human primates during perceptual attention tasks. On the other side of the coin, when word retrieval is more difficult, increased prefrontal activity could help carry out word selection. This is similar to what has been shown in other cognitive domains in working memory and decision-making tasks. To conclude, our results shed light on the respective roles of the two main groups of cortical regions associated with word retrieval in picture naming and suggest these contribute in different but complementary ways to performance on a trial-by-trial basis.

C9 Inhibitory TMS over the left inferior frontal gyrus increases semantic interference in blocked-cyclic naming. *Denise Y. Harvey[1], Rachel Wurzman[1], Priyanka P. Shah-Basak[2], Olufunsho Faseyitan[1], Daniela L. Sacchetti[1], Roy H. Hamilton[1]; [1]University of Pennsylvania, [2]The Hospital for Sick Children*

The left inferior frontal gyrus (LIFG), or Broca's area, has long been implicated in language production. However, the mechanism by which the LIFG subserves language production remains to be clarified. Neuropsychological evidence suggests that the LIFG plays a crucial role in resolving competition within the language system (Novick et al., 2010), as damage to this region results in worse performance on picture naming tasks that promote lexical competition. For instance, the blocked-cyclic naming task requires subjects to name pictures repeatedly in the context of semantically related (e.g., DOG, CAT, PIG) vs. unrelated pictures (e.g., DOG, VAN, PEAR). Typically, nonaphasic speakers are slower and more error prone when naming pictures in related vs. unrelated contexts – a phenomenon referred to as "semantic interference" (Kroll & Stewart, 1994). Patients with LIFG damage exhibit exaggerated semantic interference, suggesting that the LIFG serves to resolve lexical competition by guiding the selection of the target representation from amongst competing alternatives (Schnur et al., 2009). However, because stroke-related neural damage is rarely limited to specific neural region, it is difficult to isolate the precise role of the LIFG in language production. In the current study, we investigated the role of the LIFG in resolving lexical competition using inhibitory transcranial magnetic stimulation (TMS) in a group of 12 healthy (nonaphasic) speakers. Participants received TMS to the LIFG and a control site (i.e., Vertex) in two separate sessions. Prior to stimulation, subjects performed a naming task known to engage the LIFG (i.e., the verb generation task). Immediately following stimulation, subjects performed the blocked-cyclic naming task. Pictures in each session belonged to the same semantic categories, but depicted different category members. We hypothesized that inhibitory TMS over the LIFG would increase semantic interference relative to control site stimulation, as TMS is predicted to impede the LIFG's ability to resolve lexical competition. We analyzed response times (RTs) using a repeated measures analysis of variance (ANOVA) with participants and items as random factors. Fixed factors were within-subject variables, and included Stimulation Site (LIFG, Vertex), Condition (Related, Unrelated), and Cycle (1-4). We found a significant three-way interaction between Stimulation Site, Condition, and Cycle (p's $< .03$), which was due to longer RTs in the related condition following LIFG vs. control site stimulation. Interestingly, this difference was most pronounced in the beginning of the block, and diminished with repetition. Yet, RTs in the unrelated condition did not differ depending on stimulation site (LIFG vs. Vertex). These findings demonstrate that inhibiting the LIFG via TMS results in greater semantic interference, presumably because disrupting LIFG function results in an inability to resolve lexical competition. Together, these findings demonstrate a direct relationship between LIFG disruption and impaired language performance, which provides insight into the LIFG's critical role in language production.

C10 Mindfulness modulates cognitive control during lexical-semantic categorization: fMRI evidence *Nick B. Pandža[1], Stefanie E. Kuchinsky[1], Valerie P. Karuzis[1], Henk J. Haarmann[1]; [1]University of Maryland*

Mind wandering during reading is a common experience, particularly when the text is long or unengaging. Such "mindless reading" has been associated with shallow and inconsistent processing of the lexical information contained within the text. For example, evidence suggests that the canonical word frequency effect (WFE), i.e. slowed responses with declining word frequency, is diminished when people report that they had been concurrently mind wandering (Reichle et al., 2010). Neuroimaging studies of lexical processing suggest that the WFE is driven by

differential upregulation of cognitive control processes. Specifically, decreasing word frequency is associated with increasing engagement of the left inferior frontal gyrus (LIFG), which is thought to support lexical selection from competing alternatives (Fiebach et al., 2002). Together, these results suggest that mind wandering limits the differential engagement of cognitive control in response to word frequency during text processing. The current study tested the hypothesis that individuals who report being mindful in daily life also engage in more mindful reading, and thus increasingly engage cognitive control with decreasing word frequency. An fMRI experiment was conducted in which 38 younger-adult, native-English speakers performed a semantic sustained attention to response task (SART). Participants made a two-alternative forced-choice button response to indicate whether a presented word was an animal (e.g., WHALE) or not (e.g., STRAW). To maximize the probability of mindless reading, animal words were presented infrequently (7.1% of all words), at a slow rate (1.8 sec duration with an average of 1.8 sec jittered inter-trial-interval, TR = 2.2 sec), and for a long duration (four 15-minute runs). A subset of non-animal words were selected to vary by log-transformed word frequency while tightly controlling for a variety of other lexical variables. Participants were also given the Five Factor Mindfulness Questionnaire (FFMQ; Baer et al., 2006), which indexes individual differences in mindful behavior (namely, attending to the present moment) in daily life or, alternately, disposition to mind wandering. Consistent with previous behavioral studies, a multilevel model showed the expected main effect of word frequency on log-transformed reaction times (b = -.007, SE = .002, t = -3.35), such that participants were faster to respond with increasing word frequency. Also, consistent with previous neuroimaging studies, the current study replicated the WFE in the semantic SART: lower frequency words engaged the LIFG to a greater degree than higher frequency words ($p < .001$ unc., cluster extent $p < .05$ unc.). Importantly, individual differences in mindfulness were observed to modulate the neural WFE: increasing trait mindfulness was associated with a larger WFE in LIFG, though the behavioral effect failed to reach significance (b = -.0002, SE = .0001, t = -1.45). These results indicate that individual differences in mindful behavior in daily life have consequences for the engagement of cognitive control during text processing. The greater sensitivity of neural compared to behavioral measures of individual differences in mind wandering will be discussed.

C11 Evidence for genetic regulation of the human parieto-occipital 10 Hz rhythmic activity

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Human cerebral cortex shows several intrinsic oscillations that can be characterized with noninvasive neuroimaging methods such as magnetoencephalography (MEG) and electroencephalography (EEG). The most prominent of them is the 10-Hz "alpha" rhythm recorded over the parietal and occipital cortices. The cortical sources of alpha activity in humans have been located around the parieto-occipital sulcus, and intracortical recordings in dogs have revealed simultaneous activity in the thalamic nuclei, suggestive of involvement of the two brain regions in the rhythm generation. The rhythm is strongly attenuated by opening of the eyes, and it has important functional roles e.g. in visual attention and imagery. Its reactivity has been widely used to probe cortical functions both in healthy and clinical populations. Several EEG studies have demonstrated the high heritability of the rhythm, but little is known about its underlying genetic determinants. To uncover the possible genetic determinants of the parieto-occipital 10-Hz rhythm in a normal population, we measured spontaneous brain activity with MEG in 210 individuals (from 100 families) while the subjects had their eyes closed and open. The cortical activity was recorded with 306-channel Elekta Neuromag neuromagnetometer, and amplitude spectra at each channel were calculated using FFT. DNA was extracted from blood samples and genotyped with Affymetrix 250K array. In the analyses we used genotypes for more than 28000 markers. Brain activity was quantified from the difference spectra between eyes-closed and eyes-open conditions. Width of the main spectral peak at ~10 Hz, peak frequency, and peak strength were measured at the maximum channels over the left, middle and right parieto-occipital cortices. In accordance with earlier EEG studies, peak strengths of the rhythm were highly heritable ($h2 > 0.75$). Variance component-based analysis of the genomic markers revealed linkage for both the strength and the width of the spectral peak. The strongest linkage was detected for the width of the spectral peak over the left parieto-occipital cortex on chromosome 10[q23.2] (LOD = 2.814, nominal $p < 0.03$). This genomic region contains several functionally plausible genes, including GRID1 and ATAD1 that regulate glutamate receptor channels mediating synaptic transmission, NRG3 with functions in brain development, and HRT7 involved in serotonergic system, circadian rhythm, and sleep. Overall, our results demonstrate the potential of genetic analysis in linking macroscopic cortical phenotypes with the molecular level through association with specific genes.

Discourse, Combinatorial Semantics

C12 Experience with fiction influences connectivity in the extended language network

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Recent behavioral evidence suggests that engaging with fiction such as written narratives is positively correlated with empathizing abilities, i.e. avid readers show higher scores for empathy as compared to people who do not

read as much. The hypothesized mechanism behind this – somewhat contested - link is that engaging in fictional narratives can offer a 'training platform' for mentalizing and empathy. Indeed, narratives enable the individual to step into someone else's shoes, facilitating a better understanding of the feelings, desires, and beliefs of fictional characters and potentially other people. Here we set out to investigate the link between fiction reading and empathizing abilities by investigating connections between brain areas while people listened to literary narratives. We had healthy young participants (N=57, 31 female, mean age 22.7 years) listen to two literary narratives (approximately 7 minutes duration per story) while brain activation was measured with fMRI. Participants listened to a reversed speech version of the same stories, which served as a low-level baseline. After the scanning session participants filled out several measures of individual differences, related to reading habits ('How many fiction books do you read per year? ', Author Recognition Test), as well as empathizing abilities (Empathy Quotient), the Need for Affect scale, and the Need for Cognition scale. In the analysis we extracted the time courses for each session (narrative listening and reversed speech listening) for each subject from 96 regions of interest, spanning the whole cortical sheet (Harvard-Oxford brain atlas). We then computed correlations between all regions, and computed the difference in correlation values between listening to narratives versus listening to reversed speech. The difference in between-region correlations between narrative listening and reversed speech was subsequently correlated with individual differences across participants. A positive correlation means that people who score high on a given individual difference score, also show a higher between-region correlation for a given pair of regions during listening to the narratives as compared to listening to the reversed speech baseline. We identified robust correlations for 'connections' between regions and score on the amount of fiction reading ('How many fiction books do you read per year? '), as well as on the EQ. A mainly right-lateralized network of regions including the inferior frontal gyri bilaterally, the right middle frontal gyrus, the right supramarginal gyrus, left and right cuneus, and right lingual gyrus was sensitive to individual differences in amount of fiction reading. This network is reminiscent of the (extended) language network. Another set of areas including the anterior medial prefrontal cortex and left anterior pole, was correlated with EQ. Interestingly, the networks correlating with amount of fiction and empathizing did not overlap. Our results indicate that amount of reading is positively related to between-regions correlations within the (extended) language network, during listening to literary narratives. Connectivity between a different set of regions (during listening to narratives) is related to Empathizing abilities, which suggests that a tentative link between fiction reading and empathizing abilities is not mediated by overlapping neural correlates.

Control, Selection, Working Memory

C13 The relationship between cognitive control and speech: a dual-task behavioral study

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There is strong evidence that domain-general executive functions such as cognitive control are recruited for speech processing, particularly in degraded or difficult conditions. However, it remains unclear how these domain-general executive functions contribute to speech processes. One way to investigate the relationship between speech-specific and domain-general processes is via dual-task paradigms, e.g. tasks with high executive function demands being performed concurrently with speech perception and/or production. The two studies of this kind to date have employed concurrent overt articulation during a classic cognitive control paradigm (the Stroop task). These two studies have yielded conflicting results, with one reporting an increase in reaction time during articulation (Lemercier, 2009) and the other not finding an effect of concurrent articulation in control subjects (Brown & Marsden, 1991). It is also unclear if the interference reported between overt articulation and cognitive control demands is due to additional sensory input, articulatory mechanisms, or sensorimotor integration. The present study has two aims: (i) determine if articulation does interferes with cognitive control performance and (ii) if so, determine the components of speech production that are contributing to this interaction, namely perceptual, motor, and/or sensorimotor integration. 16 subjects completed two well-studied cognitive control tasks (the visual Stroop task and a visual letter sequence Flanker task) under the following four concurrent conditions: no secondary task, overt articulation, covert articulation and auditory presentation. The articulation conditions consisted of repeating a four consonant-vowel (CV) sequence at the rate of 3 Hz. In the auditory presentation condition, the CV sequence was presented auditorily on a continuous loop via headphones. All subjects were native English-speaking, right-handed and self-reported no history of neurological disease. Half of the subjects completed the Stroop task conditions first, half completed the Flanker task conditions first. The order of the secondary task conditions within the Stroop and Flanker tasks were counter-balanced across subjects. Subjects were trained on all tasks and monitored for compliance throughout the experiment. The results are as follows: we found the classic effect of incongruent trials yielding significantly longer reaction times than congruent and neutral trials across both tasks and all secondary tasks conditions. In the Flanker task, no significant differences between the no secondary task condition and the auditory presentation condition were found. The covert and overt articulation conditions also were not significantly different from one another, but both significantly elicited longer reaction times than the conditions without a motor component (i.e. no secondary

task and auditory presentation) suggesting that motor execution or planning, and not perceptual or sensorimotor processes, were driving the interference with cognitive control performance. However, in the Stroop task, only the overt articulation condition elicited significantly longer reaction times than the no secondary task condition, suggesting that sensorimotor integration and/or auditory feedback mechanisms were driving the interaction between cognitive control and speech. These preliminary findings suggest that the overlap between the brain networks supporting cognitive control processes and speech may be task-specific and that cognitive control resources may contribute to the motor execution and/or sensorimotor integration components of speech.

C14 Language deficits induced by topiramate (TPM) administration *christopher barkley[1], angela birnbaum[1,2], mingzhou ding[3], Serguei Pakhomov[2,4], Lynn Eberly[5], Chao Wang[6], Susan Marino[1,2]; [1]Experimental and Clinical Pharmacology, University of Minnesota, [2]Center for Clinical and Cognitive Neuropharmacology, University of Minnesota, [3]The J. Crayton Pruitt Family Department of Biomedical Engineering, University of Florida, [4]Pharmaceutical Care and Health Systems, University of Minnesota, [5]Division of Biostatistics, School of Public Health, University of Minnesota, [6]The Henry M. Jackson Foundation for the Advancement of Military Medicine, Inc., Uniformed Services University of the Health Sciences*

Cognitive impairment is a widely reported side effect of many commonly prescribed drugs. One such drug is TPM, a second-generation anti-epileptic that often causes significant speech/language problems. However, the nature of these deficits remains undercharacterized, as does the extent to which the severity of these deficits are blood-concentration dependent. The specific aim of the current study is to more accurately characterize the language difficulties arising from TPM administration. Here, we test the hypothesis that TPM selectively impairs verbal working memory, resulting in deficits in performance on tasks that assess verbal fluency. Twenty healthy adult subjects were included in the analysis of a randomized, double-blind, crossover study comparing the effects of a single 100-mg TPM dose to placebo (PLA). One hour after drug administration, subjects' language abilities were assessed using the following measures: (1) semantic-category/phonemic fluency (COWA) tasks, (2) a picture-description task, and (3) the MCG story recall task. A single blood draw was taken immediately after testing, enabling the examination of TPM concentration-dependent effects on task performance (see Marino et al, 2012). In a subset of nine subjects, EEG was recorded while they performed a modified Sternberg task (memory loads: 1-3-5) in order to assess effects of TPM on working memory processes. Behavioral results from Marino et al. (2012) showed that after receiving TPM, participants recalled significantly fewer correct words on the MCG (p=.02) than during their non-drug baseline, and that performance was negatively correlated with TPM concentration levels (Spearman's ρ=-0.65 p=0.002). On the picture-description task, TPM administration led to increases in disfluency rate, which was positively correlated with TPM concentration levels (Spearman's ρ=0.58, p=0.007). The results of the COWA test also showed a negative effect of TPM on generative phonemic fluency, but no correlation with TPM plasma concentration (p=1.0). Ongoing analyses of the results from the Sternberg task showed that TPM led to increases in reaction time (p = 0.003) and error rates (p = .037) compared to PLA. At load 5, a reduction in the amplitude of left anterior negativity, a component typically associated with verbal working-memory processes, was observed between 300 and 800 msec. post probe-onset when comparing TPM to PLA. These analyses will further investigate the influences of TPM administration on Sternberg task performance at a temporally more fine-grained level In sum, the data show that TPM disrupts language at the level of both lexical (COWA), and discourse (picture description) processes. These deficits appear to arise from working memory impairments, as participants were slower and less accurate on the Sternberg task, behavioral results that were concomitant with reductions in the amplitude of ERP indices of working memory processes. Taken together, these results elucidate the nature of TPM-induced language deficits. We have shown that, in combination with knowledge about a drug's mechanism of action, pharmacological studies that employ both behavioral and temporally precise electrophysiological techniques have the potential to shed light on the neurobiological underpinnings of language and the manner in which it is processed in real time. This work was supported by NIH/NINDS grant#R01NS076665 (PI: Marino)

C15 Oscillatory Dynamics While Reading Poetry: A Specific Role for Pre-Stimulus Alpha *Stefan Blohm[1,2], Mathias Scharinger[1,3], Matthias Schlesewsky[2,4], Winfried Menninghaus[1]; [1]Max Planck Institute for Empirical Aesthetics, Frankfurt, Germany, [2]University of Mainz, Germany, [3]University of Leipzig, Germany, [4]University of South Australia, Adelaide, Australia*

The observation that perception is not solely based on sensory evidence but crucially draws on top-down information has also repercussions for the description and analysis of human written language processing. To this end, recent research has suggested that reading poetry requires a specific cognitive style that promotes a holistic interpretation of the linguistic material and thereby favors e.g. metaphor comprehension (Gibbs et al., 1991; Riding, 1997). There is some evidence that neural correlates of this cognitive style, that is, a holistic vs. analytical processing mode, are seen in the brain's oscillatory dynamics, predominantly in the alpha (8-12 Hz) frequency band (Dunn and Reddix, 1991; McKay et al., 2002). However, it is unclear whether cognitive style can be

directly induced by instruction or whether it can only be derived from bottom-up sensory evidence. For this reason, we here presented participants with short sentences (e.g. "Vor der Türe schläft der Baum" [lit: In front of the door sleeps the tree]) and differentially instructed participant groups in a between-subject design that they were going to read short "sentences" (neutral instruction) or "verses" (poetry instruction), respectively. This enabled us to examine instruction-dependent processing differences for identical inputs. Sentences were presented constituent-wise and with fixed timing, while the electroencephalogram (EEG) was deflected from 26 head electrodes. After each stimulus presentation, participants (n = 48) had to indicate whether a probe word did or did not occur in the preceding sentence. Before and after the main experiment, we recorded resting-state EEG during which participants closed their eyes in order to estimate individual alpha activity, following the approach described in van Albada and Robinson (2013). Single-trial EEG activity was transformed into time-frequency representations using wavelet analysis. Non-baselined oscillatory brain activity seen in the averaged time-frequency representations revealed pre-stimulus power-differences within the alpha-frequency band (8-12 Hz), with higher alpha power for participants who received the poetry instruction compared to those who received the neutral instruction. Statistical analyses focusing on participant-specific alpha frequencies verified these differences to be significant. Further post-hoc analyses showed that pre-stimulus alpha power was inversely correlated with reaction times on the probe words and positively correlated with response accuracy. Furthermore, pre-stimulus alpha phase distributions were predictive of wrong versus correct decisions on the probe words. Finally, behavioral performance was on average better under the poetry than under the neutral instruction. These results demonstrate that the way written text is processed crucially depends on one's mindset: The pre-stimulus alpha-power differences are suggestive of a top-down regulated differential cognitive framing for neutral vs. poetic texts. Higher pre-stimulus alpha power under poetry instruction seems to enable a more holistic processing mode and may simultaneously correspond to the deployment of more attention to the incoming sentence stimuli (cf. Klimesch, 1999). Altogether, pre-stimulus alpha power appears to be a salient neural marker of top-down induced processing differences and a possible indicator for a specific cognitive style required to appreciate aesthetic forms of human language, such as expressed in poetry.

C16 Free Verbal fluency in Comparison with more Common Verbal Fluency Tests: an fMRI Study

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Introduction Phonemic and Semantic Verbal Fluency Tests (VFT) are worldwide common neuropsychological tests for assessing the effectiveness of information retrieval from verbal memory. Less often a free Verbal Fluency Test is used, in which subject is being instructed to produce as many words from his mind as he can for 1 minute, avoiding repetitions, people names, geographical places and numbers. We suggested free VFT to be a more demanding test and to rely more on frontal and temporal structures (executive and lexicon) in comparison with common VFTs. Method Twelve right handed healthy native speakers of Russian (mean age 21; 5 females) were performing different types of VFTs while being scanned. Five types of initial stimuli were presented on the screen: 1) free ("Any words"), 2) semantic ("Plants"), 3) phonological (one of the most frequent letters in Russian "П, С, Р, Н, К") 4) grammatical ("Verbs"), and 5) non-retrieval task "Counting". Subjects were retrieving overtly as many words as they can according to the instructions (no MR acquisition period) and stopped speaking when the big red exclamation mark appeared (MR volume acquisition period). T1-weighted structural images(176 sagittal slices, 1x1x1 mm voxel, TR 1900ms, TE 2.91ms, FA 15°) and functional T2*-weighted data in 25 axial slices (3.6x3.6x4.3mm voxels), sparse-sampling TR 7100ms with TR delay 5000ms, TE 50ms, FA 90°, 200 images) were acquired. We used the number of retrieved exemplars as a regressor in design matrix. Results. Direct comparison between pairs of VFTs revealed several differences in brain organization of the fluency tests. Several brain regions were activated more in the free VFT than in phonemic VFT in the left middle temporal gyrus (volume: 42), right precuneus (volume: 23), left middle frontal gyrus (volume: 23), right fusiform (volume: 20) and left fusiform gyrus (volume: 19), right cerebellum (volume: 22), left inferior parietal lobule (volume: 18). The contrast between free VFT and semantic VFT revealed more activation in the free VFT in the left temporal lobe (volume: 201), right temporal lobe (volume: 34), frontal superior gyrus in the left hemisphere (2 clusters, volumes: 41 and 21); supplemental motor area (volume: 22), precuneus and cingulum bilaterally (volume: 51), inferior frontal gyrus (volume: 24). The opposite contrast hasn't got any significant clusters of activation. Brain areas more activated in free VFT in comparison with grammatical VFT (4th condition) includes the medial part of the right frontal supperior gyrus and anterior part of the right cingulum (volume: 185), left middle occipital gyrus and left inferior parietal lobule (volume: 63), medial part of the frontal superior gyrus, frontal middle gyrus and frontal superior gyrus in the left hemisphere (volume: 76), left and right precuneus (volume: 292), right angular gyrus (volume: 76). Conclusions The free VFT is associated with more activation in language and executive functions specific (frontal and temporal) regions than other types of VFTs. Based on our results we may suppose that free VFT is more sensitive than common VFTs for assessing the decline in speech and executive functions.

Language Development, Plasticity, Multilingualism

C17 Pace of vocabulary development in preschool years is associated with individual differences in brain structure in school years

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Children widely differ in their language development during preschool years. One of the areas where individual differences are most striking is vocabulary development. Importantly, the pace of children's vocabulary development predicts vocabulary size at school entrance (Rowe et al., 2012). However, not much is known about the relation between individual differences in such early language development and later brain structure and function. Here we examined the association between vocabulary growth in 14 to 58 month old children and individual differences in brain structure measured in 3rd and 4th grade. The sample included 18 typically developing, socioeconomically diverse children. Participants were a subset of a larger sample participating in a longitudinal study of language development in the greater Chicago area. Our measure of vocabulary skill was based on naturalistic observations of children's spontaneous interactions with their caregivers collected every 4 months between the ages of 14 and 58 months. Specifically, we tallied the number of different word types (i.e., unique words) children used at each time point and calculated number of cumulative word types at each age (see Rowe et al., 2012 for further details). We then modeled growth in children's cumulative word types using hierarchical linear modeling (Raudenbush et al., 2001), and used empirical Bayes estimates of slope of vocabulary growth as predictors of brain structure in later childhood. In particular, we examined cortical thickness in a specific set of brain regions implicated in vocabulary learning and processing. Automated brain segmentation with Freesurfer defined cortical and subcortical gray matter regions on structural images (http://surfer.nmr.mgh.harvard.edu). Cortical thickness, defined as the shortest distance between the white matter surface and pial gray matter surface, was measured for the predetermined regions of interest, which included left inferior and middle frontal gyri, middle temporal gyrus, supramarginal and angular gyri, and superior temporal sulcus. Results showed that a cubic model best described children's vocabulary development during the early years, which included an intercept, a slope, a quadratic term and a cubic term. The different growth estimates were correlated with each other, and the slope best predicted cortical thickness (defined by the proportion of variance in cumulative word types explained). After correcting for multiple comparisons, there was significant association between the pace of vocabulary growth and cortical thickness in the left supramarginal gyrus and left middle frontal gyrus. These associations remained significant after controlling for parental socioeconomic status (as measured by parent income and education), parent word types at the first observation, overall cortical thickness, and age. These findings suggest that individual differences in early vocabulary growth are associated with individual differences in cortical structure in later childhood. Our findings are in line with literature highlighting the role of the supramarginal gyrus in vocabulary processing in adults and second language learners. Our findings move the literature forward by relating, to our knowledge for the first time, the pace of vocabulary learning in children to cortical thickness of of the supramarginal gyrus.

C18 Behavioral and Neural (fMRI) Evidence for Improved Lexical Learning in a Paired Associate Learning Paradigm After a Period of Offline Consolidation

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Previous research has identified both procedural and declarative learning mechanisms at the level of brain and behavior as potentially causal factors in reading and language disorders. Additionally, recent research has identified sleep consolidation (memory encoding during sleep) to be critical for speech and language learning, and suggests impairments in sleep consolidation are associated with language learning disabilities (LLDs) (Earle & Myers, 2014; Gaskell et al. 2015; Henderson et al. 2014; Landi et al. 2014). We investigated spoken word learning with behavioral, eye-tracking, and neuroimaging methods (fMRI) in a spoken artificial lexicon paradigm (Magnuson et al. 2003). 50 adolescent and young adult participants (ages 15- 25) were also well categorized phenotypically using an extensive behavioral assessment battery of reading, language and general cognitive ability. Participants then learned associations between 24 novel spoken words and pictures (unusual fish or minerals) over the course of ~1.5 hour of training until they met a criterion of 90% correct. On the following day, they returned for a refresher period, seeing all trained stimuli twice, and a second learning period, during which participants learned a new set of novel word-picture pairs to criterion. After the second behavioral learning session, participants were scanned using fMRI. During scanning they heard the trained consolidated words from Day 1, the trained unconsolidated words from Day 2, and a set of completely novel non-words. fMRI results revealed stronger activation of language regions surrounding the perisylvian fissure (inferior, superior and middle temporal), as well as posterior cingulate for trained consolidated vs. trained but unconsolidated and novel non-words; larger and more bilateral differences emerged for comparisons between consolidated and novel non-words. Additionally, greater activation was seen in the hippocampus for trained but not consolidated items. These findings are consistent with cortical instantiation (in spoken language processing areas)

of sleep-consolidated trained items, and lack of cortical instantiation for newly trained but not sleep consolidated items. Covariate analyses indicated that both learning "rate" as well as reading and language skills modulated these findings, such that better learners and skill in reading was associated with greater effects of consolidation in brain. These findings add to a small but growing literature on the relationship between sleep, memory consolidation and language ability/disability.

C19 Short- and long-term effects of anodal transcranial direct current stimulation on language learning in ageing

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Introduction: Advanced age is associated with a number of metabolic, structural and functional brain changes. These changes may result in deficits affecting multiple cognitive domains. Ageing also leads to reduced adaptive neuroplasticity, a process which is critical for learning and acquisition of new skills. Recent evidence suggested that non-invasive transcranial direct current brain stimulation (tDCS) can improve learning and neuroplasticity in health and disease. However, studies addressing whether tDCS can improve impaired cognition and learning in ageing are still sparse. The present study assessed whether learning and maintenance of a novel vocabulary can be improved by simultaneous excitatory (anodal-) tDCS. Method: We employed a prospective, randomised, double-blind, sham-tDCS controlled, between-subjects design and a novel word learning paradigm. Healthy older participants were trained over five consecutive days to learn associations between 36 pictures of "space aliens", a proper name, and two semantic attributes. tDCS was administered daily with 1 mA to the left inferior frontal gyrus for either 30 seconds (sham-tDCS) or 20 minutes (anodal-tDCS). Recall and forced-choice recognition performance was assessed daily before (offline effects) and after (online effects) each training session, and at 24 hour, 1 week, and 3 month follow-up time points. Generalisation to untrained cognitive functions was assessed using a computerised repeatable battery administered at baseline, and during the follow-up assessments. Results: Preliminary data analyses based on 18 participants (N=8 anodal-tDCS; N=10 sham-tDCS) showed that participants in both stimulation groups successfully acquired the novel vocabulary (approximately 70% correct name recall at the end of the fifth training day). Both groups were matched for baseline characteristics; however, participants that had learned with simultaneous anodal-tDCS showed significantly steeper learning curves than participants in the sham-tDCS group ($p=0.03$; approx. 35% more pronounced gains at day five). Results of 10 participants that completed the long-term follow-up assessment suggested that those additional gains are maintained for at least three months. Conclusions: Our preliminary data suggests that anodal-tDCS administered to the left inferior frontal gyrus over five consecutive days may be a viable tool to enhance learning and cognition in advanced age. If confirmed in the final sample, such effects hold a wider practical significance for the application of anodal-tDCS as an intervention to ameliorate cognitive decline in ageing. Such findings might also be relevant for treating elderly patients with incipient neurodegenerative disorders.

C20 Aging-Resilient Associations between Arcuate Fasciculus Microstructure and Vocabulary Knowledge

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Vocabulary knowledge appears to be resilient to age-related declines that affect other cognitive functions1. The extent of adult vocabulary knowledge may be a product of early reading abilities2-3, which facilitate acquisition of word knowledge by increasing exposure to and comprehension of written material4. This suggests that the neural structures that support early word learning will also predict adult vocabulary knowledge. In particular, arcuate fasciculus microstructure has been related to reading skills in children and adults5-6 and is hypothesized to demonstrate aging-resilient associations with vocabulary knowledge in healthy adults. We used diffusion tensor imaging (DTI) to assess the relationship between arcuate microstructure and vocabulary knowledge across the adult lifespan. Neurologically healthy adults (N=106) ranging in age from 19.92 to 88.29 years (M=54.67 years) completed cognitive assessments that evaluated vocabulary knowledge and processing speed, a control measure known to decline substantially with age. Diffusion and anatomical images were collected using a Siemens 3T Tim Trio (DTI parameters: B-values = 0, 1000; 64 directions). We computed fractional anisotropy (FA) and mean diffusivity (MD) across 100 nodes that were equally distributed along the core of tracts of interest in native space for each participant. Diffusion metrics at each node were correlated with the cognitive variables using a non-parametric permutation analysis to correct for multiple comparisons. As expected, processing speed declined with age ($r=-.64$, $p<.001$), and vocabulary knowledge did not ($r=.04$, ns). Increased fractional anisotropy (FA) in the descending temporal-parietal branch of the left arcuate predicted higher vocabulary knowledge ($r=.38$, $p<.001$), but not processing speed ($r=.16$, ns). Conversely, higher mean diffusivity (MD) across the arcuate was associated with slower processing speed (left: $r=-.41$, $p<.001$; right: $r=-.44$, $p<.001$) but was not related to vocabulary (left: $r=-.18$, ns; right $r=-.10$, ns). Importantly, controlling for age reduced the strength of the relationship between MD in the arcuate and processing speed (left: $\Delta r2=-.11$; right: $\Delta r2=-.09$) but

did not affect the relationship between FA and vocabulary knowledge (Δr2=-.001). This pattern of results suggests that distinct microstructural features of the arcuate predict processing speed and vocabulary knowledge, which are differentially impacted by age. For instance, FA is particularly sensitive to directional coherence7, whereas MD is more affected by membrane density8. Thus, the FA-vocabulary knowledge association in the arcuate appears to reflect developmental differences in fiber organization while the MD-processing speed association may reflect age-related declines in tissue structure. Our results reveal aging-resilient associations between arcuate fasciculus microstructure and vocabulary knowledge. Given that the arcuate fasciculus has been implicated in the development of phonological awareness and reading fluency, this provides evidence that the organization of neural structures that support early reading skills impact the expression of vocabulary knowledge later in life. 1Park et al, 2002; 2Carlisle, 2000; 3Lonigan et al, 2009; 4Nagy & Anderson, 1984; 5Deutsch et al, 2005; 6Klingberg et al, 2000; 7Beaulieu, 2002; 8Schmierer et al, 2008.

C21 Social interaction and contextual constraints influence adult word learning *Sonja Kotz[1,2], Laura Verga[2]; [1]School of Psychological Sciences, University of Manchester, Manchester, UK, [2]Dept. of Neuropsychology, MPI for Human Cognitive and Brain Sciences, Leipzig, Germany*

Previous studies have shown that word learning is constrained by the type of context a word occurs in (e.g. Rodiguez-Fornells et al., 2009). Further, word learning in childhood is affected by social interaction, in which a social partner tends to direct a child's attention to the correct word referent. In the current work we explored whether both factors influence adult word learning and whether these factors interact. If these factors interact, we would expect enhanced neural activity during interactive (social) learning of words presented in variable sentence contexts in areas involved in visuo-spatial attention (e.g. the middle frontal gyrus, angular gyrus, visual cortex) as well as areas engaged in word learning encompassing middle and inferior temporal gyrus, inferior frontal gyrus, temporo-parietal junction, and subcortical structures (e.g., striatum, thalamus). 41 participants (20 F, age 26 ± 3.35 years) were scanned at 3T (Siemens Trio) while learning 20 pseudo words either in the same or a varying sentence context. During learning they had to identify the picture of an object that best complemented a brief sentence (subject, verb, object; e.g., "The boy eats the egg"). If an object was identified correctly, a pseudo word constituting a new word meaning was visually displayed. Participants learned new words either in a "socially interactive" or a "non-social" way. Participants in the socially interactive situation were told they were learning new words together with a partner, who was sitting outside of the scanner; participants of the non-social situation were told they were learning new words via a computer program. Functional brain imaging data were analyzed using SPM8, by means of a General Linear Model (GLM) analysis, an Independent Component Analysis (ICA), and Dynamic Causal Modeling (DCM). The latter analysis was used to investigate the connectivity pattern within the fronto-parietal attentional reorienting network. While context type (varying > repetitive) led to increased activation of left IFG, middle occipital gyrus/inferior parietal cortex, task related efforts (social > non-social) led to increased activation of the left middle occipital gyrus, left fusiform gyrus, and right supramarginal gyrus. Further, a significant interaction of sentence context and learning dynamic was observed in the right angular and middle frontal gyrus. We also showed that social interaction strengthened the connection of the right angular gyrus and the primary visual cortex (BA 17/18) in a visuo-spatial attention network including middle frontal and occipital gyrus. The current results suggest that social interaction influences adult word learning by modulating activity in task-related areas. These data suggest that the presence of a social partner modulates activity in networks involved in language learning and visuo-spatial attention. However, we caution that this modulation task specific: If a task is easy for the learner (e.g., when the sentence context is repetitive), then social interaction does not facilitate word learning. These results confirm that social interaction engages visuo-spatial attention in variable word learning contexts and, thereby, facilitates adult word learning.

C22 Cortical mechanisms for rapid lexicon acquisition: online neurophysiological measures *Yury Shtyrov[1], Lilli Kimppa[2], Eino Partanen[1], Miika Leminen[1,2], Max Garagnani[3], Alina Leminen[1]; [1]Center for Functionally Integrative Neuroscience, Aarhus University, Denmark, [2]Cognitive Brain Research Unit, Helsinki University, Finland, [3]Brain Language Laboratory, Free University Berlin, Germany*

The human communication system is unique in having large lexicons consisting of thousands of words that we are able to store, access and use with high efficiency and apparent ease. To achieve this, humans learn new words extremely rapidly, both as children acquiring their native tongue and later in life when learning other languages. However, the neural bases of this rapid learning, which is likely an expression of a more general mechanism rooted in cellular and synaptic plasticity, are not yet understood. Here, we present a series of our recent EEG, MEG, fMRI and behavioural studies that have traced word learning in the human brain non-invasively by recording online changes in lexically-specific neural activity and comparing its dynamics throughout the learning session for different types of novel stimuli and familiar words. We show a rapid development of perisylvian cortical memory circuits for novel word forms over a short (15-30 minutes) session of auditory exposure to these items, manifest as a temporo-frontal response enhancement correlated with behavioural learning outcomes. Importantly, this effect appears to be independent of attention, reflecting a largely automatic nature of initial stages of word acquisition. At the same

time, the neurolexical memory trace build-up is specifically facilitated by including an overt semantic reference or active articulation of novel items. Furthermore, the automatic neural mechanism for memory-trace formation seems to be fine-tuned to stimuli with native phonology, likely benefiting from pre-existing phonological perception-articulation links in the brain, whereas neither non-speech sounds nor words containing non-native phonemes show similarly rapid neurophysiological learning dynamics. This suggests different neural strategies for learning words in native and non-native languages; moreover, we show that previous foreign language learning experience directly affects the neural dynamics of memory-trace build-up. Our MEG investigations of learning of written words suggest that similar automatic mechanisms operate in both auditory and visual modality, demonstrating their shared neurobiological substrate for efficient word acquisition. We also show a complex interplay between overnight consolidation and the amount of exposure to novel vocabulary, which can speed up successful learning. Fast learning effects can also be seen for morphologically complex words, suggesting rapid lexicalisation for new derivational but not inflectional forms in adults, with an even more flexible lexical system in children, in whom brief but intensive exposure to novel materials leads to lexicalisation of all complex word types. A number of brain areas, most notably neocortical structures in temporal and inferior-frontal regions appear to take part in such fast word acquisition and build-up of neural memory-traces. Critically, the currently available data not only demonstrate the role of the hippocampus in rapid encoding followed by slow-rate consolidation of cortical memory traces (a mainstream view in learning literature), but also clearly point towards immediate neocortical involvement in word memory-trace formation. Echoing early behavioural studies in ultra-rapid word learning, these neuroimaging experiments suggest that our brain is effectively capable of immediately forming new cortical circuits online, as it gets exposed to novel linguistic patterns in the sensory input.

C23 Learning novel action- and object-related words – an fMRI study *Max Garagnani[1,2], Evgeniya Kirilina[1], Friedemann Pulvermüller[1]; [1]Freie Universität Berlin, [2]University of Plymouth*

Where is the meaning of words stored and processed in the brain? Evidence from neuroimaging and patient studies lends support to embodied theories of language acquisition and processing, according to which word meaning is grounded in the perception and action systems of the brain. Word-grounding processes putatively rely on the brain's ability to associate patterns of neural activity co-occurring in different cortical areas and to bind phonological representations in perisylvian areas with corresponding semantic information in sensorimotor ones. Most previous studies investigating brain correlates of semantic processes used words from natural languages, which differ on a range of psycholinguistic variables. Recent evidence from experimental learning paradigms suggests that the development of perisylvian cortical memory circuits for novel spoken items is facilitated by active articulation or inclusion of an overt semantic reference. However, there are at present no neuroimaging studies on word meaning acquisition showing that perception of newly learned category specific spoken words selectively reactivates the sensory or motor areas that were activated during learning of such novel items. We applied functional Magnetic Resonance Imaging (fMRI) to investigate brain correlates of semantic grounding of novel action- and object-related words. A group of 24 healthy volunteers learned the meaning of novel spoken items by means of behavioural training sessions during which auditory word forms were paired with a visual semantic referent, consisting of either a familiar hand-action or familiar object (animal) picture. The mapping of novel spoken items to semantic referent was either consistent (same word always paired with the same action or object) or inconsistent (same word paired with all items of one semantic category). We used an orthogonal design, in which trained and untrained, consistent and inconsistent, action- and object-related stimulus sets were carefully matched, as were frequency of presentations of visual and auditory stimuli. Training took place over three consecutive days and was followed by scanning on day 4. In the scanner, participants heard all trained spoken words mixed with the similar-sounding untrained items, never heard before. A silent visual localiser task was also administered, during which subjects were presented with all action and object pictures. Subjects performed a word-picture matching task after each training session as well as after scanning, along with a lexical-decision / recognition test. Results of the word-picture matching test indicate that participants were able to successfully learn consistent word-meaning mappings, but mostly failed at acquiring inconsistent ones; performance was better for object-related words than for action-related items. Results from the lexical-decision task confirmed that words with consistent meaning were recognised more easily than those with inconsistent one, regardless of semantic category. Analysis of the fMRI data reveals that auditory perception of newly learned consistent-object words significantly re-activates the same parts of the primary visual cortex that are strongly active during perception of corresponding object pictures; by contrast, consistent-action words do not produce activity in such primary visual areas. These results confirm that novel spoken words are learned better in consistent object contexts and suggest brain correlates of referential semantic word learning.

C24 Neural basis of novel word learning in Spanish-English bilinguals *Roberto Ferreira[1], Gabriella Vigliocco[2], David Vinson[2]; [1]Universidad Catolica de la Santisima Concepcion, [2]University College London*

There is consensus that bilinguals use primarily the same brain regions for the processing of each of the languages they speak, and when differences in activation are found, these are attributed to factors such as AoA, frequency, or amount of exposure, among others. It is an open question, however, how bilinguals learn new words in each of their languages and whether, once controlling for the above variables by introducing novel words, intrinsic differences between languages are still observed. In order to investigate this, we conducted an fMRI study of word learning that looked at the neural basis of tightly controlled novel words in Spanish as a mother tongue (L1) and English as a second language (L2). Participants were a group of 20 sequential Spanish-English bilinguals studying at different universities within the London area. They learned new names for a set of real but unfamiliar concepts in Spanish and English over the course of two days. The following day, the novel words were presented interleaved with familiar words during fMRI scanning. Participants were required to perform a semantic categorization task, which involved classifying both familiar and novel words into living or nonliving entities. Behavioral results showed better performance for English than Spanish across novel words, but better performance for Spanish than English when classifying familiar words. This implies that participants learned better in the second language, but their knowledge of the familiar words was greater in their mother tongue. The neuroimaging data revealed that words across both languages activated overlapping brain regions including the left inferior frontal gyrus and the fusiform gyrus, but with extended and increased activation for Spanish primarily within semantic regions (e.g., middle temporal gyrus, angular gyrus, and precuneus). The significant language x familiarity interaction showed that the overwhelming semantic activation for Spanish was mainly driven by familiar words and might be the result of a combination of factors (e.g., AoA, frequency of use, and amount of exposure), which provide a more meaningful experience in the mother tongue. In order to break down the interaction, we ran further direct contrasts involving only newly learned words. These showed higher activation for English than Spanish within planum temporale and Heschl's gyrus, which might suggest increased phonological discrimination processing in L2. The reverse contrast (Spanish vs. English) showed a heightened BOLD response within dorsolateral prefrontal cortex, which may be interpreted as increased competition of semantic representations for L1 novel words in view of a larger Spanish vocabulary. Overall, these results suggest that novel words may be learned by especially engaging phonological processes (in L2) and semantic processes (in L1) but that more generally, these new lexical representations, regardless of whether they are Spanish or English, are represented in overlapping networks.

C25 Neural mechanisms associated with second language learning from social contexts

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Many linguists and psychologists claim that acquiring new words in the first and second language (hereafter L1 and L2) involves various processes including mapping semantic concepts and linguistic forms. They also claim that the way to connect meanings and forms determines cognitive processes associated with successful encoding and retrieval of words. However, limited neuroimaging studies have explored these important issues. For example, a previous neuroimaging study (Jeong et al., 2010) reported that retrieving words learnt from real life communicative contexts were processed in different brain areas from extracting words learnt through L1 translations. Jeong et al's study is limited in that they did not examine cortical mechanisms involved in encoding L2 words. The present study thus attempted to investigate neural mechanisms for encoding new L2 words from social contexts and the effect of proficiency on these mechanisms, compared with L1 translation-based learning. Participants in this study were 36 healthy, right-handed Japanese native speakers who had no previous knowledge about Korean. On Day 1, the participants memorized 24 novel Korean spoken words either by watching video clips in which these words were used in various real life communicative contexts (L2-SL) or by listening to the target words with written L1 translation (L2-TL). Each word was presented with eight different video clips or voices in the SL or TL condition respectively. To control the amount of information and repeated exposure between conditions, the L1 social context (L1-SL) and L1 text (L1-TL) conditions were included as control conditions. Brain activation was measured using fMRI at 2 time points, Time1 in which subjects initially learned words, and Time2 in which they completely memorized all words. During scanning, videos and texts were presented with a block design paradigm for 4 conditions (L2-SL, L2-TL, L1-SL, and L1-TL). After one night's sleep, which enhances memory consolidation (Day 2), subjects' knowledge of the memorized L2 words was tested outside fMRI. Statistical analyses were performed with SPM8, using a random effects model (corrected to $p<0.05$ by cluster size). First, to identify the effect of learning from social contexts, Time1_L2-SL was compared to Time1_L2-TL with inclusive masks, [Time1_L2-SL > Time2_L2-SL] to limit areas involved in learning and [Time1_L2SL > Time1_L1-SL] to control the amount of information. Greater activation in the bilateral posterior temporal areas and the right inferior frontal gyrus was found for the social context than translation conditions. These areas may be associated with encoding pragmatic knowledge of words and

paralinguistic components. No higher activation was found for the translation than social context conditions. Second, to examine the proficiency effect of each learning type, single regression analyses were performed on each Time 1 > Time 2 learning contrast using the vocabulary score conducted on Day 2. Positive correlations were found in the right temporal parietal junction, the left precentral area and the right hippocampus during social context learning (Fig.1). Higher proficiency learners recruited the motor, social cognition and memory-related areas during learning from social contexts. Our findings imply an importance of social cognition areas in language acquisition.

C26 Selective interference during memory consolidation of novel words in adults *Laura Kaczer[1], Eithan Hochman[1], Luz Bavassi[1], María Eugenia Pedreira[1]; [1]Laboratorio de Neurobiología de la Memoria. IFIByNE, CONICET. Facultad de Ciencias Exactas y Naturales. Universidad de Buenos Aires, Argentina*

Memory consolidation is a gradual, time-dependent reorganization process by which newly acquired information becomes stable. It has been proposed that consolidation plays an important role in the establishment of novel words as functional long term lexical memories (e.g. Davis & Gaskell, 2009). However, it is possible to conceive that not all components of a new word (i.e., its orthography, phonology and semantics) are equally consolidated. In the present study we used an interference procedure designed to impair memory consolidation and analyzed how this interference affected the word-form memory (phonology and orthography) and the semantic memory. Native speakers of Spanish (19-35 years) were instructed to learn nine new words (e.g. 'pefaro'), visually presented, each associated with a picture of a novel object and a definition (e.g. 'pefaro is a tropical bird'). A short term memory test was performed 5 min after learning, and a long term memory test took place 48 h after. During testing participants were instructed to name aloud the pictures (word form test), and recall the definitions when given the corresponding word name (semantics test). The interference consisted of a similar learning task, including nine novel words associated with pictures and definitions. It was presented at different times after the end of the first learning session: 5min, 30min, or 24h, each performed to a different group of participants (N= 15 in each case). These groups were compared with a control group that only learned the first set of words. Our results show that only the word-form memory was affected by the interference treatment, while the semantic memory was immune to the treatment. The interference was found to be time limited, being evident in the 5min and 30min group, but not in the 24h group. Our results suggest a dissociation between the memory systems involved in novel word learning. On the one hand, the semantic memory would be formed rapidly (probably by a fast mapping process), while the word form memory would form gradually and imply a system consolidation process.

C27 Does lexical production decline during normal ageing? An fMRI study *Monica Baciu[1,2], Naila Boudiaf[1,2], Emilie Cousin[1,2,4], Cédric Pichat[1,2], Nathalie Fournet[2,3], Alexandre Krainik[4,5]; [1]Univ. Grenoble Alpes, LPNC, F-38040 Grenoble, France, [2]CNRS, LPNC UMR 5105, F□38040 Grenoble, France, [3]Univ. Savoie Montblanc, LPNC, F-73000 Chambéry, France, [4]UMS IRMaGe, IRM 3T Recherche, CHU Grenoble, Univ. Grenoble Alpes, F-38043 Grenoble, France, [5]GIN-Neuroimagerie Fonctionnelle et Perfusion Cérébrale, Univ. Grenoble Alpes, F-38043 Grenoble, France*

Introduction. This fMRI study explores the effect of normal ageing on the cerebral substrate of word retrieval and generation. Our hypothesis was that normal ageing does not induce loss of lexical knowledge but slowdown of retrieval mechanisms and of access to word representations, by decline of executive functioning. Methods. Participants and inclusion criteria: Thirty right-handed participants were included into 2 groups, Young Group, YG (Average 42.6y) and Aged Group, AG (Average 72.2y). They were all free from cognitive impairment (Mini Mental State Examination), anxiety and depression (Hospital Anxiety and Depression scale) and episodic memory deficit ('5 words' of Dubois test). Other neuropsychological tests evaluated executive (TMT-A, TMT-B, FAB) and language (Mill Hill, Fluency test, Automatisms) functions. MR Acquisition. FMRI session included three functional scans testing for verbal fluency, object naming and semantic categorization. Performances (RT, %CR, fluency scores) have been recorded and analysed. Experiments were performed in a whole-body 3T MR scanner (Philips Achieva; gradient-echo/T2* weighted EPI). Data analysis. For each test, scores for AG and YG were compared (t-test). In AG, values of % MR signal change measured in age-related regions (resulting from AG vs. YG) were included into a correlation analysis. Behavioural performances were analysed (t-test) separately for each task to assess the age effect. Functional MRI data analysis was performed by using the general linear model, as implemented in SPM12 (Welcome Department of Imaging Neuroscience, London, UK, www.fil.ion.ucl.ac.uk/spm). After spatial pre-processing, statistical analyses were performed separately for each task. Conditions of interest (Task, Control) were modelled as 2 regressors convolved with a HRF function. We first evaluated task-related cerebral networks using one sample t-tests (K= 5; $p<.05$; T= 5. 9) and including all subjects. Secondly, we evaluated the effect of age for each of task by means of two-sample t-tests (K=10, determined empirically, $p<.001$; T=3.55) comparing AG and YG. Results. Neuropsychological results revealed that elderly showed fluency rate decrease, decline in executive functions and significant increase of automatisms and overlearned information. Behavioural results indicated that elderly performed as accurate as younger participants but they were significantly slower for semantic categorization and significantly less fluent than

younger participants. No differences between groups were obtained for naming. FMRI results showed that cerebral networks of word retrieval and generation were modulated by task. Correlation analyses for ageing-dependent regions revealed positive correlations with processing speed and executive functions and negative correlations with verbal automatism scores. No correlation was obtained with verbal scores. Conclusions. Our results suggest that elderly do not simply activate less brain regions involved during word retrieval and generation, but they show an atypical pattern of activation at an intra and inter-hemispheric level. The role of ageing-dependent regions is discussed in terms of cognitive processes and hemispheric specialization as suggested by correlations. Our main finding was that normal ageing is associated with difficulties to access word retrieval and generation stages because of slowdown of executive functions and processing speed, without loss of verbal knowledge. Several types of possible compensatory mechanisms that might be recruited by elderly, are discussed.

Language Disorders

C28 Does Naming Accuracy Improve Through Self-Monitoring of Errors?

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Introduction. This study examined spontaneous self-monitoring of picture naming in people with aphasia (PWA). Of primary interest was whether spontaneous detection or repair of an error constitutes an error signal that tunes the production system to the desired outcome. In other words, do acts of monitoring cause adaptive change in the language system? A second possibility, not incompatible with the first, is that monitoring is correlated with item strength, and strength is a causal factor in language change. Methods. Twelve PWA perform a 615-item naming test twice, in separate sessions, without extrinsic feedback. At each time point, we scored the first complete response for accuracy and error type (semantic, phonological, fragment) and the remainder of the trial for evidence of self-monitoring. Two monitoring categories were scored: (a) Error detection – verbalized disavowal of the response (e.g., "no" or "that's wrong") or change to a different response. (b) Successful repair immediately following the error or as the last naming attempt in the trial. Data analysis. The analysis centered on: (a) how often an item that was misnamed at one time point changed to correct at the other time point, as a function of monitoring; and (b) how monitoring impacted change scores in the Forward (Time 1 to Time 2) compared to Backward (time 2 to time 1) direction. The Strength hypothesis predicts significant effects of monitoring in both directions. The Learning hypothesis predicts greater effects in the Forward direction. These predictions were evaluated for the 3 error types separately, using mixed-effects regression modeling with crossed random effects. Results. Change scores for Detected-Repaired exceeded those for Not Detected in both directions for all error types (all ps < .01), while change scores for Detected-Not Repaired did not differ from the Not Detected baseline. These results support the Strength hypothesis, with the important qualification that the critical index of item strength is error correction, not error detection alone. In the interaction analyses that tested the Learning hypothesis, the predicted interaction between detection category and direction (Forward, Backward) was confirmed for the category Detected-Repaired, but only in the analysis on Semantic errors. There was no evidence in favor of the Learning hypothesis in the other error types (all ps > .10). Conclusions. (1) This is the first demonstration that spontaneous self-repair of semantic errors confers a learning benefit in the absence of extrinsic feedback. (2) Successful repair also proved to be a reliable indicator of response strength (proximity to threshold) in all 3 error types. The learning effect in semantic errors was superimposed on this more general strength effect. (3) These findings are important for theories of speech monitoring, incremental language learning, and the nature of the lexical access impairment in aphasia. Acknowledgements: Supported by grants #R01 DC000191 and #RO3 DC012426.

C29 Psychophysiological interaction analysis reveals increased connectivity between the inferior frontal lobes following left hemisphere stroke related to worse naming performance

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The role of the right hemisphere in aphasia recovery has been debated for over a century. Some argue that the right hemisphere plays a compensatory role, aiding recovery (e.g., Basso et al., 1989), while others posit that right hemisphere activity interferes with recovery (e.g., Barwood et al., 2011). In this experiment, we examined the functional networks that synchronize during covert object naming, and how the communication within this network relates to naming performance outside of the scanner. Unlike prior studies, we controlled for differences in stroke distribution that principally determine naming performance. To accomplish this, we used voxel-based lesion symptom mapping (VLSM) to first identify the critical LH area for naming. We then quantified each subject's damage to this area and controlled for this damage when examining the additional influence of fMRI activity on naming ability. Twenty participants with chronic left hemisphere stoke, as well as 25 age-matched controls, participated in this study. The participants underwent a T2* weighted MRI scan while they performed a delayed-response object naming task. Only correct trials were analyzed. Participants also underwent a battery of language and other cognitive tests, which were reduced to four factors (Naming, Motor speech, Executive function and Comprehension) using factor analysis. VLSM analyses were carried out for the Naming factor. Lesions in the

left pars triangularis and pars orbitalis were associated with worse performance on Naming. To account for relationships between lesion location and naming ability, we calculated the proportion of the VLSM results damaged in each individual (Percentage of Critical Area Damaged, PCAD). The functional data was then analyzed using a psychophysiological interaction (PPI) analysis, which identified regions that synchronized with right BA 44 specifically during word retrieval. Participants in the stroke group showed greater connectivity than controls between the seed region and left pars triangularis and insula during word retrieval. A regression was then carried out examining how activation in this spared left hemisphere region related to Naming performance, while controlling for age, gender, education, handedness, chronicity, lesion size and PCAD, in the stroke group. The level of activation in the area identified by the PPI analysis significantly predicted participant performance on the Naming factor, such that high levels of activation related to worse performance. Activation of this region during word retrieval also had a significant negative relationship with performance on the Philadelphia Naming Test. Critically, this significant negative relationship only existed when PCAD was controlled, suggesting that the activity of this area influences naming performance independent of the direct effects of the lesion itself on naming. These results show that the right frontal lobe synchronizes with spared left frontal language areas to a greater degree for stroke participants than for healthy people, and activation of this region in the left hemisphere during a language task is related to poor naming performance, when controlling for the impact of the stroke itself on naming.

C30 Object and action naming in patients before and after glioma resection

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Existing neuropsychological evidence suggests a dissociation between object and action naming in brain-injured patients (Chen and Bates, 1998; Damasio and Tranel, 1993; Shapiro and Caramazza 2003), indicating differential brain organization for verbs and nouns. For example, patients with damage to the frontal lobe of the dominant hemisphere display deficits in the production of verbs rather than nouns, while patients with lesions in the temporal lobe exhibit a contrastive profile (more problems with nouns than verbs). While such verb-noun dissociation has been a focus of much fruitful research on healthy adults and patients with aphasia, little is known about the effects of glioma and its resection on naming in tumor patients. The present study evaluated pre- and post-operative object and action naming performance in two groups of patients—those with gliomas in either the frontal (n=5) or temporal (n=5) lobes—with the goal to establish neuro-behavioral correspondences between noun vs. verb production and the location of the tumor in the brain. The neurological data consisted of MRI and/or CT scans obtained before and after tumor resection with intraoperative speech mapping in awake patients. The behavioral data included patients' performance on a 100-item naming test (50 nouns and 50 verbs matched in frequency, familiarity, imageability, etc.). The results indicate that the mere fact of gliomas in the eloquent cortices—the inferior frontal gyrus or the superior temporal gyrus—does not cause a significant deterioration of naming, although patients with gliomas in the temporal sites perform slightly worse than those with gliomas in the frontal areas even pre-surgically. Post-surgical effects were differential for the two groups of patients: while patients with the resected gliomas in the frontal lobe did not show a significant decline in either action or object naming, patients who underwent glioma resection in the temporal lobe performed much worse on both nouns (a drop of 26%) and verbs (a drop of 19%). However, much variability within the group was observed. Out of five patients with gliomas in the temporal sites, one patient showed an improvement, three patients showed a significant deterioration (a drop of more than 20%). Two of the latter had a directly opposite pattern: while one patient experienced problems exclusively with objects and had action naming almost intact, the other patient displayed deficits in action naming (avoided using verbs in favor of corresponding nominal phrases: "bottle opening" in place of "to open"). To conclude, our data do not support the idea of differential brain organization for verbs and nouns as far as naming behavior in tumor patients is concerned. Rather, we observed a differential involvement of frontal and temporal brain sites in both action and object naming. We found that tumors in the left temporal areas and their subsequent resection cause a more pronounced linguistic deficit than those located in the frontal areas, both for object and action naming. This suggests that the linguistic functions (at least those belonging to the lexical-semantic level) grounded in the temporal lobe are less reluctant to reorganization than those based in the frontal areas.

C31 The left fusiform gyrus is the crucial region underlying the core deficits of semantic dementia

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Semantic dementia (SD) is a progressive cerebral atrophy disorder characterized by the loss of semantic memory in both the verbal and nonverbal domains. Given that abnormal regions are co-atrophied in SD, little is precisely understood about the regions actually causing such semantic deficits (SD-causing regions). To address these issues, the present study conducted partial correlation and multiple regression analyses to control for the co-atrophied influence in 19 SD individuals. We found 36

atrophic regions in the patients, which primarily involved the bilateral temporal, ventral frontal, and insular cortices. Three of the atrophied regions (left fusiform gyrus, left hippocampus, and left parahippocampal gyrus) were associated with semantic impairments related to SD, and the degree of cortical atrophy of these regions [i.e., the gray matter volumes (GMVs)] significantly correlated to the scores on each semantic task (i.e., oral picture naming, picture associative matching, and word associative matching). The left fusiform gyrus was further determined as an SD-causing region, and its GMV significantly correlated to the semantic performance scores after partialling out the GMVs of the left hippocampus and the left parahippocampal gyrus. The association of the left fusiform gyrus with semantic disruptions in SD was well sustained even when we controlled for a range of potential confounding factors (total GMV, overall cognitive state, laterality of brain damage, and non-semantic task performance). These results reveal the causal structural region of the left FFG on the whole brain for semantic impairments in SD, providing direct evidence for a part of the semantic anatomical network.

C32 Does communication make aphasia therapy more efficient?: Evidence from a cross-over randomized controlled trial

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Traditional aphasia therapy focuses on language exercises such as object naming, repetition and sentence completion. These exercises are sometimes very different from the 'language games' relevant in conversation in everyday life, where words and constructions are tools for making requests, suggestions, or compliments. Therefore, a long-standing debate in aphasia research addresses the suitability of non-communicative exercises in aphasia therapy and the possibility to enhance therapy efficiency by use of language in communication similar to everyday conversation. The present cross-over RCT provided 18 patients with chronic post-stroke aphasia to an intensive therapy regime. In therapy interval A, each group received naming and word-to-picture-matching training for two weeks, three hours per day. In therapy interval B, the same pictures and linguistic forms were used in communicative language games, where patients were trained, with the same intensity, to make requests and to appropriately respond to requests, using methods known from constraint-induced aphasia therapy and intensive language action therapy (CIAT/ILAT). Participants were assigned randomly to groups; therapy order (A vs. B) was counterbalanced across groups. Results show consistent improvement only for ILAT/CIAT, with significant effects for the naming training only at therapy onset. A significant group x time interval interaction further confirmed the general efficiency of ILAT/CIAT, in contrast to the context-specificity of the effect of the non-communicative method. These results demonstrate that, in the therapy of chronic post-stroke aphasia, practicing language in request communications is more efficient than naming training, thus suggesting a beneficial influence of the embedding of language in communication. Implication of this new finding for brain language theory will be discussed.

C33 Improved Reading and Concurrent Increased BOLD Activation Following Intensive Aphasia Treatment

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Intensive comprehensive aphasia programs (ICAP) provide up to 120 hours of therapy in four weeks, which differs from the standard outpatient model of therapy. Although research is beginning to explore behavioral changes in ICAP participants, little is known about concurrent neuroplastic changes that may occur. This poster highlights one participant who made significant behavioral language changes on a reading measure with corresponding increased BOLD activation on a semantic judgment fMRI task. Nine participants in a four-week ICAP agreed to take part in pre- and post-treatment fMRI scans. At the outset, one participant, SENMA, demonstrated remarkably decreased scores on the Western Aphasia Battery reading subtest as compared to his Aphasia Quotient (AQ) score (measure of comprehension and verbal expression). His intial WAB scores were: AQ=84.1 and reading=61.0. The other participants demonstrated a different pattern with reading scores an average of 9 points higher than the AQ scores. The participants performed a visual synonym task using a block design. There were 8 interleaved control and task blocks with a 40 second duration for each block. Pairs of words were presented. Participants were instructed to press the response button only when the words were synonymous (e.g. boat and ship). During the control period, pairs of fake words (letter strings) were presented. A response was required only when the letter strings were identical. The synonym task has been shown to activate Broca's and Wernicke's area in normal volunteers. Participants performed the task prior to and at the end of the ICAP treatment. MR data were collected using a 3.0 T Siemens scanner. Structural images were collected using a T1-weighted 3-D MPRAGE; functional images were collected using routine BOLD EPI. Functional images were slice timing corrected, realigned, co-registered with the structural image, normalized to the MNI template and smoothed by a 6mm Gaussian Kernel. Contrast images (synonyms>letter strings) were compared between pre- and post-treatment sessions. Behaviorally, SENMA improved in his WAB AQ from 84.1 to 93.0, an 8.9 point improvement; reading improved from 61 to 100 (maximum score), a 39 point improvement. The average WAB AQ and reading improvement of the other participants was 7.7 and 8.7 respectively. SENMA showed increased BOLD activations post-treatment in the left inferior frontal gyrus and supplementary motor area. None of the other subjects

showed changes in BOLD activation. Changes in SENMA's reading scores from pre- to post-treatment demonstrated clinically significant improvement as compared to other participants. It is likely that participants with higher WAB AQ scores may have retained relatively good reading skills. However, the isolated deficits in SENMA's reading skills were ameliorated by participation in the intensive aphasia treatment program, which focused on all modalities of language. In summary, smaller gains on reading measures may not be represented by neuroplastic changes with an fMRI semantic judgment task. Significant behavioral improvements may need to occur before those changes are represented with scanning tasks.

C34 Verb-Based Integration and Prediction in Primary Progressive Aphasia (PPA)

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Introduction. Primary progressive aphasia (PPA) is characterized by neural atrophy in primarily left-hemisphere regions supporting language processing [1-2]. Word and sentence comprehension deficits in PPA have distinct neural substrates [1] and manifest differently across PPA subtypes: word comprehension deficits are characteristic of the semantic variant (PPA-S) whereas sentence comprehension deficits are more prevalent in the agrammatic (PPA-G) and logopenic (PPA-L) variants [2]. Little is known about the relationship between word and sentence comprehension processes in PPA, specifically how words are accessed, combined, and used to predict upcoming elements within a sentence. Listeners with stroke-induced agrammatic aphasia rapidly access verb meanings and use them to semantically integrate verb-arguments; however, they show deficits in using verb meanings predictively [3]. The present study tested whether listeners with PPA are able to access and use verb meanings to integrate and predict verb-arguments. Methods. Fifteen adults with PPA (8 PPA-G, 3 PPA-L, 4 PPA-S) and ten age-matched controls participated. In two eyetracking experiments, participants heard sentences with restrictive verbs, semantically compatible with one object in a four-picture array (e.g., eat when the array included a cake and three non-edible objects), and unrestrictive verbs (e.g., move), compatible with all four objects. The verb-based integration experiment tested access to verb meaning and its effects on integration of the direct object (e.g., Susan will eat/move the cake); the verb-based prediction experiment examined prediction of the direct object (e.g., Susan will eat/move the …). Mixed-effects logistic regression was used to compare the rate of target fixations between PPA and control listeners, and between PPA subtypes, in the first 500 ms after verb offset. Results. In the verb-based integration experiment, PPA listeners as well as controls showed rapid access to verb meaning, making more target fixations in the restrictive than unrestrictive conditions, with no significant differences between groups. In the verb-based prediction experiment, control listeners exhibited a greater difference between the restrictive and unrestrictive conditions compared to PPA listeners. A direct comparison of the two experiments' results demonstrated that prediction was more impaired than integration in PPA listeners. No significant differences were found between PPA subtypes. Conclusion. The results suggest that access to verb meaning is relatively preserved in PPA and can facilitate integration of verb-arguments. However, prediction of verb-arguments is impaired, in line with findings from stroke-induced agrammatic aphasia [3], suggesting that damage to left-hemisphere language regions can differentially impair linguistic prediction processes. The similar pattern of results across PPA subtypes should be interpreted cautiously due to small sample sizes. However, these findings suggest that – despite differences in word and sentence comprehension impairments – there may also be shared deficits across PPA subtypes in linguistic prediction ability during sentence comprehension. 1. Mesulam et al. (in press). The Wernicke conundrum and the anatomy of language comprehension in primary progressive aphasia. Brain. 2. Gorno-Tempini et al. (2011). Classification of primary progressive aphasia and its variants. Neurology, 76(11), 1006-1014. 3. Mack et al. (2013). Effects of verb meaning on lexical integration in agrammatic aphasia: Evidence from eyetracking. J Neurolinguistics, 26(6), 619-636.

C35 Functional Connectivity of Abstract and Concrete Networks in Persons with Aphasia and Neurologically Healthy Adults

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Introduction The difference in processing abstract and concrete words with a specific advantage for concrete words is called a 'concreteness effect' and has been shown to exist in normal and language-disordered populations (Paivio, 1991). Recent evidence from neuroimaging studies suggests possible dissociable neural correlates for processing abstract versus concrete words (Binder, Desai, Graves, & Conant, 2009; Wang, Conder, Blitzer, & Shinkareva, 2010). However, abstract and concrete word processing in neurologically healthy older adults (NHOA) has not been adequately addressed, although cognitive processes have been shown to change as a function of age (Cabeza, 2001). Additionally, neuroimaging exploration of abstract and concrete word representation in persons with aphasia (PWA) is scarce. Sandberg and Kiran (Sandberg & Kiran, 2013) recently compared activation between the groups; however, the group sizes were small (N=3) and functional connectivity was not explored. The present study uses graph theoretical measures to examine the functional connectivity of the abstract and concrete word processing networks in NHOA and PWA in order to shed further light on the concreteness effect in these currently underrepresented groups. Methods Thirteen (6 male) adults aged 50-67 with no history of neurological disease and ten (7 male) adults with aphasia, in the chronic stage of post-stroke recovery, participated in the experiment. All participants were right-handed native English speakers

who completed at least a high school education. Each participant completed a concreteness-judgment task presented in an event-related fMRI paradigm. Task-based functional connectivity analyses were performed using the CONN toolbox for SPM12 with anatomical regions of interest (ROI). Graph theoretical measures of degree, betweenness centrality, and clustering coefficient were calculated at the individual level and averaged across participants within each group for each ROI for each condition (abstract, concrete) to determine the importance of each node within each network. Results Both NHOA and PWA exhibited differences in all three graph theoretical measures between the abstract and concrete networks (e.g, higher node degree in R angular gyrus in NHOA for concrete vs. abstract words). Additionally, differences were noted between NHOA and PWA in all three graph theoretical measures in both abstract and concrete networks (e.g, higher node degree in R post middle temporal gyrus in PWA vs. NHOA for abstract words). Conclusions These exploratory results compliment BOLD activation studies examining differences between abstract and concrete concept representation. As BOLD activation studies have found different regions that are preferentially active for abstract vs. concrete words (and vice versa), we too found that different nodes appear to play a more important role in each network, and that these regions differ between PWA and NHOA.

Lexical Semantics

C36 Perceptual and conceptual semantic dimensions: where and when?

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It is generally assumed that semantic representations include both perceptual (i.e. prototypical size) and conceptual (i.e. taxonomic category) properties. However, little is known with regards of whether these different components of words meaning dissociate in the brain. Two competing cognitive theories support different predictions. On one hand, the embodied cognition theory predicts that word meaning is resolved by the reactivation of perceptuo-semantic properties stored in primary sensory-motor cortices (Pulvermuller, Trends Cogn Sci, 2013). On the other hand, the abstract cognition theory predicts that at least some of the key aspects of word meaning are encoded in abstract format and represented in amodal cortices (Patterson et al., Nat Rev Neurosci, 2007). Behavioral, clinical, computational and neuroimaging investigations have provided indirect support to both theories, thus so far no conclusive results has been shown. To put to test the two theories, we acquired MEG (Elekta 306-channels) recordings of 15 adult subjects silently reading words referring to concrete entities. Words varied parametrically along four orthogonal dimensions: a purely physical dimension (i.e., the number of letters composing each word), a visuo-perceptual dimension (i.e., the average real-world size of the objects the words referred to), an audio-perceptual dimension (i.e., the strength of the association with a prototypical sound) and, finally, a conceptual dimension (i.e., the semantic category and the semantic cluster as derived from subjects' similarity ratings). The task performed by the subjects was orthogonal to the dimensions investigated not to introduce any confound. By combining univariate and multivariate analyses methods, we have isolated the contribution of the different dimensions of word meaning in time and space. We found that early (i.e. between 200 and 500ms) and automatically (i.e. the task did not ask for a categorization), it was possible to classify the items along the different dimensions. Analyses at the sensors and source spaces suggest that visuo–perceptual and audio–perceptual dimensions are encoded in visual and auditory brain regions respectively, in agreement with the embodied theory of cognition. Conversely, conceptual dimensions such as the category appear to be encoded in cross-modal brain regions, in agreement with the abstract theory of cognition. Overall, our data corroborate previous findings (Sudre et al, NeuroImage, 2012) and speak against a purely embodied or purely abstract perspective, calling for a new view of semantics. In order to understand words meaning, one needs to rapidly retrieve their multidimensional semantic representations: both sensory and multimodal association areas play an important role in this process by coding for specific and complementary dimensions.

C37 The neural substrates of conceptualizing actions at varying levels of abstraction

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How does the human brain flexibly represent actions at varying levels of abstraction? Prior fMRI studies (reviewed by Spunt & Adolphs, 2014) have shown that when people think about why particular actions (e.g., riding a bike) are performed, they engage a network—henceforth "Network 1"—associated with representing beliefs, desires, motives, and other mental states (temporoparietal junction, medial prefrontal cortex, anterior superior temporal sulcus, and posterior cingulate gyrus), whereas when they think about how the same actions are performed, they engage a different network—henceforth "Network 2"—associated with representing the visual and motor aspects of body movements (posterior middle temporal gyrus, rostral inferior parietal cortex, premotor cortex, and dorsal precuneus). We tested the hypothesis that these two networks are sensitive not so much to the why/how distinction per se, but rather to higher versus lower levels of abstraction. We created a battery of 4-level action hierarchies (e.g., grip handlebars - ride bike - get exercise - maintain health), such that upward shifts answered why questions (e.g., Why ride a bike? Get exercise) and downward shifts answered how questions (e.g., How to

get exercise? Ride a bike). Although the action phrases comprising these hierarchies were matched for length and frequency, they varied in concreteness, imageability, specificity, body versus mind involvement, and valence; this variability was strongly correlated across dimensions, however, and a single component, which we call "level of abstraction" (LOA), explained 91% of the data. 19 healthy adults underwent fMRI while judging the appropriateness of question-answer pairs of action phrases that varied in LOA. Region of interest (ROI) analyses focused on the left-hemisphere areas in Networks 1 and 2, as defined by Spunt & Adolphs's (2014) functional localizer study. First, we conducted a factorial analysis that crossed the orthogonal manipulations of question type (why versus how) and LOA (binarized as high versus low). Neither of the two contrasts involving question type—specifically, [(High-Why + Low-Why) > (High-How + Low-How)], and the opposite—revealed effects in any of the ROIs. However, many effects emerged from the two contrasts involving LOA. In particular, the [(High-Why + High-How) > (Low-Why + Low-How)] contrast revealed activation in 5/5 ROIs in Network 1, and the opposite contrast revealed activation in 3/5 ROIs in Network 2. These findings were corroborated by whole-brain analyses and reproduced in a second analysis examining trialwise LOA parametrically. Finally, we conducted an additional parametric analysis that focused on the magnitudes of the upward (positive) and downward (negative) question-to-answer shifts in LOA, independently from the LOAs of the questions. As the magnitudes of upward shifts increased, activation increased in 4/5 ROIs in Network 1, but as the magnitudes of downward shifts increased, activation did not increase in any of the ROIs in Network 2; nevertheless, there were notable trends in 3/5 ROIs. These results suggest that the differential recruitment of Networks 1 and 2 during action understanding is primarily driven not by why/how questions per se, but rather by the differential effects these questions have on the LOA.

C38 Comparing Apples and Oranges: Does lexical ambiguity have effect on conceptual representations of ambiguous words?

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One of the questions that has been of interest to many researchers is whether the system of symbols that people use to communicate with each other impact the way we become aware of and interpret external stimuli. According to the label feedback hypothesis (Lupyan, 2012), language augments thought and assists people in identifying visually presented objects. The presence of a common label allegedly changes the conceptual space of corresponding words by drawing concepts closer together in our semantic memory. While the facilitative effect of language on object identification has been previously documented (Lupyan & Spivey, 2010), the presumed changes at the conceptual level have not yet been examined extensively. In the present study, we looked at the effect of lexical ambiguity (defined as the presence of common linguistic label for concepts belonging to different categories (e.g., orange, the color and the fruit)) on the conceptual representations of corresponding words. The critical stimuli for this study were images of the following objects: oranges and orange circles (ambiguous label) vs. apples and red circles (no ambiguous label). The stimuli were presented using the visual oddball paradigm, where one type of image (e.g., apple) was shown on 80% of trials (standard), while the other type of image (e.g., red circle) was shown on 10% of trials (deviant). On the remaining 10% of trials, filler images of pears and yellow circles were shown. Participants' task was to make a response when filler images were presented. There were four blocks of trials: (1) oranges presented as standards and orange circles as deviants, (2) orange circles presented as standards and oranges as deviants, (3) apples presented as standards and red circles as deviants, and (4) red circles presented as standards and apples as deviants. The ERP responses of participants to standards and deviants were recorded. The ERP component of interest was the Deviant Negative Response (DNR), a spike in the activity associated with the switch from a standard to a deviant. A significant DNR was identified in the 200 – 350 ms time-window, $F(1, 27) = 14.87$, $p = .001$. Most importantly, the DNR interacted with the presence of an Ambiguous Label, $F(1, 27) = 13.18$, $p = .001$. The magnitude of the DNR response on blocks of trials where oranges and orange circles were used as stimuli was significantly reduced in comparison to the DNR on blocks of trials where apples and red circles were presented. The size of the DNR is reflective of the proximity of objects in conceptual space (note that pairs of critical items were matched on their perceptual similarity). We believe that the common label "orange" pushed the corresponding concepts closer together in the semantic space and, thus, the switching costs for these types of stimuli were reduced. The results of this study provided a strong support for the label feedback hypothesis.

C39 Early prediction effects and delayed context effects during task-free sentence comprehension

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Recent studies have suggested that successfully predicting and pre-activating an upcoming word can influence very early stages of lexical processing (Brothers, Swaab & Traxler, 2015), likely through the pre-activation of form-based information (Laszlo & Federmeier, 2009). While this pattern has been shown consistently in single word contexts (Lau, Holcomb & Kuperberg, 2013; Luka & Van Petten, 2014), it has not been demonstrated clearly in a naturalistic sentence comprehension paradigm. To test this "primacy of prediction hypothesis", thirty-six UC Davis undergraduates read three types of sentences for comprehension while EEG was recorded from the scalp. Sentence-final words were either predictable ("The cow

gave birth to the brown calf."), unpredictable yet plausible ("Bill went to check on the brown calf."), or anomalous ("Today, she decided to wear the brown calf."). Critically, the final words of the unpredictable and anomalous sentences were matched on 1) constraint, 2) cloze probability (0%), 3) semantic association with the preceding context, and 4) semantic association with the most likely completion of each sentence. While the N400 was most strongly influenced by cloze probability (predictable vs unpredictable), we also observed an N400 anomaly effect (unpredictable vs anomalous) that was maximal between 400 and 600ms post-stimulus onset. This result is inconsistent with models such as the Retrieval-Integration account (Brouwer, Fitz & Hoeks, 2012) which assume that the N400 reflects only lexical retrieval processes. Consistent with the primacy of prediction hypothesis, the onset of this anomaly effect was significantly delayed (75-100ms) relative to the onset of the N400 predictability effect. Two distinct post-N400 positivities were also observed. All unexpected endings showed a late positivity over frontal electrodes (regardless of plausibility), while only anomalous endings elicited a positivity over posterior sites. These findings shed light on the nature of the N400, as well as the time-course of lexical pre-activation and integration during sentence processing.

C40 Role of Features and Categories in the Organization of Object Knowledge: Evidence from Adaptation fMRI

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There are two general views regarding the organization of object knowledge. The feature-based view assumes that object knowledge is grounded in a widely distributed neural network in terms of sensory/function features (e.g., Warrington & Shallice, 1984), while the category-based view assumes in addition that object knowledge is organized by taxonomic and thematic categories (e.g., Schwartz et al., 2011). Using an fMRI adaptation paradigm (see Yee et al., 2010), we compared predictions from the feature- and category-based views by examining the neural substrates recruited as subjects read word pairs that were identical, taxonomically related (e.g., saw-axe), thematically related (e.g., saw-wood) or unrelated. Importantly, the word pairs in the taxonomically and thematically related conditions involved similar function features, how similar the functions were for two objects (similarity) and how likely the purpose of use for one of the two objects was to perform action on the other one (relatedness). The feature-based view predicts that if taxonomic and thematic categories are categories by virtue of the function features they share, adaptation in function regions (i.e., left posterior middle temporal lobe, left premotor cortex) should be observed for taxonomically/ thematically related vs. unrelated word pairs regardless of the taxonomic/ thematic categories involved. In contrast, the category-based view generates the prediction that adaptation in the bilateral anterior temporal lobes (ATL) should be observed for taxonomically related word pairs and adaptation in the left temporo-parietal junction (TPJ) should be observed for thematically related word pairs. To assess the degree to which brain activity is related to more fine-grained assessments of function and categorical (taxonomic and thematic) relationships, we correlated brain activity with subject ratings of these relationships across stimuli. Consistent with the category-based view, the bilateral ATLs were sensitive to word pairs sharing taxonomic category membership while the left TPJ was sensitive to word pairs sharing thematic category membership. Consistent with the feature-based view, activity in the precentral gyri correlated with the degree that objects shared features related to action (function relatedness). However, we did not observe significant relationships between activity in the bilateral ATLs and the TPJ and the degree to which word pairs were judged as sharing the same taxonomic and thematic categories, potentially due to the specificity of the rating instructions. Instead, we observed a correlation between activity in the right ATL and the degree two objects shared similar function (similarity), suggesting that at least the right ATL carries specific feature information. Future research should further identify the aspects of taxonomic and thematic relationships that are similar across members of a given category in order to better understand how the bilateral ATL and left TPJ differentially support taxonomic and thematic categories. Altogether, we conclude that both feature and category information play a role in organizing object knowledge.

C41 Distinguishing concrete and abstract senses in polysemy: the role of the ventral anterior temporal lobe

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Recent neuroimaging studies have shown that concrete and abstract concepts recruit distinct neural representations. But how about concepts that have both concrete and abstract senses (for instance book that can refer to both a physical object and its abstract content)? Linguists hypothesise that the senses of those polysemous words are stored as a single but complex concept, which allows different specifications in different contexts (Pustejovsky, 1995; Jackendoff, 1997). In this experiment we investigated an archetypal class of those polysemous words referring to printed objects that contain information, such as book. The senses of these words can be either concrete or abstract depending on the context. Using functional magnetic resonance imaging (fMRI), we examined thirteen participants as they read the polysemous book-like words in a minimal concrete or abstract context, i.e. a verb-noun phrase. As a comparison, we also set up other two concrete-abstract contrasts which contained typical, unambiguous concrete and abstract concepts that were also in the form of verb-noun phrases. Note that one of them contained the same verbs as in the target contrast (e.g.

open the parcel vs. explain the plan) whilst the other one consisted of generic verbs and nouns referred to typical cognitive concepts and concrete objects (e.g. change the idea vs. change the sofa). A Support-Vector-Machine classifier was applied to distinguish the fMRI activity patterns associated with the concrete-abstract contrasts in six left-hemisphere regions-of-interest (ROIs) which have been found to discriminate concrete and abstract concepts, and/or be active during semantic composition. The six ROIs are 1) anterior inferior frontal gyrus (aIFG), 2) ventral anterior temporal lobe (vATL), 3) angular gyrus (AG), 4) precuneus/posterior cingulate gyrus, 5) posterior ventral temporal lobe, and 6) posterior lateral temporal cortices (PLTC). The one-sample t-test on the classification accuracy against the chance level (50%) demonstrated that the unambiguous concrete-abstract contrasts could be distinguished in all the ROIs except vATL. For the cognitive concept vs. concrete object contrast, the most reliable effect was found in aIFG (p=6.38e-06) and AG (p=0.002). For the contrast that contains the concrete and abstract verbs, PLTC showed the most reliable effect (p=0.0024). Conversely, the target contrast that contained th polysemous words could only be distinguished in vATL (p=0.0105). A repeated measures ANOVA further showed that classification accuracy of the target contrast was higher than the others (F(2,24)=2.9215, p=0.073). We attribute this exclusive distinguishing effect in the vATL to the fact that (i) for such concepts, the concrete and abstract components constitute a single representation; (ii) disambiguating such concepts involves retrieving a more specific concept representation, and the vATL plays a key role in that.

C42 The semantics of adjective-noun phrases in the brain

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As a person reads, the brain performs a complex set of operations to create higher order semantic representations. Stimulus words are perceived, their semantics retrieved, individual word semantics are combined, and a final semantic representation is created. While these steps are performed effortlessly by competent readers, we are only beginning to understand how the brain performs these actions, how semantic information flows through the brain as composition proceeds, and where the final composed semantic representation is stored in the brain. We explore semantic composition by analyzing Magnetoencephalography (MEG) recordings of the brain's activity as a person reads one of 38 adjective-noun phrases. Adjectives appear 0-0.5s, nouns 0.8-1.3s and there is 3s total time between the onset of each phrase. We use a large collection of text to create vector representations of word meaning, and behavioral data to create vector representations of phrase meaning. We then predict these vector representations using linear regression applied to MEG data, and use the accuracy of predictions to track information flow over time and through areas of the brain. This approach is fundamentally different from previous studies of composition in that 1) instead of stimuli that contrasts varying degrees of compositional difficulty, our stimulus set is comprised of only simple adjective noun phrases, and 2) instead of comparing the magnitude of the signal, we train MVPA-style predictors to predict word identity and track information flow in the brain. Our results point to several novel findings: 1) In a whole-brain analysis, the neural encoding of the adjective during adjective reading (0-0.5s) is recalled during composition (2-3s) in a way that is incredibly consistent, 2) Areas previously implicated in semantic composition (left inferior frontal lobe, left anterior temporal lobe) do not participate in this consistent semantic encoding, and 3) The neural encoding of adjective semantics are oscillatory and repeat every 100ms, aligning with alpha band frequencies. Taken together, these results imply that brain areas previously implicated in semantic composition are not the loci of composed semantics, though they may act as hubs that coordinate composition. In addition, our results lend support to the theory that patterns coupled to alpha band frequencies carry information in the brain.

C43 Complement Coercion Revisited: The Structured Individual Hypothesis for Processing Aspectual Verbs

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[Introduction] Sentences like "(1) John began the book" are often interpreted as "John began reading/writing/etc. the book." The phenomenon that an entity-denoting complement receives an eventive interpretation is called "complement coercion." Comprehending sentences combining aspectual verbs (AspVs) with entity-denoting complements like (1) requires additional processing cost. Lai et al. (2014), capitalizing on Piñango & Deo's (2012, 2015) analysis, propose the Structured Individual Hypothesis (SIH): AspVs select for structured individuals—directed path structures (DPSs) along some dimension (e.g., spatial, informational)—construed from the complement's meaning, and map the subject denotation to a subpart of the structured individuals via lexical functions. Ex: (2a) This perch begins the Appalachian Trail.—Spatial; (2b) Chapter 10 ends the book.—Informational. AspV sentences with an inanimate subject (AspVconst configuration) like "'Starry Night' started the collection." engender a constitutive reading along the spatial/informational dimension. AspV sentences with an animate subject (AspVagent configuration) like "Van Gogh started the collection." are semantically ambiguous between an agentive reading along the eventive dimension (Van Gogh started watching the collection) AND a constitutive reading along the spatial/informational dimension (Van Gogh's painting started the collection). The processing cost for comprehending AspV sentences is associated with (A) exhaustive retrieval of the dimension-functions in AspVs and (B) resolution of ambiguity induced by dimension

extraction from the complement. Both AspVconst & AspVagent involve (A)&(B), and thus should show similar cost and overlapping neurological correlates. Crucially, the available interpretations in AspVconst (in which the agentive reading--eventive dimension is unavailable) are a subset of those in AspVagent; this subset relation should induce corresponding neurological patterns. [Method] We conducted a self-paced reading (SPR), and an event-related fMRI experiment (Event1: Subject+Verb, Event2: Complement~Sentence-final). AspVs were contrasted with psychological verbs like "enjoy" (EnjoyingV) and "love" (LovingV) as control. Conditions: [AspVconst]: 'Starry Night' started the collection of impressionist oil paintings. /[AspVagent]: Van Gogh started the collection…/[EnjoyingV]: Van Gogh enjoyed the collection ……/[LovingV]: Van Gogh loved the collection…… [Predictions] In SPR, AspVconst & AspVagent will show longer reading times (RTs) than EnjoyingV and LovingV after the complement, because only AspVs involve resolution of dimensional ambiguity. In fMRI, neurological patterns will reflect process (A)&(B) for AspVs, showing overlapping patterns for AspVconst & AspVagent and the subset relation (AspVconst□AspVagent) in terms of interpretations. [Results/Summary] RTs in the SPR exp. show {AspVconst=AspVagent}>{EnjoyingV= LovingV} at the two segments following the complement ($p<.05$). The fMRI exp. reveals: (i) Both AspVconst & AspVagent involved left inferior frontal gyrus (LIFG) and left insula at Event2, reflecting dimensional ambiguity induced by AspVs. (ii) The regions recruited by AspVconst formed a subset of those recruited by AspVagent at Event2, reflecting the subset relation in terms of interpretations (AspVconst□AspVagent). AspVagent induced additional BA7 activity—an area involved in event-related memory retrieval and spatially sequential movements. This reflects the process in which the animate subject traverses the structured individual denoted by the complement in the eventive dimension. It suggests that language makes reference of spatial cognition, which underlies DPSs. (iii) Processing AspVs recruited Wernicke's area at Event1 for (A) and LIFG at Event2 for (B), compared to psychological verbs.

C44 Relationality in left inferior parietal cortex: Evidence from MEG

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The left inferior parietal cortex has been implicated for broad semantic functions such as heteromodal conceptual processing (Bonner et al. 2013), semantic integration (Lau et al., 2008) and conceptual combination (Price et al., 2015), but its precise role in semantic cognition remains elusive. A set of more specific hypotheses have also been articulated, proposing it as relevant for the representation of event concepts (Binder & Desai, 2011), the encoding of relations (Boylan et al., 2014) and the processing of argument structure (Thompson et al. 2007). Which of these closely related factors most strongly predicts activity in left inferior parietal cortex? To address this, we pitted the general integration hypothesis against the more specific eventivity and relationality accounts by varying both the eventivity and relationality of nouns while presenting them both in isolation and in combinatory contexts. In each trial, participants were presented with a target noun that varied in relationality and eventivity. High relational events described events with two participants ('murder') while low relational events only had one participant ('yawn'). High relational non-eventive nouns described relations between two entities ('mother') whereas low relational non-eventive nouns were non-relational object names ('chair'). Each noun was preceded by either an unpronounceable consonant string (e.g. 'xhlpft'), an adjectival modifier (e.g. 'cute', 'lucky'), or a possessor (e.g. 'director's', 'cowboy's'). When combined with the high-relational nouns, the possessors served to saturate one of the noun's arguments, allowing us to assess the effect of argument saturation vs. the presence of arguments/relations. The critical stimuli were followed by a type of comprehension question. Evoked neural responses were analyzed from the onset of the target noun. Distributed MEG source activity localized in the left inferior parietal cortex (BA 39 and BA 40) was analyzed using cluster-based permutation tests. A 2x2x3 ANOVA showed a significant main effect of relationality in a spatio-temporal cluster at 165-230ms after target noun presentation , with more activation for high than low relational nouns. This effect held for both eventive and non-eventive nouns and across all three contexts. The relationality effect was also confirmed in a single-trial analysis using a mixed effects linear regression model, with various lexical and morphological factors included. No effects were found for eventivity or for combinatory context. These results clearly support the relationality hypothesis over all others tested: No evidence was found for a sensitivity in the left inferior parietal cortex to either eventivity or combinatory context . More specifically, relational nouns elicited similarly increased amplitudes as compared to non-relational nouns both in isolation (murder > yawn & height > chair) and when a possessor saturated one of the relations (e.g. 'president's mother/ murder'). Thus according to our results, it is the presence of relations that drives activity in this region as opposed to the saturation of those relations. (1) Binder & Desai (2011). TiCS. (2) Bonner et al. (2013). Neuroimage. (3) Boylan et al. (2014). SNL Conference. (4) Lau et al. (2008). Nature Reviews Neuroscience. (5) Price et al. (2015). J Neurosci. (6) Thompson et al. (2007). J Cognitive Neuroscience.

C45 Age-related semantic prediction reduction was associated with smaller brain activation change

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During sentence comprehension, older adults are less likely than younger adults to predict upcoming words based on given sentence context. However, it remains unclear what is the relationship between the prediction change and brain function aging. In the present study, 41 healthy native Chinese speakers (23-70 years old) comprehended low cloze (LC) and high cloze (HC) sentences during fMRI scanning. While there were no significant age-related behavioral changes, after controlling education and sex, age-related reduction during semantic prediction (LC - HC) was found in regions including left middle frontal gyrus, left supmarginal gyrus, bilateral temporal-occipital cortex and supplemental motor cortex. It was further shown that, smaller prediction related activation change in anterior portion of left middle temporal gyrus was associated with better categorical fluency, after controlling age, education and sex. Moreover, RT interference in the Stroop task was negatively associated with prediction effect in posterior portion of left middle frontal gyrus, right middle temporal gyrus and right visual cortex. In together, the results suggest that semantic prediction was correlated with age and cognitive control change, and are in line with the notion that language comprehension mechanisms are integrated with language production mechanisms.

C46 Effects of prediction and contextual support on lexical processing in young and older readers as a function of language experience and working memory

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Variable performance in language processing in young adult and older readers has been linked to variability in working memory capacity and verbal skill (Long, Oppy, & Seely, 1994; Stine-Morrow & Miller, 2009). Older readers have more experience with language but reduced working memory capacity relative to young adults. It is currently unknown whether normal aging yields differences in the modulation of prediction and contextual support effects during reading. In the present study, we manipulated cloze probability of target completions of passages, and participants were asked to predict the target words. ERPs to completions of low and medium cloze passages were sorted by prediction accuracy in order to assess effects of prediction and contextual support on lexical processing. We evaluated how the timing of these effects was modulated by age and performance on measures of working memory and vocabulary. Young adult (n=24, average age=20.05) and older (n=24, average age=71.1) participants read 180 moderately constraining two-sentence passages. We manipulated final word cloze probability (120 medium cloze (40-60%) and 60 low cloze (0-7%)). Participants were asked to predict the final words of each passage and to indicate whether their prediction matched the actual target word completing the passage. N400 effects of lexical prediction were calculated as the difference between accurately and inaccurately predicted targets in moderate cloze passages, and effects of contextual support were calculated as the difference between inaccurate prediction in medium and low cloze conditions. 20% peak latencies were calculated for both N400 effects; N400 latencies were entered into multiple regression analyses with measures of: (i) working memory (Reading Span), (ii) vocabulary (Nelson-Denny Vocabulary), and (iii) age. Older readers had significantly delayed effects of prediction and contextual support on lexical processing relative to young readers (ps < .005). Peak latency between-group analyses revealed significant effects of age and vocabulary (ps < .027) on the latency of contextual facilitation, but not on lexical prediction. By age models showed that lower reading span (p = .067) was linked to delayed effects of contextual facilitation in young adults, while higher vocabulary (p = .020) was linked to faster contextual facilitation in older readers. This pattern of results indicates that effects of contextual support on lexical processing are modulated differently as a function of language experience and working memory in young and older readers. In older readers, higher performance on a measure of language experience predicts how rapidly context facilitates lexical processing, while working memory does not. In contrast, the speed of lexical facilitation via contextual support is predicted by young adult performance on a measure of working memory, but not by language experience. These results suggest that reading experience can ameliorate detrimental effects of reduced working memory span in older readers.

C47 ERP evidence for dynamic updating of new word knowledge

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Word knowledge is continuously updated, both through learning novel words and learning new word knowledge (e.g., new meanings) for words already known. Previous studies focused on newly taught word knowledge, but recent studies also have examined the influence of learning on existing word knowledge (Davis & Gaskel, 2009). The current study aimed to examine the interaction that occurs between new and existing word knowledge and the attempts to acquire new meaning. In particular, we were interested in observing perturbations of existing knowledge that we hypothesize to occur even before the new knowledge is consolidated. Following the training of both real words (thus with prior meanings) and novel words, we recorded ERPs during a one-back task, thus tapping implicit meaning processes. ERPs on meaning related (and unrelated) words immediately following trained vs. untrained words allowed a test of the hypothesis that the original meanings of existing words had become less accessible (subject to dynamic perturbations) during the learning of a new, unrelated meaning. In particular, the trained word can prime the meaning of a following word related to its trained meaning and this would be indicated by a reduction in the N400, which should be greater when unrelated. Twenty-three native English speakers learned new meanings for

known words and novel (pseudo-) words. Another set of known words and novel words were presented without new meanings and served as exposure controls. After the learning phase and behavioral tests, participants performed a one-back task with EEG recorded. In the task, participants were asked to press a button when they found a word was presented twice in a sequence. The stimuli included word pairs (presented one at a time) consisting of training words and meaning probes. The first word was always a training word; the second word (i.e., meaning probes) was either related or unrelated to the taught or original meanings of training words. Comparisons of most interest on brain responses to meaning probes included: a) meaning probes related vs. unrelated to the taught meanings of novel words; b) meaning probes related vs. unrelated to the taught meanings of known words; c) meanings probes related to original meanings of known words with vs. without new meanings. Even though explicit retrieval of taught meanings was not required in the task, the presentation of novel words (a) and known words (b) led to reduction of N400 on following words that were related to the newly taught meanings. Most important for the hypothesis of dynamic interference during learning, after known words were trained to have new meanings, they produced smaller reductions in N400 compared with known words without new meanings (c). Whereas learning novel words is a process of adding a new form-meaning pair, exposure to a new meaning for an existing word brings about a dynamic perturbation of the existing meaning connection. This effect can occur relatively early in learning before the new meaning becomes consolidated with the existing word form.

Methods

C48 Reliability of language network BOLD activation

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Introduction: Previous research has focused on reliability of BOLD activation at the group level, however, intra-subject reliability has received little attention and is critical for longitudinal studies of brain function and plasticity. The present study examined cognitively healthy participants' reliability of BOLD activity across scan sessions, as they performed an auditory story comprehension task, using intra-class correlation (ICC). We also investigated whether age, image quality, and behavioral performance influence reliability. Methods: Twenty-four healthy, right-handed volunteers (age range 20 to 76) listened to auditory stories (four sentences each; total words = 59-67; block duration 24 sec), recorded by a male native English speaker, and control stories (reversed versions of the stories; block duration 18 sec). Participants performed the task on two separate occasions (3 months apart). Following each scanning session, participants were asked 16 yes/no questions about the stories and accuracy was used to access task performance. MR data were collected using a 3.0 T Siemens scanner. Structural images were collected using a T1-weighted 3-D MPRAGE; functional images were collected using routine BOLD EPI. SNR (tSNR) was calculated for each participant to index image quality, and performance accuracy was computed. Functional images were slice timing corrected, realigned, co-registered with structural image, normalized to MNI template and smoothed by a 6mm Gaussian Kernel. Contrast images (Story>reversed Story) were developed for both scan sessions by participant. Six regions-of-interest (ROIs) were defined (AAL template): Inferior Frontal Gyrus, Superior Temporal Gyrus, Middle Temporal Gyrus, Inferior Parietal Lobule, Superior Parietal, and Precentral Gyrus in both hemispheres. ICC analysis was performed for each participant using the ICC toolbox for SPM8. For each ROI, ICCs were calculated using mixed effects, repeated measures ANOVAs (voxels within ROI x session) and classified into four categories: ICC>0.75 excellent, 0.75>ICC>0.59 good, 0.59>ICC>0.4 fair, ICC<0.4 poor. Results: SNR for acquired images and response accuracy ranged from 48 to 220 and 56% to 100%, respectively. ICC values varies for different ROIs. Overall ICC values for 17 of 24 (71%) participants were excellent/good, two (8%) had fair ICC, and 5 (21%) had poor ICC (<0.3). Better image quality and task performance accuracy, but not age were related to higher ICC (better reliability). Conclusion: Language activation in cognitively healthy listeners was reliable for most (but not all) participants. This finding suggests that for longitudinal studies of neural activation in both healthy and language impaired individuals, ICC values should be considered in data analysis. In addition, data quality and performance of task should be monitored. Acknowledgement: Participants were selected from the Neurobiology of Language Recovery database (CNLR; P50DC012283; Thompson), a multisite Clinical Research Center focused on biomarkers of language recovery in aphasia.

C49 From Tract Structure to Tract Function: Investigating the Arcuate Fasciculus BOLD Signal

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The arcuate fasciculus (AF), the major white matter tract connecting Broca's area to Wernicke's area, is critical to language function and has been the target of many anatomical and MRI studies. Even though resting state fMRI studies have revealed that these gray matter areas are significantly correlated at rest (Hampson et al, 2002), BOLD signal in the AF has traditionally been assumed to contain negligible information about neural activity. Thus, most previous MRI studies have been restricted to examining structural properties of the AF. However, recent evidence suggests that the BOLD signal in white matter has more information than previously thought. A number of studies report that white matter signal is related to task

performance (Gawyrluk et al., 2014), and tensors created from the BOLD signal can reconstruct pathways seen in diffusion MRI analysis (Ding et al., 2013). In this study, we investigate whether BOLD signal in white matter (AF) is related to that of two major language regions, Broca's and Wernicke's areas. Four adult participants (mean age = 28; 2 female) were scanned in a 3T Philips Achieva MRI scanner and completed both a task-based language paradigm and resting state fMRI. All data were corrected for slice timing, subject motion, and smoothed with an 8mm FWHM kernel in SPM8. The fMRI task, in which participants alternated between reading connected text and viewing patterns of symbols, was used to localize two central language regions of cortex in each individual (Broca's and Wernicke's Areas). After standard GLM analysis, spherical regions of interest (4mm radius) were manually placed along peak activations near Broca's and Wernicke's Areas in both left and right hemispheres in each individual. Our hypothesis was that, since the AF carries signal directly between these two language regions, BOLD signal in the ROIs and the white matter connecting them would be correlated at rest. At the group level, gray matter ROIs were significantly correlated with each other ($p < 0.05$). Multiple regression was then used to investigate whether BOLD signal activity in white matter in the AF could be predicted from signal in Broca's area or Wernicke's area. In three of the four participants, white matter signal in parts of the AF was significantly correlated with resting-state activity in the Broca's and Wernicke's ROIs on that hemisphere ($r > 0.5$; $p < 0.05$, corrected for multiple comparisons). Additional areas along the AF were identified when a second ROI (e.g. both Broca's and Wernicke's area) were added. Results suggest that the BOLD signal in the AF has components related to the language areas it connects. This can potentially shed new light on investigations of connectivity during language processing, by opening up the possibility for investigating not just whether an area is connected, but how it is connected. Further investigation of the signal mechanism, how it is modulated by task performance, and its relationship to functional connectivity, are of chief interest.

C50 Brain-wide networks subserving sentence processing show distinct spectral fingerprints

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Sentence processing requires concerted neural activity within a cortical network of specialised brain regions. This concerted activity may be subserved by rhythmic synchronisation between neuronal populations, and different frequency bands may reflect distinct directed network connections. To date, a reliable demonstration of dynamic neuronal synchronisation in non-invasively measured data has been notoriously difficult. Here, we combined state-of-the-art source reconstruction and connectivity estimation methods with group-level non-negative matrix factorisation to explore neuronal interactions during sentence processing. Magnetoencephalographic (MEG) data was obtained from 102 participants while reading sentences and word lists. Data were epoched from 200 to 600 milliseconds relative to word onset, and divided into 4 conditions: sentence versus word lists, and early versus late words. Source activity was estimated with beamformers at 8196 locations on the cortical surface, and subsequently parcelled into 378 regions, using an anatomical parcellation of the cerebral cortex. We computed spectrally-resolved Granger Causality (GC) between all parcel pairs, as well as reverse GC. The latter was used to statistically threshold the connectivity maps to prune out edges most likely reflecting spurious connectivity. We applied non-negative matrix factorisation to the concatenated connectivity maps, modelling the data as a low-dimensional mixture of network components with subject-specific spectral fingerprints. The network components were used as regressors to obtain condition and subject-specific spectral estimates. The latter were subjected to a non-parametric permutation test to investigate condition-specific modulations in interaction strength. We identified 18 network components, with distinct spectral profiles. For instance, we extracted a feedforward network connecting bilateral temporal regions with inferior frontal cortex in the alpha frequency range, and a left-lateralized beta band top-down network connecting inferior frontal cortex with temporal regions. The connection strength in the latter network was significantly modulated across the duration of the sentence. The present results indicate that our analysis approach yields physiologically interpretable interaction patterns. The change in connection strength across the sentence likely results from the build up of a semantic and syntactic context, where the absence or presence of context (early versus late in the sentence) requires a different top-down control from frontal to temporal regions.

C51 The Tract Terminations in the Language Network of the Temporal Lobe

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Introduction: Language is a complex skill involving the interaction of widely distributed interconnected brain networks. One such network is the language pathway of

the temporal lobe, involved in both the phonological and semantic aspects of language. Critical to the network are the white matter tracts which connect the temporal lobe to other brain regions to form functionally integrated networks, allowing information to be exchanged, manipulated and integrated between the distant brain regions involved. While much has been learnt about the organisation of the temporal language network's structural connectivity, a crucial question, however, has not been satisfactorily answered: Where in the temporal lobe do these tracts originate and terminate? In the current study a novel method to extract tract terminations (ExTracT) in the human brain from in vivo tractography data was developed and used to map the cortical termination points of the eight main fibre bundles that course through the temporal lobe. Method: A dataset containing structural and diffusion-weighted MR images from 24 healthy participants was used. Probabilistic tractography was first performed from every voxel within the temporal lobe along the interface between the grey and white matter. The resulting output was then used to define regions of interest within the following tracts: uncinate fasciculus, inferior longitudinal fasciculus, inferior fronto-occipital fasciculus, middle longitudinal fasciculus, arcuate fasciculus, cingulum, corpus callosum and anterior commissure. Finally, those voxels within the grey-white matter interface which had contributed tractographic streamlines to the relevant regions of interest were identified to delineate those voxels connected to each of the tracts examined, and generate termination maps. Results: The ExTracT technique developed for this study was successfully able to delineate the cortical termination points of the major temporal fibre tracts. These tracts were found to terminate in four distinct temporal sub regions, involving anterior, medial, ventral, and dorso-posterior divisions. The strong, clear pattern of terminations identified are consistent with the different cognitive functions ascribed to the temporal lobe, and may help to elucidate the organisation and functioning of this highly complex region. Conclusions: The tract termination maps produced in the current study have important implications for future research. Firstly, the information gleaned regarding tract terminations may be used to aid the interpretation of functional imaging data. Secondly, the understanding gained regarding the white matter tract termination points within the temporal lobe may increase our understanding of a range of neurological conditions such as the different subtypes of stroke aphasia. The ExTracT technique may be extended in the future to explore the tract termination points of other language networks.

C52 The use of Natural Language Processing combined with voxel-based lesion-symptom mapping in chronic post-stroke aphasia *Ezequiel Gleichgerrcht[1], John Delgaizo[1], Julius Fridriksson[2], Chris Rorden[2], Alexandra Basilakos[2], Leonardo Bonilha[1]; [1]Medical University of South Carolina, [2]University of South Carolina*

Language assessment in patients with aphasia post-stroke is usually conducted with batteries of standardized tests aimed at identifying residual language capacities. Many of these tests rely on patients' responses to isolated stimuli, sometimes threatening their ecological validity in certain conditions. Narrative/connected speech, however, can provide a rich source of response samples to obtain insightful information about patients' language skills. The analysis of such data, however, is highly time-consuming and requires specific training. In this study, we applied an automated computational algorithm based on Natural Language Processing (NLP) to the verbatim transcription of three picture description tasks elicited by 50 patients with chronic dominant-hemisphere stroke (including 18 non-aphasics based on WAB-R Aphasia Quotient score > 93.8) and 10 paired healthy controls. From NLP processing, we derived 57 lexical and syntactic features, which we compared between non-aphasic participants (n = 28: 10 healthy controls + 18 post-stroke patients) and patients with aphasia (all types, n = 32). Features that differed significantly between the groups (even after Bonferroni thresholding to correct for multiple comparisons) were used as predictors of WAB-AQ scores in stepwise linear regression analysis. Four features predicted WAB-AQ scores (R2 = .747): type-token ratio (TTR; a proportion of the number of different words to the number of total words), the familiarity of nouns (NFam), the number of prepositions employed (Prep), and the average width (a measure of syntactic richness) of the verbal phrases (VPWidth) elicited. On voxel-based lesion-symptom mapping with permutation thresholding across 368928 voxels (3 mm3 each): 35682 voxels survived threshold ($z>3.76$) for TTR, distributed throughout the middle and superior temporal gyri as well as the insula; 409 voxels survived threshold ($z>4.05$) for NFam, mostly concentrated in the superior temporal area; 17022 voxels survived threshold ($z>3.85$) for Prep mostly around the insula and the temporo-polar region; and 98 voxels survived threshold ($z>5.12$) for VPWidth in the retrosubicular area (BA 48) and the intersection with the premotor cortex. Network-based lesion-symptom mapping with permutation thresholding based on each patient's individual structural connectome (using 110 grey matter ROIs based on the Johns Hopkins University atlas) revealed an association of TTR with the connection between the inferior frontal gyrus pars opercularis and the precentral gyrus ($z=3.76$), and between the pre-cuneus and the lingual gyrus ($z=-4.07$), both on the left hemisphere. Our findings have possible theoretical implications in the light of contemporary models of speech processing, and clinical applications concerning the potential utility of automated natural language processing algorithms for connected speech in identifying markers of post-stroke aphasia, with possible applications to classification and individualized rehabilitation.

C53 Reliability and validity of four commonly used language mapping paradigms

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Language areas of the brain can be mapped with functional MRI. For many applications, such as presurgical mapping and longitudinal studies of recovery from aphasia, the reliability and validity of language maps are critically important. Reliability refers to the extent to which a language map is reproducible in the same participant on a different occasion. Validity refers to the extent to which the regions identified are actually important for language. Reliability and validity depend on many factors, including the choice of active and control tasks, the amount of scan time, and preprocessing and model fitting choices. While some of these factors have been investigated, it remains unclear which language paradigms are most appropriate for clinical applications. In this study, we compared the reliability and validity of four commonly used language mapping paradigms, keeping scan time and analytical procedures constant. Five healthy older participants (aged 70-78, 3 women) were each scanned on four separate sessions, two or more weeks apart. Each session included four language paradigms: (1) overt sentence completion relative to rest, with a conjunction over auditory and written presentation to exclude sensory-related activation; (2) narrative comprehension, relative to backwards speech; (3) language versus non-language segments of a naturalistic video, with auditory power covaried out; (4) overt picture naming relative to rest. Each language paradigm was 7 minutes long. Reliability was quantified by the Dice coefficient of similarity (DCS), which assesses degree of overlap of activations on a scale from 0 to 1. Validity was quantified in terms of the mean lateralization index (LI, 1 = left-lateralized, 0 = bilateral, -1 = right-lateralized), though this approach is limited in that not all healthy individuals have left-lateralized language, and the specific regions activated within the dominant hemisphere are not taken into account. We found that reliability was only modest for the four paradigms, with picture naming (DCS = 0.51 ± 0.10) and the naturalistic paradigm (DCS = 0.48 ± 0.17) yielding the most reproducible activation maps, followed by sentence completion (DCS = 0.36 ± 0.12) and narrative comprehension (DCS = 0.22 ± 0.12). The narrative comprehension paradigm produced the most left-lateralized activation maps (LI = 0.46 ± 0.31), followed by the naturalistic paradigm (LI = 0.19 ± 0.32), sentence completion (LI = 0.11 ± 0.10) and then picture naming (LI = 0.01 ± 0.09). Only the narrative comprehension paradigm met the most basic test of validity: demonstrating left lateralization of language in all participants. None of the commonly used paradigms we investigated appear to have adequate reliability and validity for clinical applications. In practice, presurgical language mapping is often performed using a battery of tasks, which is advisable given the limitations of each task individually. Furthermore, other tasks that we did not examine are often used, such as verb generation, which is highly lateralizing, but may lack validity in other respects due to its metalinguistic nature. For studies investigating reorganization of language areas over time, further research is necessary to identify reliable and valid language mapping paradigms.

C54 Right Cerebellum and Language Areas: a Seed Based rs-fMRI Analysis

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Introduction. Resting state fMRI (rs-fMRI) has several advantages over task-related fMRI for studies with patients which have severe cognitive and motor deficits (Lee et al., 2013). In order to find the language areas without conducting a task-related fMRI we suggest to use cerebellum as a seed for rs-fMRI analysis because this brain region 1) is usually preserved in language fMRI study; 2) considerably contributes to language processing, as demonstrated in many neuroimaging and brain lesion studies (Ackermann et al., 2007). We expected to find a strong relationship between the activation of the right hemisphere of the cerebellum and the left inferior frontal gyrus (IFG) in healthy participants. Method: Thirty six healthy volunteers participated in the study (mean age 38.6, SD=9.6; 18 females). T2*-weighted BOLD images (TR/TE/FA=3 s/50 ms/90°, voxel size 3.9x3.9x3mm, matrix size 64x64, 35 axial slices, 180 measurements) and T1-weighted images (TR/TE/FA=1.9 3s/3.37ms/15°, voxel size 1x1x1mm) were acquired with a 1.5T Siemens Avanto scanner. fMRI images were preprocessed with SPM8. Seed-to-voxel connectivity analysis was performed using conn15.a and the functional ROI for seed based analysis was created using the marsbar toolbox. We obtained the seed from our previous task-related fMRI study (group of 16 right-handed healthy volunteers performed noun-verb matching task and the activation in the left IFG, middle temporal gyrus and right cerebellum was revealed). The data is reported with a statistical threshold of p(FWE) < 0.001, cluster FDR-corrected q < 0.001. Results: We found multiple brain areas positively correlated with the seed in the right cerebellum: the superior, middle and inferior fontal gyri and middle temporal gyrus in the left hemisphere and inferior parietal lobule, precuneus, anterior and posterior cingulum and cerrebelum bilaterally. The timecourse of BOLD signal in our ROI negatively correlated with the right IFG, postcentral gyri and SMA signal. Discussion: We found strong positive correlations between the time courses of BOLD signal in the seed in the right cerebellum and the left IFG and middle temporal gyrus. These areas are considered as classical areas for speech production and comprehension. In contrast we revealed the negative correlations of BOLD signal time course between the seed in the right cerebellum and nonlinguistic right IFG which can be caused by reciprocal relationships between the IFG in the left and

right hemispheres. These results reflect specific functional connectivity patterns between right cerebellum and language areas.

Motor Control, Speech Production, Sensorimotor Integration

C55 Neural mechanisms underlying techniques for enhancing fluency in people who stutter: Same or different?

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People who stutter (PWS) are able to achieve temporary fluency by using various techniques, including metronome-timed speech and choral speech (speaking in time with another person). These techniques share characteristics, such as provision of an auditory timing cue for speech, but it is unclear whether the neural mechanisms involved in their fluency-enhancing effects are the same or different. To address this question, we used fMRI to scan the brains of PWS and normally fluent controls during sentence reading. There were three conditions: solo reading, metronome-timed speech, and choral speech. During the baseline, participants saw a sentence in false font, and were silent. Imaging data was acquired using sparse-sampling, allowing participants to speak without scanner noise and to hear clearly the metronome and choral speech. Control participants were fluent during all conditions. PWS were mildly dysfluent during solo reading, but fluent during metronome-timed and choral speech conditions. Here, we present analyses of the brain imaging data for 10 PWS and 8 controls (all male and right handed; we aim to scan 28 PWS and 15 controls). The group comparison (Z>2.3, k>30 voxels, uncorrected) revealed over-activity in PWS relative to controls in the right anterior insular and medial prefrontal cortex and reduced activity in the right anterior lobe of the cerebellum in each condition relative to baseline. Overactivity of the right anterior insular and frontal opercular cortex is considered a 'neural signature' of stuttering (Brown et al., 2005) and overactivity in the medial prefrontal cortex (presupplementary motor area) is associated with both the trait and state of stuttering (Budde et al., 2014). The fluency-enhancing conditions increased activity relative to solo reading in both groups (Z>3.1, k>30 voxels, uncorrected). During choral speech, the increased activity was limited to posterior superior temporal cortex bilaterally and did not differ between the PWS and control groups. In contrast, there were wide-spread increases in activity during metronome-timed speech relative to solo reading. The control group showed increased activity in the medial pre-frontal cortex and anterior insula, bilaterally, and in the ventral premotor cortex on the right. The PWS group showed increased activity in the anterior insula in the left-hemisphere only and along the inferior frontal sulcus bilaterally. Both groups showed increased activity in the inferior parietal lobule and posterior superior temporal cortex bilaterally. When the two fluency-enhancing conditions were contrasted, there was a striking difference between the two groups in the pattern of increased activity for metronome-timed speech relative to choral speech: controls showed greater involvement of the right ventral premotor cortex whilst PWS instead activated the same region on the left. Our results show that choral speech elicited changes in activity that were restricted to the temporal cortex in both PWS and controls. However, there was extensive activation during metronome-timed speech relative to solo reading in both groups, which could reflect the increased effort and decreased speech naturalness. We conclude that, although metronome-timed and choral speech can achieve similar fluency enhancement in PWS, they appear to do so via distinct neural mechanisms.

C56 Disrupted feedforward but spared feedback control during speech in patients with cerebellar degeneration

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People with ataxia due to cerebellar degeneration exhibit a range of speech deficits referred to as ataxic dysarthria (AD). Symptoms include slow speech, excessively equal syllable durations, and (paradoxically) increased durational variability in syllable repetition tasks. These deficits reflect an inability to accurately plan the fast, precise movements of the speech articulators necessary for fluent speech—computations that are highly dependent on a feedforward control system. This impairment may cause people with AD to become overly reliant on feedback control when speaking, leading to temporal delays and instability inherent in any closed-loop feedback control system. These hypotheses are consistent with results from other motor domains (reaching, walking) that suggest the cerebellum is crucial to accurate feedforward control, with reduced involvement in feedback control. We compared feedforward and feedback control in two altered auditory feedback studies. Such studies¬—analogous to the methods used to study sensorimotor adaptation in reaching—involve real-time manipulation of the speech formants, with the end result that speakers hear a different vowel than that they actually produced (either slightly altered or categorically different, depending on the manipulation). Healthy speakers compensate for these manipulations, adapting the feedforward system across productions to consistent alterations and compensating within a vowel for unexpected perturbations via the feedback system. We tested the feedforward control system by measuring adaptation to consistent vowel perturbations, introduced gradually in one block of trials and abruptly in another. For dependent variables, we measured produced formants in words spoken during 1) maximum adaptation at the end of the perturbation phase and 2) probe trials in which the production was accompanied by loud noise to mask auditory feedback. People with AD adapted less than age-matched healthy controls in both measures to both the gradual and abrupt perturbations. To test the

integrity of the feedback control system, we examined the response of the participants to unexpected vowel formant perturbations. In this case, people with AD were unimpaired in their compensatory behavior relative to control speakers. Combined, these results support the hypothesis that cerebellar degeneration selectively disrupts feedforward speech motor control.

C57 Limb Apraxia in American Sign Language *David Corina[1], Svenna Pedersen[2], Cindy Faranady[2], Corianne Rogalsky[3], Gregory Hickok[4], Ursula Bellugi[2]; [1]University of California, Davis, [2]The Salk Institute for Biological Studies, [3]Arizona State University, [4]University of California, Irvine*

Limb apraxia is a deficit in skilled movement that cannot be attributed to weakness, akinesia, abnormal tone or posture, movement disorders (e.g., tremor, chorea), deafferentation, intellectual deterioration, poor comprehension, or lack of cooperation (Koski, Iacoboni, & Mazziotta, 2002; Ochipa & Rothi, 2000). Signed language used in Deaf communities require the production and comprehension of skilled upper limb and body movements and thus are vulnerable to apraxic disturbances. Studies of deaf signers who have incurred left-hemisphere damage have reported instances of dissociation between linguistic manual actions and non-linguistic manual movements and pantomime (Corina et al 1999, Marshall 2004). Less well studied are cases where limb apraxia accompanies sign language disturbance. Here we ask how limb apraxia affects the form of sign language production errors seen in deaf aphasics. We analyzed data from 4 left hemisphere lesioned signers who show impaired performance on the Kimura test of limb apraxia and 3 subjects who exhibit sign language aphasia without marked limb apraxia. We coded each subject's errors for compositional properties of ASL; handshape, path and internal movement, location and palm orientation, as well as assessments of sequential sign actions (handshape and movement transitions within and across signs). Our preliminary data indicate that while handshape substitutions were relatively common in all of the sign aphasics, signers with limb apraxia were particularly impaired in sequential movements of the hand postures. In addition movement trajectories (i.e. path movements) were more likely to be repeated and show evidence of successive articulatory approximation. The data are consistent with limb kinetic apraxia disorder in which fine movements of the hands and fingers are particularly vulnerable to impairment following left hemisphere parietal damage, but also point to the disturbance of spatial-temporal implementation of multi-joint limb movements (Poizner et al 1997).

C58 Beta modulation reflects name retrieval in the human anterior temporal lobe: An intracranial electrode study *Taylor Abel[1], Ariane Rhone[1], Kirill Nourski[1], Hiroto Kawasaki[1], Hiroyuki Oya[1], Matthew Howard[1], Daniel Tranel[1]; [1]University of Iowa*

Introduction: Naming people, places, and things is a fundamental human ability that is often impaired in patients with epilepsy affecting language-dominant anterior temporal lobe (ATL) and also following ATL resection as part of epilepsy treatment. Convergent lines of evidence point to the importance of the ATL in name retrieval; however, the physiologic mechanisms that mediate name retrieval in the ATL are poorly understood. The purpose of this study was to characterize the electrophysiologic responses of the human ATL during overt cued naming of famous people and objects. Methods: Seven patients (all men; age 23 – 49) with suspected temporal lobe epilepsy who underwent implantation of intracranial electrodes for seizure focus localization were the subjects of this study. An electrode array specialized to provide dense coverage of ATL cortex was implanted in each subject (Abel et al., Physiol Meas 35:323-37, 2014). The subjects named 50 different pictures of U.S. presidents and 50 unique images of common hand-held tools. President and tool trials were randomly interleaved. Electrocorticographic responses were recorded during sensory processing of the visual stimuli (1 s), the wait period before cued naming (1 s), and for at least 2 s following cue for overt naming. Event-related band power was measured for each ATL recording site and visual sensory cortices, including fusiform gyrus (FG) and the occipital lobe, when available. Results: Picture naming was associated with increased high frequency (30-150 Hz) power in FG and the occipital lobe (in one subject) at the onset and offset of visual stimuli, which preceded responses from the ATL. Both the right and left ATL demonstrated robust and focal increases in beta band (14 – 30 Hz) power during person and tool naming. The onset of this response typically occurred at 400 ms, but sometimes as early as 200 ms. In some cases, beta power was found to decrease during the naming task, without associated increase in high frequency power. Person- and tool-naming responses co-localized to the same cortical sites on the ventrolateral ATL. Conclusions: Visual naming of famous people and tools is associated with robust and localized modulation of the beta band in both the left and right ATL. This beta modulation may reflect visual processing, which from the language-dominant ATL mediates name-retrieval and from the non-dominant ATL mediates recognition. In addition, given the prior literature associating beta band responses with feedback, it is possible that these responses represent feedback of the ATL on related sensory cortices (e.g. posterior fusiform gyrus). Measurement of visual naming responses may provide the groundwork for future mapping modalities to localize eloquent cortex in the ATL.

C59 The interaction between the rhythms of perceived and produced speech *M. Florencia Assaneo[1], David Poeppel[1,2]; [1]Department of Psychology, New York University, [2]Max Planck Institute*

A wide range of studies has pointed to an interaction between speech perception and speech production, both at the behavioral and at the neural levels. Furthermore, speech has a well-characterized spectro-temporal and quasi-rhythmic structure which have been shown to be used by the brain to decode spoken discourse. However, it remains unknown how the rhythms of produced and perceived speech affect each other. In this work we used a new psychophysical paradigm to address this interaction. Specifically, we asked participants to continually repeat a set of three syllables, while we blocked their own feedback and replaced it with a synthesized voice pronouncing a different set of syllables at a fixed rate. We observe that synchronization between both signals occurs only when the externally imposed syllable rate is close to the participant's own rate. The features of the coupling between the produced and perceived speech invite the hypothesis that the motor and auditory cortices behave as two weakly coupled phase oscillators. This coupling could be crucial at an early age for speech development.

C60 Stammering and synchronised speech *Sophie Meekings[1], Kyle Jasmin[1], S.K. Scott[1]; [1]University College London*

Speaking in synchrony with another person is usually central to activities that emphasise group cohesion- for example, praying or oath-taking. However, in many people who stutter, the most important consequence of synchronised or 'choral' speech is an immediate and often dramatic improvement in fluency. We used functional magnetic resonance imaging to investigate how synchronous speech is processed in fluent speakers and people who stutter (classified using Riley's Stuttering Severity Instrument, 4th ed). Participants heard either a live speaker or a pre-recorded voice. They either listened without speaking, read the same sentence aloud (synchronous speech), or read a different sentence aloud (asynchronous speech). In these conditions, questioning determined that participants were not able to distinguish the live speaker from the pre-recorded voice. There was an additional control condition in which subjects spoke on their own with no second speaker. The stammering group were compared to the controls, in whom synchronous speech resulted in bilateral activation in superior temporal gyrus. The auditory suppression response associated with speech in quiet did not occur when typical speakers synchronised with a live speaker. We discuss the implications for various models of stuttering, such as the EXPLAN model and the theory that stuttering may result from an over-reliance on auditory feedback.

C61 Monitoring of pitch and formant trajectories during speech in Parkinson's disease *Fatemeh Mollaei[1,2], Douglas M. Shiller[1,3], Shari R. Baum[1,2], Vincent L. Gracco[1,2]; [1]Centre for Research on Brain, Language and Music, [2]McGill University, [3]Université de Montréal*

The basal ganglia contribute to sensorimotor processing as well as higher order cognitive learning (Graybiel et al. 2005; Stocco et al. 2010). Parkinson's disease (PD), a manifestation of basal ganglia dysfunction, is associated with a deficit in sensorimotor integration. We recently demonstrated differences in the degree of sensorimotor compensation and adaptation in response to auditory feedback alterations during speech in participants with PD compared to healthy controls (Mollaei et al., 2013; Mollaei et al, in preparation). Participants with PD were found to respond more robustly to auditory feedback manipulations of pitch (reflecting laryngeal changes) and less robustly to formant manipulations (reflecting changes in oral shape), suggesting that their sensorimotor systems are intrinsically sensitive to the feedback manipulations. One issue that has not been addressed is whether PD patients may be limited in their ability to detect these different auditory feedback induced errors while passively listening or compensating to their altered speech. Here we combined a sensorimotor compensation paradigm with an auditory- discrimination task to investigate error detection and correction mechanisms underlying the control of vocal pitch and formant parameters. PD and age-matched control participants produced speech while their auditory feedback (F0 and first formant frequency, or F1) was altered unexpectedly on random trials. After each trial, participants reported whether or not they detected the feedback perturbation. Participants also completed an auditory discrimination task using pre-recorded samples of their own speech with the same alterations applied. PD participants exhibited a larger compensatory response to F0 perturbations in pitch; however, they showed reduced compensation to F1 perturbations compared to age-matched controls. Furthermore, while detection accuracy for F1 did not differ between the two groups during on-line speech production, PD patients were found to be less sensitive to F1 errors during listening to pre-recorded speech. The results suggest that the sensory-based control of pitch and formant frequency may be differentially impaired in PD, due in part to differences in the capacity for auditory error detection in F0 and formant frequency.

C62 Microstructural differences in right hemisphere tracts of adults who stutter *Vered Kronfeld-Duenias[1], Ofer Amir[2], Ruth Ezrati-Vinacour[2], Michal Ben-Shachar[1]; [1]Bar-Ilan University, [2]Tel-Aviv University*

Persistent developmental stuttering (PDS) is a disorder that affects individuals' ability to produce fluent speech. People who stutter vary in their symptoms, exhibiting a range of sensory, linguistic, motor and emotional deficits. Several diffusion imaging studies reported structural differences between people who stutter and fluent controls in multiple regions of white matter, but the full set of pathways affected in PDS has not been fully mapped. In this study, we traced a comprehensive set of long range fiber tracts in adults who stutter (AWS) and fluent controls, and examined group differences in the structural properties

along these tracts. Diffusion MRI data were acquired in 44 participants (25 AWS and 19 controls) using a standard diffusion imaging protocol: 3T scanner, 19 diffusion directions, 2x2x2mm3 resolution, b=1000 s/mm2, 2 repetitions. Eighteen long range fiber tracts were identified in each participant using deterministic tractography and an automatic segmentation tool (Yeatman et al., 2012). Fractional anisotropy (FA) profiles were calculated along each tract for each participant and the resulting profiles were then compared between the groups. The results indicate significantly reduced FA values in AWS in two right hemisphere tracts: the right cingulum and the right inferior longitudinal fasciculus (ILF) ($p<0.05$, controlled for family-wise error). These group differences stretched over large portions of the tracts (cluster size of 40/100 and 60/100 consecutive nodes along the right cingulum and the right ILF, respectively). No significant FA decreases were detected in left hemisphere tracts, nor did we find any significant FA increases in AWS compared with controls. Our data highlight the role of the right hemisphere in PDS, in agreement with previous functional imaging reports of a rightward shift in lateralization of brain responses in developmental stuttering. Specifically, we find differences in the right cingulum, a major limbic pathway recently associated with self-reflective aspects of emotional processing (Herbert et al., 2014), which are known to play a role in stuttering. Further, we find differences in the right ILF, previously shown to be involved in information processing speed (Sasson et al., 2013). The fact that we did not find significant differences in left hemispheric long-range tracts is surprising considering previously reported FA reductions in white matter underneath the left rolandic operculum (RO). We suggest that voxelwise differences in the left RO may localize to short-range connections, such as between the motor and premotor cortices. Such short range tracts may not be reliably identified with tractography, given their proximity to gray matter. Taken together our data provides a comprehensive examination of major white matter tracts in AWS while combining the advantages of large coverage with the sensitivity of tract based methods. References: Herbet, G. Lafargue, G., François B., Moritz-Gasser, S., de Champfleur, N. & Duffau, H. (2014). Brain, 137(3), 944-959. Sasson, E., Doniger, G.M., Pasternak, O., Tarrasch, R., & Assaf, Y. (2013). Frontiers in neuroscience, 7, 32. Yeatman, J.D., Dougherty, R.F., Myall, N.J., Wandell, B.A., & Feldman, H. (2012). PLOS ONE, 7(11), e49790.

C63 Objective monitoring of dysarthria in FTD-MND: a case study

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Objective: To evaluate the utility of objective speech measures in monitoring speech deterioration in a patient with behavioral variant fronto-temporal dementia (bvFTD) and motor neuron disease (MND). Background: bvFTD is a subtype of the FTD spectrum of disorders associated with marked changes in behavior and personality. A subset of people with this disorder also develop MND with associated dysarthria. Clinicians usually assess dysarthria subjectively, which poses difficulty in identifying subtle change over time. Acoustic measures of speech may help to quantify change in patients' speech over time in order to monitor the emergence and progression of dysarthria. Methods: VP initially presented to the Eastern Cognitive Disorders Clinic, Melbourne, Australia with bvFTD, however later progressed to FTD-MND. VP provided a speech sample at two time points, two years apart. VP's speech was assessed perceptually and rated on domains of articulation, resonance, prosody, voice quality and intelligibility. Acoustic analyses were used to quantify changes in VP's speech and included measures of speech rate (words/minute, mean pause time, percentage of pause in sample), and a vowel articulation index (VAI). Speech measures were compared with those of three control participants with a diagnosis of bvFTD without MND, who were assessed at the same time points. Results: VP's speech demonstrated deterioration on subjective ratings of speech on scales of articulation, resonance, and prosody. Acoustic measures of mean pause time and percentage of pause time reflected the decline of VP's speech rate, with each changing at a rate greater than two standard deviations of the control participants mean change. VAI decreased by 39% for VP, compared to a mean decrease of 7% for controls, and indicated a deterioration of articulatory precision for vowels. Conclusion: Our findings demonstrate the emerging potential for objective speech measures to be used in the monitoring of dysarthria in FTD with MND, however further studies with greater participant numbers are needed to establish the validity and sensitivity of these measures.

Signed Language

C64 Deaf signers are less reliant than hearing non-signers on fact retrieval from verbal long term memory during arithmetic processing: fMRI evidence

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Behavioural evidence suggests that the lag reported for mathematics in deaf signers is caused by difficulties related to verbal processing of numbers, while magnitude processing seems unaffected by deafness. Neuroimaging, as well as behavioural evidence, from hearing individuals suggests that simple arithmetic tasks are solved by fact retrieval from verbal long term memory engaging primarily the left angular gyrus (lAG). In contrast, more elaborate arithmetic tasks require the involvement of magnitude manipulation processes which involve

recruitment of right horizontal portion of the intraparietal sulcus (rHIPS). With difficulties in verbal processing of numbers deaf signers might engage rHIPS instead of lAG for simple arithmetic. The aim of the present study was to investigate whether there are differences in neuronal correlates of simple arithmetic between deaf signers and hearing non-signers. Our hypothesis was that hearing non-signers will solve simple arithmetic tasks using verbal processing recruiting lAG whereas deaf signers will solve the same tasks using magnitude manipulation processes recruiting rHIPS. fMRI data was acquired from 16 deaf signers and 16 hearing non-signers, carefully matched for sex, age, education and non-verbal intelligence, while they performed five tasks related to arithmetic and phonology as well as a visual control task. The stimuli for all tasks consisted of a digit/letter string (consisting of three digits and three letters). In the present study two simple arithmetic tasks and the visual control task were analysed. In these tasks the participants were asked to either determine if any number multiplied by, or subtracted from, another number equals the third (i.e. simple arithmetic tasks) or to determine if there are two dots over any of the letters (i.e. the visual control task). fMRI data was preprocessed in SPM using standard analysis procedures. After fitting a first level general linear model, we defined two regions of interest (ROI), lAG and rHIPS, using the probabilistic cytoarchitectonical maps from SPM anatomy toolbox, version 1.8. Parameter estimates for the contrasts multiplication > visual control and subtraction > visual contrast were extracted from each ROI. Behavioural data from the two simple arithmetic tasks was collected and entered as covariates. A 2x2x2 analysis of variance, with task (multiplication, subtraction) and region (lAG, rHIPS) as within subject factor and group (deaf signers, hearing non-signers) as between subject factor, revealed a significant interaction effect between group and region. lAG was significantly more activated for hearing compared to deaf individuals, whereas no significant differences between group was found in rHIPS. No other main effects or interaction effects were significant. These preliminary results partially support our hypothesis by showing that hearing non-signers engage lAG more than deaf signers during simple arithmetic, providing neurocognitive support that deaf signers are less reliant than hearing non-signers on fact retrieval from verbal long term memory during arithmetic processing.

Syntax, Morphology

C65 A neural marker of the construction of sentence meaning

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Introduction How does a sequence of sounds or letters create a complex meaning in one's mind? Although we have long known where language is processed in the brain, we know almost nothing about how neural circuits extract and represent complex meanings. Sentence comprehension occurs rapidly, and can only be understood at a mechanistic level by discovering the precise sequence of underlying computational and neural events. Yet we have no continuous and online neural measure of sentence processing with high spatial and temporal resolution. Here we report such a measure. *Methods* Four epilepsy patients, with subdurally implanted electrodes placed over left-hemisphere fronto-temporal cortices, read sentences and three kinds of control materials (Fedorenko et al., 2010) presented one word/nonword at a time: word lists, "Jabberwocky" sentences, and pronounceable nonword lists. We measured the time-course of gamma activity of the ECoG signal, which is closely related to spiking activity of neuronal populations underneath each electrode. To analyze our data with maximum power while guarding against the dangers of statistical non-independence and hidden degrees of freedom, all hypotheses, data analysis choices, and selection of electrodes were made based on half the data (odd-numbered runs), before the other half (even-numbered runs) were inspected. The key finding from the odd-run data was that over half of the language-responsive electrodes showed a monotonic increase of gamma power over the eight words in the sentence condition while failing to increase for the control nonword-lists condition. *Results* To test the reliability of this finding, for each subject we selected electrodes of interest (EOIs) that showed (in odd-run data): a) a reliably greater mean response to sentences than nonword-lists averaging across word positions, and b) a monotonic increase over the eight positions in the sentence condition. Fifty-one EOIs were identified across four subjects, distributed across the frontal and temporal cortex. Response magnitudes of each EOI in each subject were then quantified (from even-run data) for each condition. Indeed, the even-run data showed a higher response to sentences than nonword-lists ($p<0.005$) and, critically, each subject also showed a monotonic increase in gamma power for sentences (correlation between word position and response, $ps<0.05$), but not nonword-lists. To find out whether the observed response increase is primarily driven by the presence of word meanings or syntax, we measured responses to word lists (meaning with little syntax) and Jabberwocky sentences (syntax with little meaning). The time-courses reveal that neither syntax, nor word-level meanings on their own, are sufficient to account for the response increase (correlations between word position and gamma were not significant for either Jabberwocky or Word-lists). Thus, the response increase apparently reflects the construction of sentence meaning. *Conclusions* The increase in gamma response over the course of the sentence constitutes a novel neural marker of the construction of sentence-level meaning. Although the precise nature of this effect and its specificity for linguistic vs. other meaningful

representations remain to be determined, this marker offers promise for tackling deep questions about how we extract and represent complex linguistic meanings.

C66 Neural correlates of syntactic subjecthood *John T. Hale[1], Jonathan R. Brennan[2], Wen-Ming Luh[3], Christophe Pallier[4]; [1]Department of Linguistics, Cornell University, [2]Department of Linguistics, University of Michigan, [3]MRI Facility and Department of Biomedical Engineering, Cornell University, [4]INSERM-CEA Cognitive Neuroimaging Unit, Neurospin center, Univ. Paris-Saclay*

INTRODUCTION Recognizing the syntactic subject of a sentence is an important operation in language comprehension. To better understand the brain bases of this cognitive operation, we analyzed fMRI data obtained during ordinary listening to an audiobook. METHODS: STIMULI The stimulus came from first chapter of Lewis Carroll's Alice in Wonderland. We parsed this text using the Stanford parser (Klein & Manning 2003) and tagged words that appeared (i) phrase-finally in a noun phrase which (ii) was itself a tree-geometric sister to a verb phrase. This configurational characterization of syntactic subjects dates back to Chomsky's Aspects (1965). Applying it in conjunction with automatic parsing yielded mostly nominative pronouns, proper names and common nouns. METHODS: NEUROIMAGING Eleven right-handed participants were scanned at the Cornell MRI Facility. While in the scanner, participants listened to a spoken recitation of the chapter, as performed for librivox.org by Kristen McQuillan. This auditory stimulus lasted about 12 minutes. Afterwards, participants took a multiple choice quiz having to do with events described in the story. ANALYSIS AND NUISANCE PREDICTORS We carried out a whole-brain analysis using a GLM using SPM8. The offset of each word in time was taken as a point event, and convolved with SPM's canonical HRF to create a `word' regressor. `Subjecthood', a binary indicator variable equal to 1 when a word was a syntactic subject and 0 elsewhere, was entered as a parametric modulator of the `word' regressor. Nuisance variables came from an ECG heart monitor and a respiratory belt, as well as six inferred movement parameters. We also included a predictor for periods of silence. The individuals' maps assessing the effect of Subjecthood were smoothed with a Gaussian kernel (FWHM 8mm isotropic) and entered in a second level analysis (one sample t-test). RESULTS Whole-brain analysis revealed that Subjecthood modulates activity in the left anterior temporal lobe (aTL) $p_{FWE} < 0.05$. The right aTL and the precentral gyrus were also detected at a lower statistical threshold ($p<.001$ voxelwise uncorrected). All participants scored significantly higher than chance on the post-scan quiz $p < 0.001$. CONCLUSION The GLM analysis suggests that aTL does extra work around the time that a left-corner parsing algorithm (see e.g. Hale 2014) would recognize a noun phrase as the syntactic subject of a sentence. Activity in this same region was shown to be correlated with the number of syntactic right brackets by Brennan et al 2012. However the Subjecthood predictor in the present study is uncorrelated with this bracket-count predictor ($r=0.002$). These convergent results lend credence to the view of aTL as a combinatorial hub that in some way recognizes syntactic configurations.

C67 Examining individual differences in the processing of pronominal reference using event-related potentials *Alison Gabriele[1], Robert Fiorentino[1], Lauren Covey[1]; [1]University of Kansas*

Recent studies have shown variability in the processing of pronominal reference in ambiguous contexts (Two potential referents: David shot at John as he...vs. One potential referent: David shot at Linda as he) and in contexts of 'referential failure' in which there is no gender-matching antecedent (One vs. No referent: The boy thought that he/she....) (Osterhout and Mobley, 1995; Nieuwland and Van Berkum, 2006; Van Berkum and Nieuwland, 2008; Nieuwland, 2014). These contexts have been shown to give rise to a sustained, frontal negative shift (Nref) or a P600 (or both components) depending on both the task and individual differences in working memory (e.g. Nieuwland, 2014). For cases of 'referential failure,' it has been proposed that the presence of an explicit acceptability judgment task may give rise to P600s, suggesting attempts at co-reference despite the mismatch in the gender of the pronouns (Osterhout and Mobley, 1995; Nieuwland, 2014). In both ambiguous contexts and contexts of 'referential failure,' it has been suggested that individuals with high working memory are more likely to yield Nref, a component that indexes the inability to assign a unique referent, as opposed to P600 (Nieuwland and Van Berkum, 2006; Nieuwland, 2014). The present study further examines individual differences in pronominal processing, including a wider range of cognitive measures. Experiment 1 targeted ambiguous pronouns (One/Two referent: Linda/Tyler grabbed Eric because he was falling down the stairs) and Experiment 2 targeted referential failure (One/No Referent: Nicole believed Steven/Alice because he was a very genuine person). N=33 native English-speaking participants completed the ERP study as well as tests of working memory (counting span/reading span), attentional control (Stroop), and an offline measure assessing the ambiguity of the experimental sentences. In the ERP study, participants read 240 sentences (160 targets, 80 fillers) and were asked to respond to fill-in-the-blank recall questions on one third of the trials. Results of Experiment 1 for all participants showed no significant effect of ambiguity. However, follow-up analyses following Van Berkum and Nieuwland (2008), revealed two distinct groups of participants: Individuals who showed a positivity in the posterior region between 500-1400ms (n=18) also showed a significant positivity in the anterior region, revealing a broad positivity which may index revision of the initial reference assignment at the pronoun or analyzing the gender of the pronoun as a grammatical violation. Individuals who did not show a

positivity in the posterior region (n=15) showed a sustained frontal negativity in the anterior region (Nref). The size of the Nref was significantly correlated with performance on the counting span task, suggesting in line with previous research that the Nref is larger in individuals with high working memory. Results of Experiment 2 showed a significant positivity in the posterior region between 500-900ms, consistent with the P600, suggesting that participants may attempt co-reference even in the absence of an explicit acceptability judgment task. The P600 effect size was significantly correlated with the reading span task. Our findings underscore the need for further research on the nature and sources of variability in native language processing.

C68 A parametric study of hierarchical structure building in fMRI and MEG

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INTRODUCTION: The contrast of sentences vs. unstructured stimuli has identified a set of brain areas potentially involved in hierarchical structure building: the left inferior frontal gyrus (IFG), posterior temporal lobe (PTL), and the anterior temporal lobe (ATL). Recently, Pallier et al. (2011) presented sentences, word lists, and phrases of varying lengths, finding increasing activation in IFG and PTL with increasingly long structured sequences using both natural and jabberwocky stimuli, and in ATL for natural stimuli only. However, other studies have failed to find structural effects in the IFG, and the responses of the PTL and the IFG are often coupled, raising questions about what stimuli under what contexts elicit structural effects in these regions. Also, unstructured stimuli in many studies include morphology, which may induce inadvertent structural processing, and task demands such as sentence comprehension may result in reduced attention to unstructured conditions. Finally, the timescale of these structural effects are uncertain, as is whether open- and closed-class items contribute equally to structural processing. We examined structure building responses in both fMRI and MEG, in order to address these issues and identify the timecourse of processing associated with structural effects. **METHODS**: We used a parametric manipulation of structure and content, presenting six-word stimuli in a 3 (STRUCTURE: sentence/phrase/list) x 2 (CONTENT: natural/jabberwocky) design, with an additional control condition (a counting task). Sentences and phrases had a fixed template of alternating closed- and open-class items, and lists contained these same items scrambled across six-sequence blocks. In the jabberwocky condition, real content words were replaced with pronounceable nonwords. We presented stimuli in a block design, and informed subjects in advance whether they were beginning a sentence, phrase, or list block to encourage parsing at the intended level. We removed overt morphology from open-class words, and counterbalanced the conditions such that the same exact words were presented in all conditions across three experimental lists. The task in all conditions was a single-word recognition memory probe that appeared at the end of a given trial. **RESULTS & DISCUSSION**: Here we report an initial dataset of 9 participants. In fMRI, we replicate previous findings of increased activity for natural sentences vs. lists in the left IFG, PTL, and ATL (Pallier et al., 2011; Humphries et al., 2007). Critically, unlike Pallier et al. (2011) we do not find effects of intermediate-sized structures in the IFG and PTL, in either natural or jabberwocky conditions. Like Pallier et al. (2011) we observe a trend towards a sentence vs. list effect in IFG for jabberwocky as well, but we see no sign of such an effect in the PTL. These findings suggest that structural effects in the IFG and PTL may be contingent on whether the subject expects the stimuli to be "sentence-like". In MEG, preliminary analyses suggest differential activity between 100-250 ms after stimulus onset for the sentence (full structure) and phrase (intermediate structure) conditions compared to the list condition (no structure), with the same effect on both closed- and open-class items.

C69 Electrophysiological evidence for recovery of meaning of elliptical sentences

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A process of semantic recovery is required to successfully interpret elliptical sentences (e.g. "John bought a book, and Sally too."). Ellipsis may be resolved by inserting a copy of the missing structure (e.g. "bought a book"). Such a 'copy-paste' procedure predicts a low processing cost - regardless of the size of the antecedent. In contrast, a more laborious inferencing mechanism may be applicable for ellipsis resolution. Such a mechanism involves step-by-step structure building, while a more fully interpreted discourse representation of the antecedent is integrated. This predicts the recruitment of relatively more processing resources. Using a word-by-word reading task, we studied the online processing of a particular type of ellipsis, i.e. 'stripping', in Dutch. We recorded event-related brain potentials while 30 Dutch participants read sentences containing stripping constructions (equivalent to "and Sally too") interspersed with filler sentences. Critical measure point was the onset of the word 'ook' (too). The conditions differed with respect to the size of the elided structure: verb-noun (condition A), verb-adjective-noun (condition B), adjunct-verb-noun (condition C) or adjunct-verb-adjective-noun (condition D). Every stimulus sentence was followed by a comprehension question. We counterbalanced which sentence parts (including elliptical phrases) were questioned. To control for individual differences, participants also performed a working memory task. We conducted repeated measures ANOVAs for 100 ms time windows. We observed a significant effect of the factor condition on the mean amplitude between 300 and 400 ms after onset of 'ook'. A Bonferroni post-hoc test

revealed that condition A did not differ from B. Compared to condition A, a significant centro-frontal positive deflection could be established in both conditions C and D. Between conditions C and D, no significant difference was apparent. However, after 400 ms the positivity appeared to be sustained and broadly distributed in condition D. The participants' performance on the comprehension questions did not differ between conditions. We found a weak, non-significant positive correlation between the accuracy on the comprehension questions and the scores on the working memory test. These results show that recovery of relatively large structures increases demands on processing resources, which suggest a more laborious inferencing mechanism for these structures. We conclude that the established positivity is a member of the P600 family that - depending on scalp topography, onset and duration - relates to retrieval and integration processes: the early onset points to a retrieval process while the latency is modulated by the amount of information to be integrated. In addition, high processing cost does not negatively affect the understanding of stripping constructions.

C70 Hemispheric differences in processing Chinese referential expressions—an ERP investigation

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Unlike Indo-European languages, nearly no morpho-syntactic markings exist in Chinese, it is therefore unclear whether maintaining referential coherence usually done through agreement involves similar neural mechanisms in Chinese or instead relies more on the semantic relations between pronominal expressions and their antecedents. In view of this as well as recent reports suggesting different sensitivity to grammatical anomalies across cerebral hemispheres, we combined ERPs and visual half-field presentation techniques to investigate pronoun comprehension in Chinese. ERPs were recorded while participants read sentences containing two characters and a pronoun. The stereotypical gender associated with each character and types of pronouns were manipulated, such that the pronoun can be associated with (1) only one character (e.g., Meiyu(female) invited Zhenghong(male) to her wedding), (2) both characters (e.g., Meiyu(female) invited Wenling(female) to her wedding) or (3) neither character, where the pronoun was either a human pronoun mismatching with both characters in gender or a non-human pronoun which imposes greater semantic conflict (e.g., Meiyu(female) invited Wenling(female) to his/its wedding). Sentences were presented word-by-word centrally on a screen with the pronoun laterally to either visual field. Participants performed either a word recognition test or an acceptability judgment task on a subset of the trials. Twenty-two right-handed Taiwanese young participants were tested; none had left-handed blood relatives. ERP responses to both mismatch pronouns elicited larger N400s (300-450ms) relative to unambiguous pronouns bilaterally. Human mismatch pronouns additionally elicited a P600 effect (550-1200ms) with right visual field (RVF) presentation only. These results thus suggest that syntactic processing is also involved in Chinese pronoun comprehension, consistent with past findings in English and Dutch (Nieuwland & Van Berkum, 2006; Osterhout & Mobley, 1995). However, perhaps due to the lack of morpho-syntactic marking, greater tolerance was given to referential failing pronouns such that gender mismatching pronouns were processed as lexical-semantic anomalies. Furthermore, relative to unambiguous pronouns, ambiguous pronouns elicited a bilateral Nref effect (sustained negativity starting from 200 to 800ms), consistent with prior literature showing bilateral contributions in processing referential ambiguity (Nieuwland, Petersson, & Van Berkum, 2007). Interestingly, ambiguous pronouns also additionally elicited a late positivity effect (850-1200ms) with RVF presentation only. This left lateralized effect was not found in prior research using a similar design (Nieuwland et al., 2007) and given the low sentential constraint up to the point of the pronoun, is likely to be different from the frontal positivity observed from lexical unexpectedness (e.g., Thornhill & Van Petten, 2012; Wlotko & Federmeier, 2007). This positivity is more anteriorly distributed than what was observed in human mismatch pronouns, but the topographic differences were not statistically reliable. It is possible that this positivity indexes a qualitatively similar process observed in the human mismatch condition (imposed by the acceptability judgment task and emerging later due to the sustained Nref effect), or additional inferential process to solve the referential ambiguity. Together, these results add to our understanding of the neural mechanisms involved in comprehending Chinese pronominal expressions across the two hemispheres.

C71 ERP effects of expectation and task attenuation on head reassignment in German compounds

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Nouns are typically syntactic and semantic heads. Therefore, the parser should expect nouns to be heads. But when a second noun appears, creating a compound, there should be a cost of reassigning the head from N1 to N2 (Whelpton et al. 2014). We test this hypothesis in German, where gender agreement can provide grammatical cues about coming structure (Koester 2004, Koester 2013). Conditions: Full Gender Match (FGM) - Der Finger/nagel (Masc-Masc-Masc) Gender Agreement (GA) - Die Glass/tür (Fem-Neut-Fem) Gender Violation (GV) - Das Tier/artz (Neut-Neut-Masc) We examine the effect of head-expectation by contrasting GA (gender cue for compound) with FGM (no gender cue): In FGM, subjects should commit to the head at N1; there should be a reassignment cost at N2. This should also be true for GV compared to GA; in addition there should be a gender violation cost at N2. Experiment 1: 18 native German speakers read 20 compound phrases from each condition (300 filler non-compounds). Word length, compound and gender

frequencies are controlled for. Sentence presentation was RSVP (600ms SOA) and randomized for each subject. 32 electrodes were used for measurement. 256Hz sampling rate; filter 0.01 to 40Hz. Reference- Linked mastoids. Results: In the 480-550ms window, a broad left negativity was found for FGM when comparing it to GA at N2. For GV, we found a strong left anterior negativity, as well as a broad left negativity when compared to GA. Discussion: We interpret these results as costs for overlapping semantic and syntactic restructuring (and for the gender violation) at N2. If restructuring were indeed due to the parser's expectation that N1 is the syntactic head, the observed effects at N2 ought to be modified where N2 can be anticipated. Hence, Experiment 2. Experiment 2: Subjects see only compounds, so N2 is expected in all conditions. 15 native German speakers read 50 FGM, 50 GA, and 20 GV compounds (crucially, no fillers). All else matched Experiment 1. Results: In the 325-470ms window, a broad posterior negativity was found for FGM when comparing it to GA, which was significant in both posterior quadrants. In the 490-560ms window, a negativity was found in the left posterior quadrant for GV when compared to GA. Discussion: The frontal/left negativities of Experiment 1 due to syntactic restructuring have vanished because the parser can predict N2. We do not even see the LAN associated with gender violation because the ratio of violations increases (1:5 compared to 1:15 in Experiment 1), diminishing their effects. But the parser cannot predict what semantic reanalysis remains because there are many possible semantic relations between N1 and N2. Thus, we interpret the observed centroparietal negativities as the costs of semantic reanalysis. (These were likely not seen in Experiment 1 because they overlap temporally with the syntactic restructuring effects.) Conclusion: The parser expects a noun to be a head. When it is not, reassignment bears a cost. This is confirmed by the absence of syntactic restructuring costs when the task allows prediction of an N2.

C72 ERP Signatures of Attachment Height Variations in English

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Previous research has suggested that attachment height preferences are language-specific. Cuetos & Mitchell (1988) conducted a questionnaire study aimed to establish native English speakers' preferences in the attachment height of ambiguous relative clauses by using sentences with RCs that could attach to high or low nodes. For example, in the sentence, "The policeman shot the maid of the actress who was on the balcony", the RC "who was on the balcony" can be attached to two NPs: "the maid" and "the actress". English speakers favored low attachments when asked about their preferred attachment site for the RC. More recently, Fernandez (2002) conducted an RT study, in which sentences taken from Cuetos and Mitchell (1988) were manipulated so that one attachment site would be valid and the other ungrammatical (i.e."The maids of the bride who was on the balcony." Here, the RC should attach to the NP "the bride" and not to "the maids" because the verb is singular). RT delays at the VP were found when the lower NP disagreed with the VP, and such delays were absent when the disagreement involved the higher NP. Fernandez (2002) argued that this asymmetry was caused by native English speakers performing low attachments by default (i.e. automatically attaching RCs to the lowest possible node). These previous studies have used end-point-of-process measures, which do not show what occurs during the entire parsing process. The current study aims to analyze the ERP responses of native English speakers to the ungrammaticality triggered by the disagreement between NPs located in low and high nodes and a VP in a subsequent relative clause. ERPs, which have not been used in previous research with these structures, can elucidate the detailed time course of the processing of attachment height variations. These responses will facilitate the comparison of the processing of high and low attachments, which will demonstrate whether one attachment site is preferred. 33 subjects participated in a self-paced reading task while EEG was recorded. Subjects read 24 declarative sentences (taken from Fernandez (2002)) in each of two conditions: (1) High Attachment Ungrammaticality (HAU) ("The policeman shot the maids of the actress who was on the balcony"), and (2) Low Attachment Ungrammaticality (LAU) ("The policeman shot the maid of the actresses who was on the balcony"). 24 control sentences with a fully ambiguous RC were added ("The policeman shot the maid of the actress who was on the balcony"). ERPs were locked to the VP inside the RC. We found that both HAU and LAU conditions trigger Posterior Negativity, peaking 400msec after the critical VP. This indicates that English speakers are sensitive to the ungrammaticality triggered by both high and low attachments, which suggests that the parser processes both attachments simultaneously. These findings converge with the Race-based Parallel Parsing model presented by Lewis (2000), which states that the parser generates several simultaneous attachments for an ambiguous structure, and contradict Cuetos & Mitchell (1988) and Fernandez (2002), who claim that English speakers only parse the structure that corresponds to low attachments.

C73 Vikings who can gulp down beer mugs, cook bean cans, and slurp wine glasses: An ERP study of ambiguous heads in complex Icelandic words

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Semantic and syntactic heads in transparent noun-noun compounds are always aligned (Scalise & Guevara, 2006). Icelandic seems to provides a striking exception: It is possible to say, 'Ég þynnti þrjá kaffibolla' ('I diluted three coffee-cups') where the numeral agrees in number and gender with the syntactic head 'cups', but 'coffee' is the semantic head (it is what I drank). Also, in Icelandic, it is

possible to 'break three coffee-cups'; here, the semantic and syntactic heads are aligned in the normal way at 'cups'. Thus, compounds with container nouns (cup, can, bowl, etc.) are ambiguous depending on the choice of verb. Harley (2015) proposes two structures: (i) where a coffee-cup is broken, 'cup' is both the syntactic and semantic head of a noun-phrase, and 'coffee' is a modifier ('Aligned-Head'); (ii) where a coffee-cup is diluted, 'cup' is the head of a measure-phrase, and 'coffee' is the head of a noun-phrase ('Split-Head'). Since heads would have to be processed separately to distinguish the two interpretations of 'coffee-cup', this contrast speaks directly to the issue of how complex words are accessed, requiring that they be decomposed into component parts. We conducted two ERP studies using RSVP to examine the processing of split-heads compared to a baseline of aligned-heads. Experiment 1: 22 native-speakers of Icelandic read 37 sentence-pairs involving either split- or aligned-heads. ERPs time-locked to the onset of the compound were analyzed using repeated-measures ANOVA with Condition (split, aligned) and ROI (Anteriority, 2 levels; laterality, 2 levels) as factors. Results revealed a significantly greater anterior-left positivity for split-heads during the 450-600ms time-window. We interpret this as a cost of processing the more complex head-structure inherent in split-heads. However, it could be due merely to the semantic implausibility of C1 as the head in aligned-heads ('coffee' cannot be 'broken') (Staub et al. 2007). Hence, Experiment 2: 20 (new) Icelandic subjects took part. All stimuli were identical to Experiment 1, except that C1/C2 were presented separately. Thus, the only difference at C1 was the semantic anomaly in aligned-heads. No ERP effect was found at C1, suggesting that the ERP finding in Experiment 1 was indeed due to the processing of a complex-head structure. Because in all compounds, the first constituent (C1) could not stand alone (it mismatched a preceding numeral in gender or number), so a second constituent (C2) was entirely predictable in both conditions. The prediction would be for an aligned-head since that is typical. At C2, we found an early anterior-left negativity (125-225ms) for split-head, which likely reflects surprise at encountering a measure-phrase. This is followed by a posterior-right positivity (275-350ms) that may constitute a P3a, associated with evaluating the consequences of surprise, i.e., with reanalysis from an expected aligned-head to a split-head structure. More generally, we conclude that split-head compounds are decomposed into noun-phrase and measure-phrase heads. More significantly, aligned-head compounds must also be decomposed into modifier and head to render them distinguishable from split-head compounds, supporting decomposition models of complex-word processing (Taft, 2004; Fiorentino & Poeppel, 2007).

C74 Differential ERP and EEG Effects of Contextual Cue Type and Relative Clause Attachment during Sentence Reading

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INTRODUCTION. Previous work has found a low-attachment preference in English (Carreiras & Clifton, 1999). For example, readers preferentially interpret the relative clause of the following ambiguous sentence as attaching "low" to "the actress" rather than attaching "high" to "the servant": "Someone shot the servant of the actress who was on the balcony". However, in sentences like those tested in the current study, the attachment of the relative clause is not ambiguous; rather, it is disambiguated by contextual cues. The goal of this study was to use EEG/ERPs to examine the influence of such cues on the processing of high-attaching structures. This study focused on oscillatory power in the theta frequency band (~4-7Hz), which has been shown to increase in response to semantic-memory retrieval demands during sentence processing (Bastiaansen, van Berkum & Hagoort, 2002a,b), and the P600, which has been shown to be sensitive to the processing of dispreferred syntactic structures (Kaan & Swaab, 2003). METHODS. EEG was recorded while 28 participants read sentences that contained relative clauses, in the following conditions: A: Low-Attachment (Syntactic Cue): …the retriever behind the Labradors that WHINE… B: High-Attachment (Syntactic Cue): …the Labradors behind the retriever that WHINE… C: High-Attachment (Semantic Cue): …the Labradors behind the fences that WHINE… D: High-Attachment (Syntactic+Semantic Cue): …the Labradors behind the fence that WHINE… Words were presented one at a time, for 300ms each (200ms ISI). ERPs were time-locked to the critical words (capitalized above for demonstration only), and power in the theta frequency band was also calculated. RESULTS. ERPs: Results showed that all high attachment conditions (B,C,D) elicited a significantly more positive deflection than the low attachment condition (A) ($ps<0.05$). This effect occurred in a relatively late time window (1000-1200ms) and was maximal over posterior electrode sites. EEG: Results showed that frontal theta power was significantly increased for both syntactic cue conditions (A,B) compared to both conditions in which a semantic cue was present (C,D) ($ps<0.05$). CONCLUSIONS. The ERP results show a late P600 effect of attachment difficulty, indicating that readers preferred low-attaching structures to high-attaching structures. This finding confirms that high-attachment was indeed more difficult to process in this study. The low-attachment preference was not affected by the type of cue: the ERP signature was similar for all high-attaching structures. In contrast, the EEG results showed frontal theta effects of cue type, such that frontal theta was increased for both syntactic cue conditions compared to the two conditions in which a semantic cue was present, but not of attachment type. Thus, in this study, the P600 effects "tracked" attachment, whereas the frontal theta effects tracked the type of contextual information that was available to the reader in determining attachment of the critical relative clause. This pattern of results suggests (1) that the process captured by the late P600 effect in this study was associated with the assignment of a dispreferred

syntactic parse, and (2) that frontal theta effects reflected the processing demands associated with the type of contextual cue(s) available to the reader in assigning a parse.

C75 From minimal dependencies to sentence context: Neural correlates of agreement processing. *Ileana Quinones[1], Molinaro Nicola[1], Mancini Simona[1], Carreiras Manuel[1,2,3]; [1]BCBL, Basque Center on Cognition, Brian and Language, [2]IKERBASQUE. Basque Foundation for Science. Bilbao, Spain, [3]University of the Basque Country, UPV/EHU. Bilbao, Spain.*

Language comprehension is incremental, involving the integration of formal and conceptual information from different words, together with the need to resolve conflicting cues when unexpected information occurs. However, despite the extensive amount of findings regarding how the brain deals with these information, two essential and still open questions are 1whether the neural circuit(s) for coding syntactic and semantic information embedded in our linguistic code are the same or different, and 2whether the possible interaction(s) between these two different types of information leaves a trace in the brain response. A convenient tool to isolate these two different types of information is offered by the Spanish agreement system. Interestingly, taking advantage of the diversity of this system it is possible to tune down some of these factors (i.e., syntactic and lexico-semantic) and, as a consequence, boost others, allowing us to disentangle the different mechanisms sub-serving agreement comprehension. The current study seeks to investigate this phenomenon from a neuro-anatomical perspective. Experimental manipulations concerning different agreement features and the elements involved in an agreement relation, allowed us to characterize the neural network underlying agreement processing. This study comprised five experiments: while experiments I and II explored nominal dependencies in local as well as non-local relations, experiments III, IV and V explored subject-verb relations in a more complex sentence context. To distinguish between purely syntactic mechanisms and those where semantic and syntactic factors would interact during language comprehension, different types of agreement relations and/or agreement features were manipulated in well- and ill-formed constructions. The interaction effect between the different factors included in each experiment is always the critical comparison. In general, our results include firstly a functional dissociation between well-formed and ill-formed constructions: while ill-formed constructions recruited a bilateral distributed fronto-parietal network associated to conflict monitoring operations, not language specific, well-formed constructions recruited a left lateralized fronto-temporo-parietal network that seems to be specifically related to different aspects of phrase and sentence processing. Secondly, there was an anterior to posterior functional gradient associated to the middle and superior temporal cortex that consistently appears across experiments. Specifically, while the posterior portion of the left MTG-STG seems to be related to the storage and retrieval of lexical and morpho-syntactic information, the anterior portion of this region was related to syntactic-combinatorial building mechanisms. Critically, in the most anterior part of the left temporal cortex, corresponding with the middle and superior temporal pole, form-to-meaning mapping processes seems to be represented. Thirdly, the response of the left temporal cortex appears to be controlled by the left inferior frontal regions (LIFG). Finally, left parietal regions such us the angular gyrus showed increased activation for those manipulations involving semantic factors (e.g., conceptual gender and Unagreement constructions), highlighting its crucial role in the processing of different types of semantic information (e.g., conceptual integration and semantic-discourse integration). Overall, these findings highlight the sensibility of the agreement system to syntactic and semantic factors embedded into an agreement relation, opening new windows to the study of agreement computation and language comprehension.

Poster Session D

Friday, October 16, 1:00 – 3:00 pm, French and Walton Rooms

Discourse, Combinatorial Semantics

D1 Pupil dilation in natural story listening during fMRI *Katerina Kandylaki[1], Jens Sommer[1], Tilo Kircher[1], Richard Wiese[1], Ina Bornkessel-Schlesewsky[2]; [1]University of Marburg, [2]University of South Australia*

Pupil diameter in language processing is sensitive to cognitive load (Hyönä et al., 1997) and surprisal effects (Frank&Thomson, 2012). Neurobiologically, pupil dilation reflects the phasic release of norepinephrine (NE) from the Locus Coeruleus (LC), leading to increased neuronal gain for relevant stimuli and optimal task performance (Aston-Jones & Cohen, 2005). Previous neurolinguistic studies examining pupil dilation have mainly used reading paradigms and limited context. Here, participants listened to 20 two-minute long stories within a naturalistic paradigm in a concurrent fMRI-pupillometry setup. Within the rich context of these stories we manipulated voice (active, passive) and causality (high, low) as cues of foregrounding the upcoming referent in a 2x2 design: 1.Act/Pass-high: Sent["The engineer pushed the pharmacist quickly back into the car,/ the engineer was pushed quickly into the car by the pharmacist] because due to the traffic one could not stay for long in the narrow street." Ref["The engineer] sped off immediately." 2.Act/Pass-low "[The pharmacist held the engineer in very high esteem/ The pharmacist was held in very high esteem by the engineer.] They knew each other for a long time so they had developed a strong friendship." Ref[The pharmacist] was waiting in the

car...". We measured pupillary responses in two positions: during the manipulation (sentence) as well as during the referent (referent) thereby creating a 2x2x2 design. We hypothesised that 1. if pupillary responses in auditory comprehension capture surprisal effects, we would see stronger effects for the referent in contrast to the sentence, 2. passive would increase the future predictability of the referent, as manifested in a change in pupil size compared to processing the referent after active voice, 3. causality would interact with voice in the pupil measurements. The pupillary data were collected with an infrared camera and pre-processed with Matlab-based-in-house scripts. We corrected for blinks by rejecting all data points during each blink and 5 data points before and after it and for slow drifts of pupil size by modelling a baseline event within the intervening context sentence and subtracting the event from the baseline pupil sizes. In a preliminary analysis we modelled these differences with mixed effects models following the previously mentioned 2x2x2 design and added the maximal random effects structure that allowed the models to converge. The best fitting model included the three-way interaction and an additional interaction with order of presented story ($p<.0001$). Against hypothesis 1, we observed no significant effects on the referent in comparison to the sentence. As hypothesised in 2 and 3, a significant two-way interaction of voice and causality was found for sentence, mainly driven by pupil dilation during processing of Pass-low (estimate 182, std.error=30, t-value=6). Our results show increased pupil dilation for passive voice in interaction with causality of the event (e.g. hitting vs. seeing), thus suggesting that LC-NE activity is sensitive to the match between the semantic properties of an event and how it is expressed grammatically. In a follow-up analysis we aim to investigate the neural correlates of pupillary responses to auditory stories by correlating pupillary with fMRI data.

D3 Neural Oscillation Patterns during Natural Reading Vary with Text Complexity and Reading Skill *Erika J C Laing[1,2,3], Ben Rickles[4], Kim Muth[1], Charles Perfetti[1]; [1]University of Pittsburgh, [2]Carnegie Mellon University, [3]University of Pittsburgh Medical Center, [4]Georgia State University*

Increasingly, evidence suggests that neural oscillatory patterns are important to supporting distributed cognitive processing, including reading and language comprehension. Using authentic narrative texts, we explored the oscillatory activity associated with two inter-related aspects of text comprehension: 1) the effects of text complexity and 2) the skill of the reader. Our study compared EEGs recorded during reading with resting states. We hypothesized that shifts between frequency bands (especially theta and alpha bands) would be associated with reading vs resting states and with degree of complexity (greater theta for more complex tasks) and reader skill. EEGs from 29 college-aged participants were recorded using EGI 128-electrode nets during blocks of resting, reading, and eye movement tasks. Reading Passages included Jane Eyre Easy, Jane Eyre Hard and Ulysses. Reading skill was assessed by an offline comprehension test. Texts were presented in 2-3 sentence displays that readers advanced at their own pace. A novel ocular artifact removal procedure was developed and applied to the resting and reading conditions. Within each passage, Power Spectrum Density (PSD) was computed on data segmented into two-second 'trials'. The PSD's in Theta (5-7Hz) and Alpha (7.5-12.5Hz) frequency ranges were examined across 20 clusters (ROIs) of three to four electrodes each. Resting States significantly differed from Reading States in both the Theta and Alpha ranges and across Lower and Higher Skill Comprehenders. In the Theta range, LowerSC's exhibited increased PSD in the Right Fronto-Temporal ROIs during reading of all texts compared to resting states. Additionally they exhibited increased PSD at 7Hz for the Ulysses text distributed across the Left Parieto- to Occipito-Temporal ROIs. In contrast, the HigherSC's exhibited only the Theta increase over the Right Fronto-Temporal ROIs. In the Alpha range, LowerSC's show high PSD values surrounding 10Hz in the resting conditions in the Occipital ROIs. They also, unexpectedly, showed equivalent Alpha patterns across reading and resting states, except in Mid to Right Occipital. In contrast, the HigherSC's exhibited highly distributed Alpha PSD in the resting state, including Occipital clusters plus a set of Frontal and Parietal clusters. Interestingly, when HigherSC's read any text, Alpha PSD dropped dramatically across all electrode groupings. We found that text complexity and reading skill were associated with shifts in oscillation patterns during text reading. Theta range frequencies showed increased power across all texts in right frontal and anterior temporal regions, suggesting greater reliance on working memory processes associated with the cortico-hippocampal loop linked to Theta oscillations. LowerSC's also showed an increase power in the Theta range in Left parietal to occipito-temporal areas during the reading of Ulysses, reflecting that this uniquely difficult text challenged these readers differently from the HigherSC's. In the Alpha range, HigherSC's exhibited a more distributed pattern during resting state, but a reduction everywhere when reading. Meanwhile, LowerSC's showed very little difference in alpha power between reading and resting states. Taken together, these data suggest that Highly Skilled readers engage attentional suppression (reflected in alpha) more effectively, while also showing less working memory effort (reflected in theta).

D4 EEG can track the time course of successful reference resolution in small visual worlds. *Christian Brodbeck[1,2], Laura Gwilliams[1,2], Liina Pylkkänen[1,2]; [1]New York University, [2]NYUAD Institute*

Behavioral research with the so-called visual world paradigm has shown that language comprehenders resolve reference quickly and incrementally, but little is known about the neural processes involved in the interpretation

of simple, unambiguous referential expressions. Studies of visual short term memory suggest that access to the representation of an item in a previously seen display is associated with a negative posterior EEG potential contralateral to the location of the item in that display. As a starting point for unpacking the neural computations involved in reference resolution in a visual domain, we predicted that resolving the reference of a noun phrase to an object in a previously seen visual display should be associated with a similar effect. We recorded EEG during a task adapted from the visual world paradigm: In each trial, participants saw a display composed of 3 objects (e.g., from left to right: a pink fish, a green fish and a green boat), followed by a question about the objects presented word by word ("Was the pink fish next to a boat?"). Questions differed in whether the color adjective allowed the reader to resolve reference (as in the example) or whether the noun was needed as well (as in the context of an alternate visual display containing two pink objects). Based on past eyetracking research using the visual world paradigm we predicted that participants incrementally use the information made available by the color adjective, and access the representation of the referent if the color adjective picks out a single object. Consistent with our hypothesis, reference-resolving color adjectives were associated with a response that reflected the location of the referent on the previously seen display. As predicted, evoked potentials were more negative at posterior electrodes contralateral to the referent compared to ipsilateral posterior electrodes starting approximately 335 ms after the onset of the adjective. We also found a corresponding effect at nouns, with a very similar onset time at 350 ms. Nouns were associated with a negative potential contralateral to the site of the referent regardless of whether the adjective or the noun resolved reference. Our results confirm that reference resolution is quick and incremental at a neural level and describe a new brain marker of referential processing. What is particularly interesting about this marker is that it reflects the physical location of the referent in the referential domain. Our results imply that by 350 ms, readers had used the semantic information from the word to access the relevant part of the representation of the referential domain, the visual display. The nature of the effect also suggests that reference resolution in our visual domains involved, at some level, modality-specific, topographic representations. Finally, the response at the noun suggests that although reference resolution is incremental, referential processing does not stop when the referent can be identified: The activity at nouns after reference-resolving adjectives suggests that readers continued processing the relation between the referential expression and the referential domain.

D5 Neural basis for discourse comprehension—a quantitative meta-analysis of neuroimaging studies *Xiaohong Yang[1], Huijie Li[1], Nan Lin[1], Yufang Yang[1]; [1]Key Laboratory of Behavioral Science, Institute of Psychology, Chinese Academy of Sciences*

Introduction Discourse comprehension is central to human communication. To understand the intended meaning of discourse, one must be able to go through several sub processes: inferences for bridging successive utterances, mental construction of text content, and pragmatic interpretations (Ferstl, Neumann, Bogler, & Von Cramon, 2008). Despite the host of neuroimaging studies focusing on discourse comprehension, there are still open questions. First, the brain anatomy that supports the sub-processes of discourse comprehension remains to be refined. Second, how the brain regions that support discourse comprehension interact at a systematic network level remains to be elucidated. We addressed these two questions in the present study. Methods An online search of Web of knowledge, Pubmed, and APA was performed to identity pertinent studies. A final set of 1128 foci from 51 studies with 1011 participants was included in the present meta-analysis. We performed an overall contrast and a contrast between discourse and nonlinguistic material to reveal the brain mechanisms for the general process of discourse comprehension. More importantly, we also performed three sub-contrasts to reveal the brain anatomy for the sub-processes of discourse processing: a contrast between implicit and explicit expressions for the inference process, a contrast between coherent and incoherent expressions for the mental construction of text content, and a contrast between non-literal and literal expressions for pragmatic interpretations. According to the ALE results, we separately calculated the number of significant voxels that overlapped the masks generated for the seven large-scale neural networks proposed by Yeo and colleagues (2011). Results Discourse comprehension involved widely distributed brain regions including bilateral inferior frontal gyrus and middle temporal gyrus, left middle frontal gyrus and precentral gyrus, dorsomedial prefrontal cortex, bilateral inferior and superior temporal gyri, cuneus/precuneus, and parahippocampal gyrus. Inference processes relied mainly on left inferior and middle frontal gyri. Mental construction of text content involved mainly posterior middle temporal gyrus and dorsomedial prefrontal cortex. Pragmatic interpretation relied mainly on dorsomedial prefrontal cortex. Brain-network analysis revealed that discourse comprehension relied primarily on the default network. Activations were also found in other networks including the attention network, the executive control network, the visual network, the somatomotor network, and the limbic network. Mental construction of text content was found to rely on the default network, the visual network, the executive control network and the attention network. Both the inference process and the pragmatic interpretation were found to rely mostly on the default network and the attention network, but the attention network was recruited to a greater extent for the inference process. Conclusion The comprehension of a

discourse involves a distributed network of brain regions and distinct sub-processes recruit different pool of neural resources. Core network of discourse comprehension (the default network) interacts with other networks (the attention networks and the executive control networks) to establish successful comprehension. Keywords: discourse comprehension, neuroimaging, meta-analysis, brain networks.

D6 Simulation and mental imagery of complex events: differences and communalities. *Franziska Hartung[1], Peter Hagoort[1,2], Roel M. Willems[1,2]; [1]Max Planck Institute for Psycholinguistics, [2]Radboud University Nijmegen, Donders Institute for Brain, Cognition and Behaviour*

How do our brains construct a narrative when reading fiction? The nature of mental representations, e. g., when comprehending language is a highly debated issue. Despite sometimes being considered controversial, effects of mental simulation are a robust and frequent finding in neuroimaging and behavioral research. Yet, which underlying processes those effects reflect is a matter of dispute. It is often assumed that simulation is a reduced form of mental imagery. However, experimental evidence suggests that imagery and simulation do not necessarily recruit the same brain regions (Willems et al 2009). It is reasonable to assume that simulation plays a relevant role in language comprehension at the discourse level, where more complex information needs to be integrated in order to construct situation models. Moreover, contextually embedded information is likely to decrease variance between subjects in event representations, e.g. throwing without context can activate very different action representations, while throwing a dart or throwing a tennis ball reduces the probability that subjects activate different types of events. Especially stories seem to be highly appropriate to test simulation in language comprehension, as they promote situation model construction and deep-level processing while warranting adequate similarity across individuals. In the present study, we used functional MRI to investigate simulation during natural listening to literary stories compared to mental imagery in 1st and 3rd person perspective. First, subjects (N=60) listened to two literary stories without a specific task. Then, they listened to the stories again and were asked to 'imagine being the main character' (1st person imagery) and 'imagine being an uninvolved observer' (3rd person imagery) in two subsequent runs. A baseline condition with unintelligible speech was used to subtract irrelevant activation for all conditions in the data analysis. The order of tasks was counterbalanced across participants. In the analysis, we used an event related design with action and mentalizing events as canonical examples of simulation to compare brain activations in natural comprehension with imagery. The results show partial overlap of the brain regions activated in simulation and imagery. Listening shows recruitment of additional areas in frontal and temporal regions compared to the two imagery tasks, whereas activation patterns during mental imagery averaged across perspective are to a large degree included in the network active when subjects listen to a story without task. Looking at 1st and 3rd person perspective imagery separately reveals a more differentiated picture: 1st person imagery shares substantial overlap in activation with listening, whereas in 3rd person imagery temporal regions are less pronounced and additional left posterior middle frontal regions are recruited. Comparing the two imagery conditions confirms this finding that 1st person imagery is more associated with temporal regions while 3rd person imagery is more associated with posterior middle frontal regions in story comprehension. Our results give evidence that simulation in language processing partially overlaps with mental imagery. Simulation during natural story comprehension shows a more global network distribution whereas imagery tasks recruit specific areas. Moreover, participants seem to prefer 1st person perspective when engaging with stories without task requirements.

D7 The language network and the Theory of Mind network show synchronized activity during naturalistic language comprehension *Alexander Paunov[1], Idan Blank[2], Evelina Fedorenko[3]; [1]Massachusetts Institute of Technology*

Introduction Abundant evidence now suggests that the human brain is comprised of a number of large-scale neural networks, i.e., sets of brain regions that show similar functional profiles and synchronized activity during naturalistic cognition, and are anatomically connected (Power et al., 2011; Hutchison et al., 2013). Although the number and functional interpretation of these networks remain open questions, a number of networks emerge consistently across studies, including i) the fronto-temporal language network whose regions selectively engage during language processing (e.g., Fedorenko et al., 2011), and ii) the system that supports social cognition, including, critically, Theory of Mind (our ability to think about other people's thoughts), comprised of bilateral regions in the temporo-parietal cortex and a number of medial cortical regions (e.g., Saxe & Kanwisher, 2003). Both of these systems have been implicated in human communication. However, communicative success plausibly requires not only the proper functioning of each system, but also some degree of coordination (information passing) between them. One way to implement such coordination is via temporary synchronization in neural activity between the regions of one system and those of the other system (e.g., Cole et al, 2013). Here, we asked whether the language and Theory of Mind (ToM) systems are synchronized during language understanding. Method Twelve participants were scanned with fMRI while listening to naturalistic narratives. Preprocessed blood oxygenation level dependent time series were extracted from each participant's regions of interest in the language and ToM networks, functionally defined using "localizer" tasks that have been extensively validated in prior work

(e.g., Fedorenko et al., 2010; Saxe & Kanwisher, 2003). A small number of voxels overlapping between the two systems were excluded. Functional correlations were then estimated within and between networks (for all pairs of regions). These Pearson's correlation coefficients were then submitted to a second-level random effects analysis. Results We observed high within-system correlations (rs>0.47) for both the language and ToM networks, and these were reliably higher than the between-system correlation (ps<0.001). This pattern is consistent with the idea that these sets of regions constitute internally integrated and dissociable functional networks. Critically, however, we observed a sizeable and reliable correlation between the regions of the language network and the ToM network (r=0.23, p<0.0001). Conclusion Two functionally dissociable systems important for communication – the language system and the Theory of Mind system – showed synchronized activity during naturalistic language processing. Given that both systems are involved in interpreting the linguistic signal, this synchronization may be interpreted in terms of information exchange between the systems. Importantly, such between-system synchronization does not occur for any pair of large-scale networks supporting high-level cognition. For example, the language system does now show any such synchronization with the fronto-parietal cognitive control or "multiple demand (MD)" network (Blank et al., 2014) whose regions support diverse goal-directed behaviors (e.g., Duncan, 2010, 2012; Fedorenko et al., 2013). The functional importance of the synchronization observed between the language and ToM networks remains to be discovered.

D8 Use of contextual information and prediction in reading by low-literate adults: an ERP and reading-time study

Shukhan Ng[1], Kara D. Federmeier[1], Elizabeth A. L. Stine-Morrow[1]; [1]University of Illinois at Urbana-Champaign

Introduction. Context can be used to facilitate language comprehension. ERP patterns have revealed evidence for graded, context-based facilitation of word processing in young adults, as indexed by reduced N400 amplitudes, as well as processing costs when predictions are violated (Federmeier et al., 2007). However, the use of prediction-based strategies is not ubiquitous, as healthy, educated older adults and second language learners show reduced evidence for predictive processing and overall poorer use of context information to facilitate word processing (Federmeier & Kutas, 2005; Martin et al., 2013). This raises the question of whether predictive strategies are used among adults with lower literacy skills. According to NRC's 2012 report, 65 million adults in the U.S. were able to read only simple texts. It is generally agreed that literacy skill in adulthood is reflected pervasively in standardized assessments reading components, but there is very little understanding of online comprehension. For example, it remains unclear whether low-literacy adults use context to predict upcoming words (which may compensate for their weaker decoding skills; Stanovich, 1980), or whether message-level representations are even constructed so as to enable the incremental accumulation of contextual information. In our study, participants read sentences of four types: a strongly constraining context completed by a target word that was expected or unexpected (SCE, SCU; e.g., The prisoners were planning their escape/party.); or a weakly constraining context with a target that was expected or unexpected (WCE, WCU; e.g., He slipped and fell on the floor/rock.). The fully graded effects of cloze probability indicated effective use of context. The differential cost of processing the unexpected targets under different levels of constraint (SCU vs. WCU) provided evidence for predictive processing: the SCU text strongly constrained for a word, resulting in higher processing costs for an unexpected word if predictive processing was used in online reading. Methods. Participants were higher-literacy (HL; N=20; MAge=46.3 yrs; MRdgLevel=11.4) and lower-literacy (LL; N=20; MAge=46.1; yrs; MRdgLevel=7.1) community-dwelling adults. Stimuli were 140 passages with a sentence-final target word in the following conditions: SCE (cloze=.9), SCU (cloze=.03), WCE (cloze=.4), WCU (cloze=.03). Participants self-paced to read the passages one word at a time while their brain waves and reading times were recorded. Results. HL participants showed effects typical of college students, with N400 amplitude graded by cloze probability (SCE<WCE<SCU=WCU). Among HL participants, the cost of prediction was observed in the reading times of the target word: SCU elicited longer times than other conditions, including WCU. For LL participants the N400 for SCE targets was smaller than those from all other conditions. In particular, they did not differentiate the expected and unexpected words in the weakly constraining context. The graded effects of constraint and expectancy in reading times were observed at the word following the target (SCE<WCE<SCU=WCU). The difference between SCU and WCU was observed in neither ERPs nor reading times for the LL participants. Conclusion. Low-literate readers can quickly use strongly but not weakly constraining contexts to facilitate reading comprehension. They nevertheless do not seem to use predictive processing.

D9 Visual attention, meaning, and grammar: neuro-computational modeling of situated language use.

Victor Barrès[1], Michael Arbib[1]; [1]University of Southern California

We present a system-level computational model of the human language faculty integrating visual-attentional processes with language processes (Barrès & Lee, 2013). The model focuses on the dynamic interactions and interfaces that exist between attention and language during both the production and comprehension of visual scene descriptions. It offers a bridge between the dynamical and incremental processing approaches focusing on simulating both psycholinguistic and neuropsychological results (e.g. CIANet Mayberry, Crocker, & Knoeferle, 2009; U-space

Vosse & Kempen, 2000) and the cognitive analyses of the relations between linguistic knowledge and sensory-motor systems (e.g. ECG Feldman & Narayanan, 2004, or FCG, Steels, 2011) while adding the architectural constraints necessary to simulate the functional consequences of brain lesions. The model rests on three main principles: Construction grammar and visually anchored semantics. The model uses and expands the formalism of Template Construction Grammar (TCG), a visually grounded construction grammar that bridges between schema theory and cognitive linguistic theory (Arbib & Lee, 2008). Neural architecture: Multiple functional routes. In addition to the dynamic interaction between visual and language processing, a two-route functional architecture of the model attempts captures neuropsychological data highlighting how, during comprehension, world knowledge plays a role alongside grammatical knowledge and can survive lesion to a "grammatical route" (e.g. Caramazza & Zurif, 1976), as well as neuroimaging results pointing towards the multi-stream nature of the language system, distinguishing functionally between a syntactic/algorithmic stream and a semantic/heuristic stream (e.g. Rogalsky & Hickok, 2011). Dynamical distributed system. The model uses cooperative computation to operationalize distributed processes both within and between functional routes in a way that is consistent with the dynamic nature of neural activity and that allows for the simulations of functional degradations. This focus on dynamics also emphasizes the intrinsically time dependent nature of all visual and linguistic processes. The model is tested on a vision-language dataset built of sentences/utterances and visual scenes extracted from a canonical aphasia test (Caplan, Baker, & Dehaut, 1985) and from visual-world paradigm literature (Knoeferle & Crocker, 2006). For both production and comprehension, the model is able to replicate key psycholinguistic results based on the visual-world paradigm: influence of saliency and attention on grammatical structural choice made during the production of visual scene descriptions, anticipatory saccades effects observed during comprehension reflecting the incremental online integration of linguistic, perceptual, and world knowledge. We show how lesions to the model can simulate the differences in comprehension performances observed in agrammatic aphasic both between canonical and non-canonical word order sentences (Caplan et al., 1985) and between reversible and irreversible sentences (Caramazza & Zurif, 1976). We also use the model to investigate the reported patients' group differences, focusing here only on the passive vs. active construction processing (Berndt, Mitchum, & Haendiges, 1996) and assessing related data collected on normal subjects showing the "good-enough" aspect of comprehension (Ferreira, 2003). Finally, relations between receptive and production aphasia are explored.

D10 Altering mechanisms of combinatorial semantics through brain stimulation to the angular gyrus

Amy Price[1], Jonathan Peelle[2], Michael Bonner[1], Murray Grossman[1], Roy Hamilton[1]; [1]Center for Cognitive Neuroscience, University of Pennsylvania, Philadelphia, PA, [2]Department of Otolaryngology, Washington University in St. Louis, St. Louis, MO

A defining aspect of human cognition is the ability to integrate conceptual information into complex combinations of concepts. For example, we can comprehend "plaid" and "jacket" as separate concepts, but we can also effortlessly integrate this information to form the combination of a "plaid jacket". This function is essential to human cognition, but little is understood about the neural mechanisms underlying this integrative process. Many neuroanatomic models of semantic memory have proposed that convergence zones, or hubs, help to integrate the semantic features of word meaning to form coherent representations from stored semantic information. However, little work has examined causal relationships between high-level hub regions and specific integrative processes in semantic memory. Previous neuroimaging studies implicate the left angular gyrus in the process of successfully integrating conceptual information. Here we applied a novel version of transcranial transcranial direct current stimulation (high definition; HD-tDCS) to an fMRI-guided region of interest in the left angular gyrus. High-definition tDCS allows for relatively focal current application by using a ringed array of compact scalp electrodes centered on the cortical region of interest. In a within-subjects design, 18 healthy adults received an anodal left angular gyrus stimulation session, an active sham stimulation session, and an anodal control region session on separate days. Participants viewed adjective-noun word pairs on the screen and indicated by button press whether the word pair formed a meaningful combination (e.g., tiny radish) or non-meaningful combination (e.g., fast blueberry). We hypothesized that anodal stimulation to the left angular gyrus would alter the processing of meaningful relative to non-meaningful word combinations. Across the 18 subjects, we found that left angular gyrus stimulation resulted in reduced reaction time for the meaningful relative to the non-meaningful word pairs. This was observed for left angular gyrus stimulation but not for sham stimulation or stimulation to a control region (all p's<0.05). There were no effects on control tasks assessing visual discrimination and attention. Next we examined individual word pairs in the meaningful category to test for fine-grained effects of stimulation. In an item-analysis, we found that the size of the effect from stimulation correlated with degree of semantic coherence across the individual word pairs (as assessed by a separate norming study). This effect was specific to the left angular gyrus session, and was not observed in the brain stimulation control or sham stimulation sessions. These findings provide causal evidence that the left angular

gyrus plays a critical role in integrating lexical-semantic information into high-level semantic representations for comprehension, and that high-definition anodal tDCS can be used to specifically target these combinatorial mechanisms.

D11 The grass is not always greener: Property integration in adjective-noun combinations

Sarah Solomon[1], Sharon Thompson-Schill[1]; [1]University of Pennsylvania

Each time a concept (e.g., grass) is activated, it will not be instantiated in exactly the same way. Rather, context will influence the specific cluster of properties recruited to represent the concept. Sometimes these influences are implicit — properties of grass found in a well-manicured lawn are likely different from those of grass found in a dry savanna — but sometimes these properties are made explicit, such as in adjective-noun combinations (soft grass, sharp grass), wherein properties are directly ascribed to concepts. Much neuroimaging work has been done on assessing the information contained in individual concepts, and multivoxel analysis methods have been used to explore the extent to which distinct concepts relate to each other. Here we use those well-established techniques to explore the neural transformation that takes place when a concept is modified by an adjective. How is the informational content of a single concept changed when it is modified by properties that are either strongly associated with the concept (green grass) or those that produce uncommon combinations (sweet grass)? In the present neuroimaging study, we restrict our stimuli to eight nouns (e.g., grass, cookie) and eight adjectives (e.g., green, sweet), such that each object concept is linked to one property with which it is strongly associated. In the scanner, subjects read the concept words (event-related design) and viewed images (block design) that depicted these concepts, and were encouraged to attend to the stimuli for meaning. Each subject participated in 6 runs, from which multivoxel patterns were extracted for noun-words, noun-images, adjective-images, adjective-words, and adjective-noun combinations ("green grass"). Using a multivoxel pattern similarity analysis that compared patterns evoked by words versus images, we isolated voxels within the typical semantic network (e.g., fusiform gyrus, medial temporal gyrus, anterior temporal lobe) that contained conceptual information independent of stimulus modality. Within these voxels, we explored how the neural representations underlying object concepts are transformed in adjective-noun combinations. For each object concept, we computed the correlation between the noun-image pattern and each of the eight adjective-noun patterns; this "resemblance" measure reflects the extent to which the modified object concept resembled the original object concept. We also devised a measure of "property integration" for all possible combinations (including typical and atypical properties) by computing the extent to which the similarity between each adjective-noun combination and the corresponding adjective-image was greater than the similarity between the isolated noun-word and the adjective-image. We found that modifying a concept with a strongly associated property (green grass) results in information that more closely resembles the original concept (grass), and that more property integration occurs with uncommon properties (sweet grass). These complementary analyses suggest that (1) conceptual representations in semantic neural regions contain information relating to multimodal properties associated with that concept, and (2) in adjective-noun combinations, properties that are not already in the representation will be integrated into this concept. Results support a theory in which concepts are dynamic, and are transformed online during language comprehension such that new, relevant information can be stirred into the conceptual structure.

D12 Motor coordination predicts literal and figurative action sentence processing in stroke

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Introduction: Considerable evidence exists for the involvement of sensory and motor systems in concept representation. Crucial questions now concern the precise nature of this involvement. Actions involve many levels of processing, from details of specific movements such as direction and speed, to higher level planning and coordination. If action concepts are grounded in motor systems, what roles do these different levels of representations play? Here, we investigated action performance and action semantics in a cohort of 40 stroke patients in order to examine their relationship. Methods: Subjects performed two action tasks using a planar endpoint robot in an augmented reality environment. One action task required subjects to use paddles attached to each hand to hit as many objects as possible as the objects moved towards the subjects in the horizontal plane (Object Hit task). A second task was similar, except that subjects only hit objects of certain shape and avoided hitting objects of other shapes (Object Hit and Avoid task). Both tasks require bimanual coordination for better performance. We examined Hit Bias (bias in the hand used for hits) and Movement Area Bias (bias in the movement area of the hands). A high bias on either measure indicates a lack of bimanual coordination. Subjects were tested separately on a semantic task, in which they made meaningfulness judgments on sentences with action or abstract verbs. Three kinds of action sentences were used: literal action (They boy lifted the pebble from the ground), metaphoric action (The discovery lifted the nation out of poverty), and idiomatic action (The country lifted the veil on its nuclear program). These three conditions represent levels of abstraction in action meaning, in that literal sentences describe physical actions, idiomatic sentences convey an abstract meaning through a formulaic phrase that uses the same action verb, while non-idiomatic metaphors are at an intermediate level. Abstract sentences (The discovery

eliminated poverty in the country) served as controls. One hundred meaningful sentences (25 in each condition) and 50 nonsense sentences were presented aurally in random order, and subjects gave a yes/no response to each with a buttonpress. We computed scores representing the difference between accuracy in each action condition and the Abstract condition. These difference scores were correlated with measures from the two action tasks using Spearman's correlation. Results: We found that the difference score for each of the action conditions was correlated with bias measures in both tasks, such that a higher bias (reduced bimanual coordination) predicted action-specific reduction in sentence processing accuracy. The overall score in the action tasks showed no correlation. Conclusions: These results show that a higher order action parameter, bimanual coordination, is strongly associated with action semantics in the context of sentence processing. Furthermore, this role persists even when action sentences are metaphoric or idiomatic, and convey an abstract meaning. Thus, higher order action systems of the brain play a causal role in both literal and figurative action sentence semantics, and provide grounding for conceptual content.

D13 Composition of complex numbers: Delineating the computational role of the left anterior temporal lobe

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Introduction: What is the neurobiological basis of our ability to create complex messages with language? Results from multiple methodologies have converged on a set of brain regions as relevant for this general process, but the computational details of these areas remain to be characterized. The left anterior temporal lobe (LATL) has been a consistent node within this network, with results suggesting that although it rather systematically shows increased activation for semantically complex structured stimuli, this effect does not extend to number phrases such as 'three books' (Del Prato & Pylkkänen, 2014). In the present work we used magnetoencephalography to investigate whether numbers in general are an invalid input to the combinatory operations housed in the LATL or whether the lack of LATL engagement for stimuli such as 'three books' is due to the quantificational nature of such phrases. As a relevant test case, we employed complex number terms such as 'twenty-three,' where one number term is not a quantifier of the other but rather, the two terms form a type of complex concept. Methods: 25 native English speakers participated in a number naming experiment where participants viewed rows of numbers and depending on task instruction, named them as complex number terms ('twenty-three'), numerical quantifications ('two threes'), adjectival modifications ('blue threes') or non-combinatory lists (e.g., 'two, three'). Magnetoencephalography activity was recorded during the planning for production, prior to motion artifacts, with primary analyses focusing on the LATL. Results: The comparison between adjectival modification and non-combinatory lists elicited significant increases in activity in the LATL at 150-400 ms, while complex number composition revealed a qualitatively similar increase at 400-600 ms. In contrast, quantificational phrases failed to engage the LATL. Conclusion: Our results show that while the LATL does not participate in the enumeration of tokens within a set, exemplified by the quantificational phrases, it does support conceptual combination, including the composition of complex number concepts. Further, this finding suggests that the LATL is not a general purpose combiner of meanings but rather specializes in some version of conceptual combination, potentially delimited to situations where one combining element characterizes a property of the other. Additionally, the finding of combinatorial activity for our complex number condition sheds novel light on the representation of complex numbers and conforms to theories suggesting that complex numbers undergo a composition process before being produced, as opposed to being holistically processed and retrieved. References: Del Prato, P., & Pylkkänen, L. (2014). MEG evidence for conceptual combination but not numeral quantification in the left anterior temporal lobe during language production. Frontiers in Psychology 5(524).

D14 The grounding of temporal metaphors

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The semantic processing of temporal concepts, while very common in language, is a mystery. According to grounded cognition theories, the processing of conceptual knowledge cued by language relies on the sensory-motor regions of the brain. Does temporal language similarly engage brain areas involved in the processing of experiential time? The grounding of temporal language has been investigated in the domain of experiential space, but not in the domain of experiential time. We hypothesized that some level of grounding is maintained in the temporal accumulators of the brain and in the regions implicated for motion, when time is talked about in terms of motion figuratively. 23 healthy, native-English-speaking undergraduates participated in the fMRI study. The materials consisted of 372 sentences divided into 6 conditions. Sentences in the target condition described temporal events with figurative/fictive motion (FM-time) e.g. "Her seminar stretches across the afternoon" and their static controls "Her seminar is in the afternoon". As comparisons, two other conditions were included. One described spatial layouts using fictive motion (FM-space) "Her backyard stretches across the desert" and control "Her backyard is in the desert". The other described literal motion (LM) "Her arm stretches across the table" and control "Her arm is on the table". Between conditions, sentences were matched for comprehension difficulty via pretest (participant N=16) and the numbers of words, phonemes, syllables, word frequencies, and concreteness. Fillers of semantically and syntactically well-formed sentences were added. During scanning, each sentence was displayed for

2.3 s, and a fixation cross was displayed during the inter-trial interval. In 25% of the trials, a relatedness question appeared at the end to ensure participation. MR data were collected on a Siemens Medical Systems 3T Trio and analyzed using AFNI. Focused analyses were carried out for examining activations in the regions associated with temporal processing (using a meta-analysis of temporal processing studies) and motion processing. Spherical ROIs were placed at coordinates reported in prior literature. The FM-time > FM-time-control showed more activation in ROIs in the following time areas: left inferior frontal gyrus, insula, precentral gyrus and right posterior superior temporal sulcus, claustrum, supplemental motor area; and in the motion area of bilateral posterior superior temporal sulcus. The FM-space > FM-space-control showed more activations in the left posterior inferior temporal sulcus, an area anterior to MT+ and associated with motion semantics. This provides the first evidence of involvement of time processing areas in temporal language. Processing temporal semantics, when temporal events are described with fictive motion, activates some of the areas that function as temporal accumulators to keep track of time intervals, despite the fact that the temporal intervals described in the sentence are long, providing grounding for temporal concepts. Furthermore, this activation is not just due to use of motion verbs, and also not only due to the metaphoric nature of the sentences, because the FM-space sentences compared to their controls do not show this difference. Thus, the temporal nature of the sentences appears to be the critical factor in eliciting activation in temporal regions.

D15 N400 Modulation Profile Across Sentential Contexts Informs Time Course of Semantic Activation During Referential Processing

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To form a coherent discourse representation, comprehenders must regularly establish coreference between anaphors, such as pronouns, and their antecedents. Behavioral, eye-tracking, and event-related potential (ERP) evidence suggest that comprehenders may rapidly resolve pronouns to their antecedents (Shake and Stine-Morrow 2011, Arnold et al. 2000, Osterhout et al. 1997). Moreover, mismatches on coarse semantic features between pronouns and their antecedents elicit a differentiable brain response within several hundred milliseconds (Osterhout et al. 1997). The current study addresses the question of whether more detailed semantic features of the antecedent are retrieved from long term memory at the time of pronoun resolution. In this ERP study, we manipulated the concreteness of sentence-medial nouns, and examined the processing consequences of this concreteness manipulation both at the target noun and further downstream, where a pronoun referred back to the target. If an ERP concreteness effect were elicited at the pronoun, this would constitute evidence that semantic information about the antecedent had been retrieved from long-term memory and, possibly, used to generate a mental image. EEG was recorded from 32 participants as they read for comprehension sentences such as: "The beer (concrete) / joke (abstract) did not go over well, since it didn't suit the guests' taste" (62 items per condition on each of two lists, counterbalanced). Sentences were centrally presented using rapid serial visual presentation (RSVP) (word duration = 200 ms, ISI = 300 ms). Participants were told that they would be given a comprehension quiz after reading the sentences and were discouraged from memorization. After reading all sentences, participants indicated whether they remembered having read each of the critical nouns (half of which they had seen). At the critical noun, we found a robust ERP concreteness effect (concrete more negative than abstract) in the 300-500 ms time window, but no evidence of a later effect (as measured at 500-900 ms) that others have taken as an index of mental imagery. At the pronoun, we found no difference between the concrete and abstract conditions in either the early (300-500ms) or late (500-900ms) time windows. In a secondary analysis, we checked for lexical association priming by the critical noun (a reduced N400 for lexically associated words) at various sentence positions. If lexical association priming by the critical noun became stronger immediately following the pronoun, this could also be taken as evidence of semantic reactivation. We found significant lexical association priming at sentence positions 2, 3 and 4 words following the critical noun, but did not find an increase in priming following the pronoun relative to word positions immediately preceding it. Although null results should be interpreted with caution, our findings are consistent with the idea that detailed semantic information about the pronoun's antecedent was not brought online from long-term memory shortly after reading the pronoun. This could either be because a.) the antecedent's semantic representation remained active from the time that the noun was presented, or b.) the antecedent's detailed semantic representation was not accessed in the course of pronoun resolution.

D16 Event-related brain potentials reflect processing of object-state representations in language comprehension

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The present study examines the ERPs that are related to keeping track of an object's state in language comprehension. Recent work has demonstrated the need to activate multiple representations of the same object in different states, reflecting the 'before' and 'after' of events that cause that object to change. For example, in a sentence such as "the woman will drop the ice cream", the comprehender must represent the ice cream both before and after it has been dropped. Moreover, these distinct instantiations appear to compete during language comprehension (Altmann & Kamide, 2009; Hindy et al., 2012). In this experiment, electrophysiological responses

were collected from the scalp of participants (n=29) while sentences were presented by means of the word-by-word rapid serial visual presentation (RSVP) method. Each stimulus consisted of three sentences. The first sentence describes an event that either involved a minimal change (labelled as "No change") or a substantial change (labelled as "Change") that would happen to the target object (e.g., "The woman will choose/drop the ice cream"). The second sentence referred to the object again (e.g., "And then, she will look at the ice cream"). The third sentence described the object (e.g., "It is a Ben & Jerry's"). ERPs at the time windows 300 ms – 500 ms and 400 ms – 1000 ms after onset of the object name in the second sentence were analysed. No difference in ERP amplitudes were found during the time window 300 ms – 500 ms, regardless of the type of events described in the first sentence. However, the Change condition induced more negative ERPs than the No Change condition at both the anterior and posterior areas of the left hemisphere 400 – 1000 ms. This difference in the ERPs across the two conditions is similar to that observed elsewhere during episodic memory retrieval of attributes of objects in the old/new task (e.g., Curran, 2000; Johansson & Mecklinger, 2003). The findings reveal an electrophysiological response that is consistent with the need to keep track of, and retrieve, object-state representations from episodic memory. There was no component in the ERP differences across condition corresponding to an N400, suggesting that episodic retrieval, rather than semantic integration, mediates object-state tracking during event comprehension.

D17 Frontal theta and disconfirmed predictions *Joost Rommers[1], Danielle S. Dickson[1], James J.S. Norton[1], Edward W. Wlotko[2], Kara D. Federmeier[1]; [1]University of Illinois, [2]Tufts University*

A strategy for dealing with rapid input streams, as characterizes language among other cognitive domains, is to use context to predict likely upcoming information. Despite strong evidence for prediction during language comprehension, the underlying mechanisms -- and the extent to which they are specific to language -- remain unclear. Predictive forward models inspired by action research have been used in accounts of language comprehension, and it has been proposed that prediction is a general neural mechanism for perception and action. Shared mechanisms would presumably manifest as neural signatures of predictive processing that look similar across verbal and nonverbal tasks. Here, we investigated spectro-temporal EEG signatures of dealing with disconfirmed predictions. In nonverbal tasks, similar manipulations have been associated with frontally distributed theta (4-7 Hz) increases. In sentence reading, semantic anomalies have been associated with theta increases, but such manipulations are open to interpretations other than prediction-related processing. In the present study, 32 participants read predictable words or plausible alternatives in strongly constraining contexts ("The children went outside to play/look") and in weakly constraining contexts ("Joy was too frightened to move/look"; Federmeier et al., 2007). Time-frequency representations of power in the four conditions were contrasted using cluster-based permutation tests. A frontally distributed theta increase to plausible alternatives relative to predictable words was seen only in strongly constraining sentences. A late frontal ERP effect from the same contrast, reflecting processing differences for confirmed vs. disconfirmed expectations, correlated with the theta effect across participants. At the same time, removing the phase-locked power (time-frequency analysis after subtracting the ERPs from individual trials) left the theta effect largely unchanged, suggesting related but at least partially distinct signals. These results are in agreement with those observed in nonverbal tasks, where theta has been linked to cognitive control and controlled memory retrieval. Immediately preceding the critical final word, strongly constraining sentences showed an occipitally distributed alpha decrease (8-10 Hz) relative to weakly constraining sentences. Alpha decreases have been associated with attention increases. The alpha constraint effect was correlated with the theta expectancy effect, such that participants with stronger constraint-driven alpha decreases preceding the critical word showed weaker theta increases in response to plausible alternatives (as well as smaller late positivies). Thus, although future research should clarify this, the alpha decrease might reflect enhanced attentional preparation for the input, which co-varies with how the reader subsequently processes the input. Similar pre-stimulus alpha decreases have been observed in processing predictable sequences of non-linguistic visual shapes. Taken together, the spectro-temporal signatures of making and assessing predictions in our sentence reading task appear consistent with mechanisms that are not specific to language.

Language Development, Plasticity, Multilingualism

D18 Repetition priming in object naming is associated with repetition suppression, earlier termination of activity, and changes in task-engaged neural synchrony *Stephen Gotts[1], Alexandra Ossowski[1], Shawn Milleville[1], Alex Martin[1]; [1]National Institute of Mental Health, NIH*

Object repetition commonly leads to long-lasting improvements in the speed and accuracy of identification ("repetition priming"), along with decreased neural activity ("repetition suppression"). In the current study, we use fMRI and overt picture naming (N=32 subjects) to evaluate several prominent models of the relationship between repetition priming and suppression. Subjects named a set of 100 pictured objects 3 times prior to fMRI. During fMRI, they overtly named "old" pictures randomly intermixed with "new" pictures that were matched in category and name frequency. The use of a slow-event-related fMRI design aided in movement artifact separation, as well as

improved isolation of BOLD responses to individual trials for the purposes of task-based functional connectivity analyses. In addition to the standard effects of repetition suppression in occipitotemporal and lateral frontal regions, we also observed a significant alteration in the time course of the BOLD response following repetition, with earlier termination for old pictures, consistent with predictions of Facilitation and Predictive Coding models. Functional connectivity analyses performed on the individual item responses further revealed that: 1) increased connectivity with left inferior frontal cortex during old relative to new pictures predicted greater priming magnitudes across subjects (consistent with the Synchrony model), and 2) increased connectivity with dorsal parietal regions during new pictures also predicted greater priming through slower new RTs, consistent with slowed responding due to a heightened novelty/orienting response. Thus, priming appears to reflect a combination of more rapid, synchronized activity to old pictures and novelty-related slowing and heightened attention to new pictures.

D19 Simultaneous Interpreting Training Induces Brain Structural Connectivity Changes *Alexis Hervais-Adelman[1,2], Barbara Moser-Mercer[2], Narly Golestani[1]; [1]Brain and Language Lab, Faculty of Medecine, University of Geneva, [2]Department of Interpreting, Faculty of Translation and Interpreting, University of Geneva*

Simultaneous interpreting (SI) may be considered to be the most cognitively challenging linguistic task that there is. It demands simultaneous management of two languages and their associated lexico-semantic and syntactic inventories as well as ongoing control over both speech production and perception processes, while buffering and extracting the message of the incoming speech stream before rendering it in the appropriate target language. Recent functional neuroimaging investigations of SI have revealed that the network of brain regions implicated in executing this extreme language control task includes not only classical language areas, but also several regions associated with executive control and working memory, including the dorsal striatum, pre-SMA and left inferior frontal gyrus. Subsequent longitudinal investigation demonstrated that training reduces the recruitment of the right caudate nucleus during SI, and that it produces distributed functional alterations detectable with multivariate pattern classification methods. Here we pursue the longitudinal investigation of the broad impact of SI training on the brain by applying whole-brain multivariate analyses to identify brain-wide patterns of grey and white-matter changes induced by SI-training 32 students enrolled in a Master's programme in conference interpreting underwent T1 structural (1mm*1mm*1.2mm) and diffusion-weighted imaging (2mm*2mm*2mm, 64 gradient-directions) at the beginning and end of their 15-months of training. A group of 33 matched controls was scanned at the same interval with the same protocols. Multivariate analyses of grey-matter voxel-based morphometry data were carried out, which demonstrated that distributed structural adaptations throughout the network of brain areas known to be functionally involved in SI significantly distinguish the SI trainees from controls. In order to further explore the structural differences, a whole-brain connectomic approach was used. Brain structural images were automatically parcellated into 74 cortical and 9 subcortical regions per hemisphere in addition to the corpus callosum (subdivided into 5 regions) and the brain-stem. These regions were used as seeds for whole-brain connectivity analyses. The likelihood of connection from each to every other cerebral parcel was calculated using probabilistic streamline tractography. The resulting 172 * 172 region connectome was analysed as follows. Connectomes were individually thresholded to include only their top 5% of most probable connections, and the within-subject difference between time 1 and time 2 was calculated. Principal components analysis (PCA) was carried out on all connections for which data had been retained for over 50% of the participants (739 connections). The first 48 components of the PCA accounted for over 90% of the variance, and were submitted to a linear discriminant analysis (LDA). A 65-fold leave-one-out cross-validation procedure was applied, in which LDA clearly separated the two groups (classification accuracy: 92%). Permutation-testing (5000 permutations) was carried out, and the classification was found to be extremely reliable ($p<.0001$). Results indicate that SI training results in a pattern of white-matter connectivity changes that is consistent, and different to that of control participants. Forward stepwise regression determined that the PCA components significantly contributing to the discrimination mapped onto intrahemispheric connections involving left inferior frontal gyrus and bilateral temporal regions, regions shown previously to be functionally implicated in SI.

D20 ERP and time-frequency analysis of intra-sentential codeswitching in bilinguals *Kaitlyn Litcofsky[1], Janet G. van Hell[1,2]; [1]Pennsylvania State University, [2]Radboud University Nijmegen*

A hallmark of bilingual speech is that bilinguals often alternate between their two languages, as in "I ate huevos para el desayuno [eggs for breakfast]". While this codeswitching is seemingly fluent in natural conversation, previous ERP research (Moreno et al., 2002, Ng et al., 2014; Proverbio et al., 2004; Van Der Meij et al., 2011) on intra-sentential codeswitching has found that the comprehension of codeswitches, as compared to non-switches, incurs a processing cost in terms of an N400 and a late positive component (LPC), indicating reliance on both lexical and sentence-level integration processing. However, these studies have not systematically studied the effect of language switching direction (switching from the first to the second language, or vice versa). This despite the fact that studies on isolated item language switching, in which unrelated single pictures or words are presented and the language of the stimulus or of the response can alternate

between languages across trials (Meuter & Allport, 1999), have found that switch costs are modulated by the direction of the language switch. Moreover, codeswitching research has only focused on traditional evoked response (component) analyses of EEG. Oscillatory dynamics are another method of EEG analysis, which reflect synchrony of functional neural networks (Bastiaansen & Hagoort, 2006). Synchronization (power increases) indicates active engagement of the functional network and de-synchronization (power decreases) suggests disruption of the network. Power changes in theta (4 – 7Hz) and gamma (> 30Hz) frequency bands have been associated with lexico-semantic processing, and power changes in beta band (15 – 30Hz) with sentence-level unification and integration (Bastiaansen & Hagoort, 2015). Time-frequency analysis has recently begun to be used to study language processing, but not yet bilingual codeswitching. The present study examined the effect of language switching direction on the comprehension of intra-sentential codeswitching using both ERP component and event-related changes in EEG power analyses. Twenty-five highly proficient Spanish-English bilinguals read sentences that contained intra-sentential codeswitches in both switching directions, along with unilingual sentences in each language, while EEG was recorded. ERP analysis showed that switches elicited only an increased LPC, and only for switches going into the weaker language (compared to unilingual weaker language sentences), but not for switches going into the dominant language (compared to unilingual dominant language sentences), suggesting that codeswitches require sentence-level restructuring related to activation of the weaker language. Time-frequency analyses found that switches into the weaker language showed desynchronization in the lower beta (15 – 18Hz) frequency range between 300 and 600ms, while switches into the dominant language showed synchronization in the theta frequency range between 300 and 650ms. These time-frequency results suggest that switches into the weaker language disrupt ongoing sentence-level integration processes as compared to non-switches, in line with ERP results, while switches into the dominant language engage lexico-semantic processing to a greater degree than non-switches, though the ERP results did not find such effects. This study also shows that studying traditional ERPs and oscillatory dynamics together provide a more comprehensive picture of the neurocognitive processing of intra-sentential codeswitching.

D21 Working memory and context of learning: Accounting for individual differences in second-language processing signatures over time

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Investigations into the neurocognitive mechanisms underlying linguistic processing among late second language (L2) learners reveal significant variability (e.g., Foucart & Frenck-Mestre, 2011). Despite a number of studies that have explored factors that may impact L2 neurocognitive responses, research has yet to fully account for the variation that exists among adult L2 learners. Recent theoretical claims suggest that L2 development may be mediated by domain-general cognitive factors, such as individual differences in working memory (WM; e.g., Williams, 2012). Furthermore, research suggests that the role of WM in L2 development may vary in different learning contexts, such as at home or study abroad settings (e.g., Sagarra & Herschensohn, 2010). The current study examines the complex relationships between the neurocognitive mechanisms underlying L2 development, individual differences in WM ability, and context of learning (At Home and Study Abroad) in order to provide explanatory insight into issues of L2 variability. Twenty-six native English-speaking participants, who were enrolled in intermediate-level Spanish courses either at their home university (At Home) or abroad (Study Abroad), completed a cognitive assessment session followed by pre- and post-semester language assessment sessions. During the cognitive assessment session, participants completed three measures of WM from which a composite score was calculated. During the language assessment sessions, event-related potential (ERP) data were collected while participants completed a Spanish grammaticality judgment task designed to assess processing of morphosyntactic violations. ERP data were examined in two time windows: 300-500ms ("N400") and 600-900ms ("P600"). No significant group-level effects were evidenced, however, individual learners' neural responses to morphosyntactic violations varied greatly at both pre- and post-testing within both groups, falling along a negative to positive continuum in both time windows. In order to investigate the relationship between WM and individual differences in ERP responses, pre- and post-testing effect magnitudes were calculated using mean amplitude of violation minus correct items in a central-parietal region of interest in the time windows indicated. Change in overall response magnitude (size of neural response over both time windows) and response dominance (relative N400- or P600-dominance) from pre- to post-testing were also calculated for each participant (following Tanner, Inoue, & Osterhout, 2014). These variables were submitted to correlation and regression analyses with WM composite scores. Within the At Home group, higher WM was associated with a greater change in overall response magnitude for morphosyntactic violations, such that higher WM learners exhibited a greater increase in neural response size from pre- to post-semester testing. Regression analyses further revealed WM to be a unique positive predictor of increase in response magnitude. No relationship was found between WM and morphosyntactic processing for the Study Abroad group. These results indicate that WM may indeed play a role in the development of neurocognitive processing of morphosyntax among intermediate-level learners in classroom settings, specifically for a redundant structure

that occurs frequently in L2 input. These results underscore the importance of examining the role of individual differences in domain-general cognitive abilities in L2 development and processing among learners in different learning contexts.

D22 Bilingualism modulates the white matter tracts of the arcuate fasciculus

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Recent diffusion tensor imaging (DTI) studies have shown that bilingualism induces structural white matter (WM) changes. So far, previous studies have mainly investigated where in the brain the effects of bilingualism are seen while research on more local effects has been scarce. Here, we examined how bilingualism affects local WM connections along major language trajectories. More specifically, we focused on changes in the arcuate fasciculus, a pathway connecting temporal, parietal and frontal language regions via one direct and two indirect trajectories between Broca's and Wernicke's regions. Full-brain MRI data was acquired with 64 diffusion directions using a 3T Siemens scanner. Motion and distortion corrections for image and direction data were applied before robust tensor estimations, data quality assessments, and deterministic tractography of the arcuate, which were done using ExploreDTI. Placement of ROIs was based on known anatomical regions and unrelated/divergent tracts were trimmed with NOT ROIs. Bilateral tractography dissections of the three segments of the arcuate were obtained from 24 healthy young adults (9 early bilinguals, 15 late second language speakers), matched for demographic features. Early bilinguals (Finnish-Swedish) had learned both their languages since birth, while late L2 speakers had had no bilingual exposure before school. Both late L2 and early bilingual groups had learned English in school within the Finnish basic education program. Both groups rated themselves as highly proficient in all aspects of English and reported active usage of English. Due to their identical exposure to foreign language in school and to their high proficiency in English, emerging differences between the groups can be attributed to the difference in their bilingualism status. Tract-Based Spatial Statistics (TBSS) revealed significantly higher fractional anisotropy (FA) values for early bilinguals only in the left temporal projection of the arcuate. A further a-priori constrained TBSS analyses of the arcuate revealed more fine graded patterns of higher FA values for early bilinguals bilaterally along multiple segments. For segmentwise analysis, the mean and standard deviation of the FA values were calculated and fed into one-way ANOVA. The results showed highly significant differences between groups in the left long segment, along with less pronounced, yet significant, differences in all other segments, excluding the left posterior segment. The late L2 speaker group did not exhibit higher FA values in any of the analyses. The left long segment has been suggested to relate to phonological language functions, while left indirect trajectories have been proposed to underlie semantic language functions. The FA difference along the left long segment might therefore be best explained in terms of early bilinguals developing more integrated pathway to account for increased phonological processing demands. The absence of an effect on the left posterior segment backs up the theory that semantic representations are shared across languages, as proposed by e.g. the Revised Hierarchical Model of bilingual language processing. Taken together, our results suggest that bilingualism causes specific WM changes along major language pathways. Changes were the most evident in the left long segment, possibly due to bilinguals facing increased phonological processing demands from early on.

D23 A new approach to examine the relationship between brain responses to Mandarin lexical tone changes and reading ability

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The present study aims to examine how brain responses to Mandarin lexical tone changes correlated with reading ability by employing the ensemble empirical mode decomposition (EEMD) method for signal decomposition. Mismatch negativity (MMN) is an event-related potential (ERP) component to index auditory change detection in the pre-attentive stage. Previous studies used the multi-deviant oddball paradigm with a low dipping tone (T3) as standard (80%) and high rising (T2) and high level tones (T1) as large and small deviants (10% for each) in adults and children (aged 4 to 13 years). The large deviance (T1/T3) elicited typical MMNs in both adults and children. As for the small deviance (T2/T3), adults and older children (over 10 years old) showed MMNs while younger children from 4 to 10 years old tended to show positive mismatch responses (P-MMR). The nature of P-MMR remains largely unknown, yet the transition from P-MMR to adult-like MMN has been suggested a developmental transition, which might be affected by factors such as neuronal maturation, stimulus features, familiarity and more. Some studies have suggested that transition from P-MMR to MMN may represent the developmental trade-off of two overlapping components, MMN and a slow positive wave. This study utilizes the EEMD to extract the component signals and to examine how the individual event-related mode (ERM) correlated with other behavioral measures, including WISC-III, PPVT-III, Phonological Awareness tests (PA) and Graded Chinese character recognition test (CCRT) and

Chinese phonetic symbols Zhu-Yin-Fu-Hao recognition (Zhuyin). Two ERMs (ERM5 and ERM6, frequency ranging from 3 to 6Hz and from 1 to 3Hz, respectively) were identified to compose the MMN and P-MMR in the original ERP analysis. As expected, both ERMs in the case of large deviance did not reveal any significant correlation with behavioral measures. As for the T2/T3 contrast, both ERMs showed significant negative correlation with age. Moreover, the mean amplitude of ERM5 revealed significant correlations with verbal IQ, PPVT, CCRT, and Zhuyin recognition between 250 to 300 msec. Children with higher WISC verbal, CCRT, PPVT and Zhuyin scores tend to show more negative ERM5 in this time window. The mean amplitude of ERM6 also revealed significant negative correlations with CCRT from 100 to 300 msec. These findings support that there might be two overlapping components contribute to the transition of polarity of mismatch responses in developmental data. However, only ERM5 showed better correlation with reading related measures. Compared with the traditional ERP analysis, the new approach for signal decomposition successfully increases the signal-to-noise ratio of event-related brain response and the sensitivity in relating the brain response with behavioral measure.

D24 Examining structural lateralization in language areas of the brain using components of volume

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The functional lateralization of language within the brain has received considerable attention in previous research, both for typical and disordered populations. Results often show a left dominance in activation for language tasks once the brain is fully developed, though the divide is more complicated when different communication skills are examined more specifically (Brown et al., 2005). Structural comparisons of language regions made between hemispheres are typically evaluated volumetrically. However, results of more recent research show that the components which make up cortical volume, surface area, and thickness have distinct genetic origins with independent developmental trajectories (Brown & Jernigan, 2012). The goal of this research is to analyze five cortical areas associated with language (Greve et al., 2006), looking individually at each hemisphere across measures of thickness, area, and volume. This could indicate that these measures should be examined individually within the cortex if they are inconsistent for a specific region. It will also specify if lateralization is consistent across measures. Five subjects were examined in this study from the Pediatric Imaging, Neurocognition, and Genetics (PING) database http://ping.chd.ucsd.edu. As part of PING protocol, potential participants were excluded if they indicated any serious developmental, psychiatric, or neurological disorder, history of brain injury, prematurity, head trauma marked by a loss of consciousness greater than thirty minutes, or maternal prenatal substance use lasting for at least one trimester of the pregnancy, or if they were unable to receive a MRI for any reason. MRI imaging data for participants across sites was taken using a standardized protocol set out by the PING guidelines. All subjects were male, from 15.25 to 17.83 years old, with normal language skills. Absolute measures for area and thickness were taken from the PING database for the pars triangularis, pars opercularis, transverse temporal, superior temporal, and whole cortex for both hemispheres. Measures of area and thickness were multiplied for each area to calculate volume. A laterality index (LI) was used to compare the measures (Greve et al., 2013). The LI was found by subtracting the right measure from the left measure, and then the resulting difference is divided by the sum of the right and left measures. A negative score would indicate stronger right lateralization; a positive would indicate stronger left. This facilitated the evaluation of the relationship between the different amounts of laterality across thickness, area, and density. Results indicate certain patterns between scores and hemispheres for certain areas. Overall, lateralization of volume was most strongly driven by surface area, especially in the regions that appeared to favor one hemisphere more substantially, the pars triangularis, Transverse Temporal, and Superior temporal. The whole cortex and the pars orbitalis were not as substantially lateralized, and did not show the same relationship between surface area and volume. Of the more lateralized regions, both within the temporal lobe, showed a left lateralization, while the pars triangularis appeared more right lateralized. These results favor the need to examine each of these measures individually, as comparisons between hemispheres across the three measures were not consistent.

D25 Verbal memory specialists (Vedic Sanskrit Pandits) show white matter increases in language, memory and visual tracts

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Preliterate cultures rely on oral tradition for recording and maintaining their cultural heritage. The brain organization that supports this practice is unknown because populations studied with neuroimaging are typically sampled from highly literate cultures where oral knowledge is de-emphasized. The Vedic Sanskrit Pandits of the Indian subcontinent, however, maintain a formal oral tradition dating back over 3000 years. Pandits train for ~10 years from youth to orally memorize and recite Vedic Sanskrit texts containing 40,000+ words, preserving exact pronunciation and invariant content. After training is complete they continue spending several hours daily reciting in groups and individually.. We examined changes in white matter in a group of 21 Pandits and 21 controls, matched for gender, age, handedness, eye-dominance,

and multilingualism. We acquired diffusion data with 60 diffusion encoding directions using single-shot EPI with a b-value of 700 mm2/s, and 10 b0 volumes (saved as a single averaged volume). We then used FSL's Diffusion Toolbox (FDT) to conduct an atlas-based Probabilistic Tractography analysis. We found increased white matter in Pandits in all 20 of the major JHU-ICBM white matter tracts. In 17 tracts, the magnitude of increase exceeded 10% of the total atlas tract size. The largest changes occurred in Superior longitudinal fasciculus (54% of the right JHU-ICBM atlas tract, 39% of the left), Cingulum hippocampus (52% left, 11% right), Cingulum cingulate gyrus (44% left, 25% right), Inferior frontal occipital fasciculus (49% left, 34% right), Inferior longitudinal fasciculus (42% left, 25% right), and the temporal part of the Superior longitudinal fasciculus (29% left, 17% right). Our data suggest that long term, intensive recitation and memorization of oral language content, phonology and prosody results in widespread changes in white matter tracts, including ones considered crucial for language comprehension. These latter changes may indicate plasticity related to specialization in precise language production, and close monitoring of and synchrony with others' production. Changes in MTL and ACC tracts likely indicate use of these systems for memory store and access, with continuous short term processing in the MTL coordinated with long-term ACC storage and retrieval. The findings indicate the Pandits serve as a very useful model for studying neural plasticity in an otherwise normal population.

D26 Early vocabulary growth and white matter microstructure: dorsal or ventral? *Salomi Asaridou[1], Özlem Demir[2], Susan Goldin-Meadow[2], Steven Small[1]; [1]Department of Neurology, University of California, Irvine, [2]Department of Psychology, University of Chicago*

Learning new words requires mapping sounds to articulation (the integration of auditory and motor information), as well as mapping sounds to meaning (the integration of auditory and semantic information). It is suggested that these two processes are supported by dorsal and ventral processing streams emanating from auditory cortex. Previous studies focusing on adult second language learning provide evidence for the involvement of both tracts in novel word acquisition. However, little is known about the role of these streams in first language vocabulary acquisition. In the current study we wanted to test whether one or both of these two streams are associated with vocabulary growth in typically developing children. More specifically, we investigated the degree to which white matter microstructure in the left dorsal and ventral tracts is related to individual differences in the early vocabulary acquisition rate. The rate (slope) of vocabulary growth was estimated based on longitudinal observations of spontaneous child – caregiver interactions between the age of 14 – 58 months on 62 children selected from the Chicago area. From that cohort, DTI data were acquired from 20 children, at the age of 7-9 yrs. The data were preprocessed and the tensors fitted using FSL's Diffusion Toolbox. Participants' FA data were aligned into common space using the nonlinear registration, and the mean FA skeleton representing the centres of all tracts common to the group was created using Tract-Based Spatial Statistics. The aligned FA data were projected onto this skeleton. We used the JHU white-matter tractography atlas in FSL to create tract-of-interest (TOI) masks for the superior longitudinal fasciculus (SLF) and the inferior fronto-occipital fasciculus (IFOF) in the left hemisphere. Mean FA values in these masks was estimated and fed into a multiple regression with the children's slope of vocabulary growth, age, gender, parental education and income as predictors. The regression equation was significant ($F(5, 10)= 4.233$, $p =0.025$), with $R^2= 0.5187$. The results showed that the slope of vocabulary growth was a significant predictor of FA in the temporal part of the left SLF ($t=3.418$, $p= 0.006$), after correcting for the number of tracts/comparisons. None of the other predictors reached significance. Our study demonstrates that individual differences in early vocabulary growth during preschool years is associated with differences in FA in dorsal tracts for language at school age. More specifically, children who acquired vocabulary at a faster rate in early childhood showed higher FA in the temporal part of the left SLF. This is in agreement with the literature on adult phonological second language acquisition findings and supports the importance of auditory and motor information integration in novel word acquisition. Our results are also in agreement with concomitant grey matter findings in the same sample that reveal a significant association between the pace of vocabulary growth and cortical thickness in the left supramarginal gyrus, which is part of the dorsal stream for language.

D27 The neural network of reading: Does writing help the brain accommodate for linguistic diversity? *Aurelie Lagarrigue[1], Marieke Longcamp[2], Jean-Luc Anton[3], Bruno Nazarian[3], Laurent Prevot[4], Jean-Luc Velay[2], Fan Cao[5], Cheryl Frenck-Mestre[2]; [1]Brain and Language Research Institut, CNRS Université d'Aix-Marseille, France, [2]Lab. Neurosciences Cognitives, UMR 7291 CNRS Université Aix Marseille, France, [3]Centre IRMf, Institut des Neurosciences de la Timone, UMR 7289 CNRS Université Aix Marseille, France, [4]Lab. Parole et Langage (LPL) - UMR 6057 - CNRS Université de Provence, France, [5]Michigan State University*

INTRODUCTION The languages of the world vary substantially across all levels of processing, from their phonetic inventory to syntactic structures. The mapping from spoken to written language is a typical example of this cross-linguistic variation. We used fMRI to examine the impact of the type of training (handwriting vs. pronunciation) on the brain network involved in reading words when adult French readers learned Chinese. Moreover, we examined whether learning generalized to novel characters that shared common (phonetic or

semantic) radicals. Learning morpho-syllabic characters via writing should shape the spatial distribution and the level of activation of the brain network sustaining reading, towards a more Chinese-like network. Such should also generalize to new characters that share radicals with trained characters. METHOD Twenty one French students enrolled in Chinese classes learned 24 characters via writing and 24 via pronunciation, an hour per day for five consecutive days. In both conditions, the Chinese character was presented along with the corresponding pinyin, its auditory pronunciation and the written translation in French. Depending on the modality, participants either wrote the character or pronounced it. Accuracy was tested using pencil and paper tests. fMRI images were acquired using a 3-T MEDSPEC 30/80 AVANCE whole-body imager (Bruker, Ettlingen, Germany), We used an event-related factorial design. fMRI was measured during a reading task that required access to semantic and phonological features. A functional localizer was run to delineate the brain network involved in the actual writing and pronunciation of known Chinese characters. Images were pre-processed using SPM8. Individual functional images were entered in a first level GLM with reading trials modeled as events convolved with the HRF. In the second level analysis, we used GLMflex, (http://mrtools.mgh.harvard.edu/index.php/Main_Page, Aaron Schultz) and modelled Training modality (Writing vs Pronunciation); Radicals (Semantic vs Phonetic) and Generalization (trained vs. new) as well as their interactions. We report the brain activations influenced by the training modality ($p < .05$ cluster-wise corrected threshold) RESULTS and CONCLUSIONS Resuts showed a main effect of training modality. We found greater involvement of bilateral fusiform gyri and superior parietal lobules, brain regions previously highlighted as being preferential for reading Chinese compared to alphabetical scripts, for characters trained by writing. The left superior parietal lobule corresponds to one of the main activation peaks found in the writing localizer task. In addition, the interaction between Training and Character indicated stronger activation of the left superior frontal gyrus,(Exner's writing area), and of the left primary motor cortex when participants read novel characters sharing radicals with handwritten-trained characters. These activations matched the network defined with the localizer. Finally, the left middle frontal gyrus was more strongly activated for new characters with semantic radicals, but only when the radicals had been trained by handwriting. Together our results support the idea that accommodation of the brain to a new writing system is facilitated by repeated writing of the characters (Cao et al., 2013). They also strongly suggest that when readers are faced with new Chinese characters, their available writing knowledge is reactivated.

D28 The relationship between hemispheric lateralization for speech production and language proficiency in young children: A longitudinal fTCD study

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Left hemisphere dominance for language processing is well characterised in adults (Vigneau et al., 2006; Price, 2012). Whether this leftward asymmetry develops through childhood, and whether it relates to language proficiency, is less clear (Bishop, 2013; Paquette et al., 2014). Research focusing on hemispheric dominance for language processing in children has been sparse, in part because of the strict movement constraints of many neuroimaging techniques. Consequently, many studies of child language processing adopt passive speech perception tasks with neonates (e.g. Mingawa-Kawai et al., 2012) or higher order language tasks with older children who have begun school. These latter studies report left-lateralized activity that develops with age (Szaflarski et al., 2012) and proficiency (Groen et al., 2012). However, given the individual variation in strength of hemispheric dominance, it is possible that cross-sectional designs or those that do not have online measures of task performance may underestimate developmental effects on the strength of lateralization. Functional transcranial Doppler sonography (fTCD) is a fast and non-invasive way of establishing hemispheric dominance during cognitive tasks (Deppe et al., 2004). The technique measures relative changes in the speed of blood flow in left and right middle cerebral arteries compared to a baseline period of rest. In the current study we used fTCD to examine lateralization of language processing in 18 preschool children (mean age at time 1 = 3.8 years (range 3.2 – 4.3). Children completed a video animation description task, while fTCD data were collected (Bishop et al., 2013). They also completed a battery of standardized and experimental language assessments including handedness, BAS-III verbal and nonverbal assessment, rapid automatized naming, letter knowledge, digit span and a test of lipreading skill. The same children were tested again 12 months later on both the fTCD task and on the same battery of language assessments. In addition, since the children had started formal literacy tuition, they were also tested on early word reading. Given the very young age of the participants in the study, a number of them had difficulty in remaining quiet during the baseline period. Therefore care has been taken to remove trials in which the baseline may have been ineffective at normalizing blood flow speed. Preliminary data analyses suggest an increase in the proportion of children categorised as left lateralised from time 1 to time 2. The longitudinal relationships between hemispheric lateralization for language and performance on the off-line language measures will be reported. These data have the potential to offer unique insights into individual variability of functional lateralization and its relationship to language and literacy development in the early years.

D29 Improving foreign accent by optimizing variability in vocal learning *Anna J Simmonds[1], Robert Leech[1], Richard J S Wise[1]; [1]Imperial College London, UK*

Rapid vocal motor learning is observed when acquiring a language in early childhood, or learning to speak a second language in later life. Accurate pronunciation is one of the hardest things for a late learner to master and they are almost always left with a non-native accent. Here we propose a novel hypothesis that this accent could be improved by optimizing variability in pronunciation attempts during learning. We investigated behavioral and neural variability using high-resolution fMRI optimized for the striatum, while still including peri-sylvian regions. Twenty-eight participants were scanned while repeating bisyllabic novel non-native words (Mandarin and Spanish) and bisyllabic English non-words. We grouped participants according to their variability in performance (low and high), measured by change in the acoustic signal. In low variability participants, activity declined over time during non-native speech in bilateral caudate and thalami and right putamen, as well as in right inferior and middle frontal gyri and right superior temporal gyrus. In high variability participants, activity declined only in bilateral inferior and middle frontal and middle temporal gyri. Region of interest analysis in the caudate revealed that activity during native speech declined over time for both groups. Low variability participants also demonstrated a decline in caudate activity during non-native speech, and this activity was maintained for longer in high variability participants. Much of the neurobiology of human vocal motor learning has been inferred from studies on songbirds. Essential for song learning is a pathway, the homologue of mammalian cortical-basal ganglia 'loops', which includes the avian striatum. Jarvis (2004) put forward the hypothesis that as in songbirds there exist two pathways in humans: one for learning speech (the vocal learning pathway), and one for production of previously learnt speech (the motor pathway). Learning novel motor sequences that are necessary for accurately pronouncing foreign speech is a challenge, and we argue that late learners of a foreign language may end the learning phase too early. They return to the motor pathway and their original native motor patterns for producing speech, which results in speaking with a foreign accent. Further, we suggest that optimal variability in behavioral performance maintains activity within the vocal learning pathway and supports accurate pronunciation. Recent theoretical and experimental work on motor learning suggests that variability in the motor movement is necessary for the development of expertise. We suggest that when using the motor pathway production is stable, with little trial-by-trial variability (as in our low variability speakers). When using the vocal learning pathway, trial-by-trial variability gradually increases, reflecting an exploratory phase in which the learners try out different ways of pronouncing the words, before decreasing and stabilizing once the 'best' performance has been identified (as in our high variability speakers). The hypothesis proposed here could be tested using behavioral interventions that optimize variability and engage the vocal learning pathway for longer, with the prediction that this would allow them to develop new motor patterns that result in more native-like pronunciation accuracy. Reference: Jarvis, E.D. (2004) Ann N Y Acad Sci 1016, 749-777.

D30 Visual properties of object semantics are experience related *Peter Boddy[1], Eiling Yee[1,2]; [1]Basque Center on Cognition Brain and Language, [2]University of Connecticut*

Because sensorimotor accounts hold that object representations are experience-based, they predict that representations of objects with which we have relatively more visual experience should involve brain areas supporting vision more than those with which we have relatively less. In line with this, accessing representations of "more-visually-experienced" objects should interact with performance on a concurrent visual task more than "less-visually-experienced objects", because of competition for shared neural substrates in brain areas supporting both visual task performance and representations of "visually-experienced" objects. In the current study, participants performed a Multiple Object Tracking visual task while making verbal concreteness judgments about auditorily presented object names which varied (according to ratings from separate participants) in the relative amount of visual experience with which they are associated (e.g. "fork" = less-visual, "photo-frame" = more-visual). In experiment 1, accessing representations of "more-visual" objects elicited more interference to the correct performance of the visual task than "less-visual" objects. In experiment 2, participants had greater difficulty, as indexed by RT latencies, making concreteness judgments on "more-visual" objects than on "less-visual" objects while performing the visual task. Thus, thinking about "more-visual" objects can interfere with performing a visual task, and performing a visual task can interfere with thinking about "more-visual" objects. When taken together, these complementary results suggests that: (a) the conceptual representations of frequently seen objects share resources with parts of the visual system required to perform Multiple Object Tracking, (b) visual information is accessed when performing concreteness judgments on "more-visual" words, (c) experience determines how much of an object's representation is encoded in regions that support visual processing.

D31 Development of neural processes for language in young children: A longitudinal event-related potential study *Amanda Hampton Wray[1]; [1]Michigan State University*

Language skills develop rapidly throughout the preschool years. Children progress from simple, two- to four-word utterances to novel, connected discourse with relatively

complex syntactic structures in a short period of time, typically between two and five years of age (Bates et al., 2003). Additionally, rapid changes in neurodevelopment occur during this same time period, including experience-based synaptic pruning and myelination (Huttenlocher & Dabholkar, 1997), which fine-tune cognitive functioning . To date, few studies have used event-related brain potentials (ERPs) to evaluate neural processes underlying language in young children, during this period of rapid neural change. These studies have revealed that toddlers and preschool-aged children exhibited an N400-like component elicited by semantic anomalies (Silva Pereyra et al., 2005a; Silva-Pereyra et al., 2005b), which are thought to index ease of lexical access or integration (Kutas & Federmeier, 2011), as well as P600-like responses to violations of syntactic structure (Oberecker et al., 2005, Silva Pereyra et al., 2005a; Silva-Pereyra et al., 2005b), which are thought to reflect difficulty of syntactic repair and/or reanalysis (e.g., Friederici, 2002, Kaan et al., 2000). However, studies evaluating the developmental trajectory of these neural processes underlying language have been limited to cross-sectional studies. The present study aims to extend the existing literature by evaluating the longitudinal changes of neural processes underlying language in typically developing children from age four to five. The current study consisted of typically developing four- and five-year-olds who were part of a larger longitudinal study on developmental stuttering. At age four, children completed receptive and expressive language, nonverbal IQ, phonological processing, and working memory tasks. ERPs were recorded at age four and again at age five using an ecologically valid narrative cartoon overlaid with auditory sentences (Weber-Fox et al., 2013). The sentences contained five linguistic constraints: semantic anomalies, phrase-structure violations, regular verb agreement violations, irregular verb agreement violations, and phrase-structure violations embedded in jabberwocky sentences, with canonical sentences for each constraint. Children viewed five cartoons at age four and five different cartoons at age five, such that no child watched the same cartoon in consecutive years. Results revealed that the development of neural processes underlying semantics and syntax from age four to age five varies depending on specific aspects of linguistic constraints. Compared to syntactic processing, semantic processing was more adult-like, with the presence of an N400 at age four that remains quantitatively similar at age 5. In contrast, adult-like neural processes for phrase structure violations, indexed by the P600, emerged at age four and became more robust at age five, while regular verb agreement violations only began to elicit a later positivity at age five. These findings reveal differentiated time courses for language processing in typically developing children. Understanding longitudinal changes in neural processes for language can provide valuable information about language development. Furthermore, a more refined understanding about the developmental time course and ERP patterns associated with subsystems for language can serve as a foundation for interventions aimed at improving language abilities in young children. (NIH NIDCD DC00559)

Lexical Semantics

D32 An episodic component of lexical knowledge

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The role and content of the lexicon has been recently debated in the psycholinguistic literature. From the point of view of some connectionist and radical pragmatic approaches, meaning is always constructed by integrating cues from different sources, and in that sense the 'meaning' of a word does not exist independent of context. One empirical issue that has been brought to bear on this matter is the pervasive priming between event-related nouns and typical participants, agents and instruments. The type and amount of information that can be quickly accessed from the lexicon, as shown by these experiments, argues against those theories that posit a rigid meaning associated with words, favoring a more shallow, context-dependent access to various types of information, as in connectionist models. An alternative interpretation is that lexical semantics is stored more or less rigidly, but that there is also a store of instances where these words were used, episodes, which are frequently accessed. In this work we tested this prediction by using priming and event related potential (ERP) studies. In the first set of experiments, we show that the reported priming 'promiscuity' is also present in our set of Spanish stimuli. We then show that the N400 component of centro-parietal ERPs also displays evidence of the aforementioned facilitation. In our third experiment, we tested the hypothesis that these priming relationships are different from the usual semantic priming by the application of a bimodal priming paradigm combined with EEG recordings. We selected as primes ambiguous nouns that denote events, agents, participants and instruments of events, but which also have another meaning unrelated to the event. We created context sentences that bias the meaning of these items toward either the event meaning or the semantic meaning, and we also collected target words that are related to the meaning of the primes in each type of context. Classical results predict that at very short SOAs there should be no advantage for congruent over incongruent prime-target pairs in the case of regular semantic priming. On the other hand we predicted an advantage both in reaction times and modulation of ERPs for congruent prime targets in the event condition. In order to reach the lowest SOA we used bimodal presentation of stimuli, sentences and prime words were presented serially in the visual modality and targets were presented in the auditory modality at the same time as the primes. The results show that the facilitation of usual lexical semantic relationships and those related to events is different, both

in reaction times and ERPs. We argue that this difference is more consistent with our model than with alternative interpretations and we propose that this memory for events is a form of episodic storage.

D33 Vertical presentation effects to lexical access and predictability in the cerebral hemispheres

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We recorded ERPs in two divided visual field (DVF) experiments to investigate the influence of sentential context on lexical access in the brain hemispheres. Recent N400 evidence suggests both hemispheres are sensitive to contextually-determined predictability, with the left employing more predictive strategies, and the right more integrative mechanisms (Wlotko&Federmeier, 2007;2013). One concern regarding DVF studies, however, is potentially lower visual acuity to words presented in the left visual field (LVF), which may systematically disadvantage right hemispheric processing (Bourne, 2006). To exclude this confound, we present two ERP studies of predictability and frequency, using horizontal and vertical DVF presentation, respectively. Predictability of context sentences (high/low), frequency (high/low) and visual field of presentation (LVF/RVF) of target words were manipulated. Item sets (as in Dambacher et al., 2012) consisted of a context sentence presented in it's entirety, followed by word-by-word presentation of a neutral host sentence, in which the lateralized target word appeared either horizontally (Exp. 1) or vertically, read top-to-bottom (Exp. 2). Horizontal presentation: P2 (100-250ms) analyses yielded a global three-way interaction. High frequency words presented to the RVF(left hemisphere) yielded a greater positive deflection for low compared to high predictability targets. Only low frequency words presented to the LVF(right hemisphere) exhibited a significant P2 effect of predictability. This may reflect hemispheric differences in early lexical processing, with high frequency words being accessed more easily after RVF presentation while low frequency words require larger semantic network support for access, enhanced by LVF presentation (e.g. Beeman and Chiarello, 1998). Later N400 (400-600ms) results at centro-parietal sites showed main effects of predictability and frequency, a two-way interaction between predictability and visual field, and a three-way interaction. N400 effects for the RVF were inversely proportional to target word frequency, with low frequency words showing larger predictability effect than high frequency words. LVF presentation showed no significant N400 modulations. Vertical presentation: P2 analyses revealed no significant predictability modulations for either visual field of presentation, possibly due to the unusual word-form presentation. The N400 time-window (centro-parietal sites) revealed main effects of all three factors, a two-way interaction between frequency and predictability and a three-way interaction. N400 predictability effects for RVF presentation showed larger modulations for high frequency words and smaller modulations for low frequency words. This pattern was reversed compared to N400 effects for horizontal RVF presentation, perhaps indicating earlier stages of processing compared to the easier presentation format. Words presented in the LVF had additive effects of predictability and frequency: the N400 effects were equally large across frequency conditions, which may indicate separate lower and higher level processing mechanisms for vertical presentation to the LVF. Horizontal presentation findings suggest that word processing in context differs in the two time-windows, with the two hemispheres exhibiting differential specialization for high and low frequency conditions during early lexical access (P2). Later, the left hemisphere displayed more nuanced sensitivity to frequency and predictability (N400). Following vertical presentation, however, N400 effects indicated delayed lexical access, modulated by the additional, stronger influence of supporting context.

D34 Grounding Education on brainwaves: Evidence from semantic categorization

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Neurolinguistic research is mostly carried out on University students, from Western Educated Industrialized Rich and Developed (WEIRD) countries, and this makes the generalization of results problematic (e.g., Heinrich, Heine & Norenzayan, 2010). We aimed at paving the way to deconstructing the WEIRD bias, by describing the neurophysiological correlates of language comprehension as influenced by differences in Education across subjects. We used a semantic categorization task in which participants read semantic category cues (e.g., A piece of furniture) followed by a target word that could be either a highly typical category member (chair) or atypical (foot rest). This task has already been implemented to describe the effects of aging (Kutas & Iragui, 1998) and semantic fluency (Federmeier, Kutas & Schul, 2010), thus providing straightforward predictions for atypical category members, i.e. a larger N400 followed by an enhanced Late Positive Complex (LPC). We hypothesized that highly educated participants would be less sensitive to the cognitive costs associated to processing atypical category-member relations. 30 young adults (mean age: 26) attending a higher learning institution (Scuola Normale Superiore in Pisa) represented the higher Education group (19.6 years of education); 25 subjects (mean age: 23) the lower Education group (12.64 of education). 90 semantic categories (and associated pairs of targets) were selected from existing norms in the literature. To capture also individual variation we collected a battery of psychological measures: Author Recognition Test, Verbal Fluency, Autism Quotient, Verbal Working Memory Capacity and verbal IQ. EEG was recorded from 64 electrodes. ANOVAs on individual EEG

averages in the N400 and LPC time-windows confirmed the biphasic effect (Fig.1): compared to Typical, Atypical targets elicited more negative ERPs in Parietal electrodes [$F(2,98)=6.16$, $p<0.01$], and few ms later, more positive ERPs across scalp locations [$F(1,49)=6.76$, $p<0.05$]. Most notably, when examining the unaggregated dataset, generalized linear mixed-models highlighted relevant interactions between education, psychological measures and the EEG amplitude. For instance, the N400 amplitude was predicted by the interaction between Word Frequency and Education group (quasiF=7.36, $p<0.01$), with the positive slope associated to word frequency steeper for lower Education compared to higher Education group. In the LPC time window, the frontally distributed part of the effect of Condition was negatively correlated with individuals' verbal fluency (quasiF=6.28, $p<0.05$), with a larger LPC for individuals with lower semantic fluency. Finally, the LPC effect in parietal electrodes was larger for participants with low verbal IQ (quasiF=24.76, $p<0.001$) and low verbal Working Memory (quasiF=6.09, $p<0.05$) scores. Overall, our data show that Education might reduce the effect of word frequency on lexical access, as measured in the N400. Moreover, these findings suggest that, in addition to formal Education, a constellation of psychological factors have measurable effects on both lexical and post-lexical mechanisms. Specifically, Verbal intelligence and Verbal Working Memory capacity ease the costs of processing atypical semantic relations. Using individual differences and multivariate statistical methods instead of relying on grand averages allows for new insights on language processing, towards a better grounding of education and global cognition on the brain response.

D35 The internal mechanism and brain oscillatory signature of semantic prediction during sentence comprehension

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Predictive processing is essential for successful everyday interaction, such as language comprehension. Although numerous studies have demonstrated that processors can predict upcoming information during reading or speech comprehension, there is still no clear picture of the anticipatory stage of language processing. We do not know what happens before the predicted or unpredicted information appears: is prediction initiated by simple automatic activation process or actively generated on the basis of given information? What's the brain oscillatory signature of this predictive process? The present EEG (electroencephalograph) study aimed to examine the semantic prediction process during sentence comprehension, and brain oscillations underlying semantic prediction. Mandarin Chinese sentences were used as stimuli, with each sentence including a critical noun. On the one hand, the critical nouns are congruent or incongruent; on the other hand, the sentences have a highly or lowly predictive context (namely, the congruent critical nouns have a high or low close probability). Importantly, the critical noun in each sentence is preceded by two words (a critical verb and an adjective, with the adjective providing no cues for the following critical noun) that are exactly the same in the high- and low-prediction conditions. Sentences were presented visually word-by-word. Therefore, the period from the onset of the verb to the onset of the critical noun reflects the anticipatory stage of semantic processing, and the period after the critical noun appearing reflects the later integration stage. The ERPs time-locked to the critical verbs showed that, first, relative to congruent nouns, incongruent nouns elicited a larger N400-P600 under the highly predictive context and only a larger N400 under the lowly predictive context, indicating that the unpredicted incongruent nouns are more difficult to integrate in a highly constrained context. Second and importantly, relative to the low-prediction condition, the high-prediction condition evoked a larger negativity before the critical nouns appeared, and elicited a smaller negativity (N400) after the predicted critical nouns appeared. The reduced N400 reflects facilitated semantic processing at the integration stage, and the enhanced negativity reflects that readers are actively generating the candidates of the upcoming nouns. That is, the anticipatory stage of semantic processing is an active process, but not an automatic activation spread in the lexical network. Third, relative to the low-prediction condition, the high-prediction condition induced larger theta power decreases (4-7 Hz) and larger high-beta power decreases (19-25 Hz) before the critical noun appeared. This high-beta power decrease was significantly correlated to the N400 reduction effect at the integration stage, which is consistent with the findings of previous visual research and temporal prediction research by indicating that beta oscillation is closely related to active predictive processing. In summary, during sentence comprehension, processors actively predict upcoming information, which is in line with the "predictive coding" and "analysis by synthesis" models, but can't be accounted for by the TRACE model. Meanwhile, the present oscillatory results, combined with early researches on temporal prediction and visual processing, indicate that beta oscillation contributes to predictive processing. Key words: semantic prediction; predictive coding; sentence comprehension; brain oscillations.

D36 Do brain activations differ between semantic-association and semantic-categorization at an early stage in visual word recognition?

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Association (e.g., frog - TADPLE) and categorization (e.g., shirt - SWEATER) are two common manipulations for studying semantic processing and the structure of semantic representation, respectively. However, it is still unclear how the brain differentiates between

semantic-association and semantic-categorization and how early this differentiating processing takes place. The present study used functional magnetic resonance imaging (fMRI) technique to investigate the processing of semantic relation. We compared Chinese word pairs that represented either association or categorization in terms of their semantic relation in a subliminal priming paradigm where the participants had to perform animacy judgment. We hypothesized that, while semantic categorization mainly relies on lexical-semantic retrieval, semantic association was additionally supported by combination and integration processes. In line with the anatomical framework for semantic processing proposed by Lau, Phillips, & Poeppel (2008), we predicted that, the priming effect elicited by semantic-association paris might engage more extensive brain areas than those by semantic-categorisation pairs, which included the regions related to combination, interaction, or the control of retrieval. The experiment had three within-participant variables: Animacy (i.e., living or nonliving), semantic relation (i.e., association or categorization), and prime-target relation (i.e., neutral, non-repeated, semantic related, and repeated prime). Experimental material comprised forty-eight pairs of two- or three-character Chinese word. Word frequencies, stroke numbers and subjective semantic-relatedness scores rated by an independent group of participants were matched across conditions. Seventeen Taiwanese graduate or undergraduate students participated in experiment; all of them are fluent, native Chinese speakers and readers. Because the semantic priming effect has not been robustly shown in the previous studies, we first checked the robustness of the semantic priming effect globally. The RTs data showed a global facilitatory effect of semantic priming. Although this effect was not observed in canonical whole brain analysis of fMRI data, when we correlated participants' semantic priming effect observed in RT data with their brain activation, a positive correlation was found in the left middle and inferior temporal gyrus, the left superior temporal pole, the right middle/inferior frontal gyrus, the right superior frontal gyrus, the bilateral insula, the bilateral putamen, and the bilateral caudate. The results suggest that the semantic processing happened at an early stage in visual word recognition. To further examine whether the semantic priming effects were elicited differently between semantic-association and semantic-categorizaion pairs, the interactions between the type of semantic relation (i.e., semantic-association vs. semantic-categorization) and the effect size of semantic priming were examined. The behavioral data showed that the interaction was significant in mean accuracy, but not in RTs. The analysis of regions-of-interest (ROIs) of fMRI data showed the significant interaction at the left inferior frontal gyrus, but not at the left middle temporal lobe, nor at the left superior temporal lobe. The current data supported our hypothesis that the early processing for differentiating between semantic-association and semantic-categorization in visual word recognition was not supported by the lexical-semantic retrieval, but by the controlled mechanism of retrieval.

D37 Melting or Breaking the Ice: Controlled Semantic Retrieval is Related to Microstructural Differences in Long-Range Fiber Pathways.

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Coherent communication is possible thanks to a complex language processing system that requires us to interpret sensory input, access our semantic memory, then select the concepts and words that will best carry out communication. In everyday conversation, we make many rapid choices between competing concepts and words in order to accurately convey our intent. Intraoperative stimulation studies in patients with gliomas have implicated a uniquely human white matter tract called the inferior fronto-occipital fasciculus (IFOF) in semantic retrieval (Duffau, 2013) The IFOF connects extrastriate cortex to lateral/orbital frontal cortices. The uncinate fasciculus (UF), is a white matter tract connecting anterior temporal lobe, amygdala, and perirhinal coretx with the lateral orbital frontal cortices that has also been implicated in facilitating semantic control in populations with semantic aphasia (Harvey, 2013) and semantic dementia (Agosta, 2009) . Here, we used diffusion tensor imaging (DTI) in a cohort of neurologically normal young adults to further investigate the relationship between these tracts and semantic processing. Deterministic tractography was performed to compute the microstructural properties of the IFOF and the UF. In a verb generation task (Snyder et al., 2010), participants were presented with a series of nouns and asked to generate the first verb that came to mind for each noun. Nouns were manipulated in terms of retrieval demand, and indexed by association strength and reaction time. Our results revealed a significant relationship between semantic retrieval and IFOF and UF microstructure These results indicate the IFOF and the UF not only play a role in language processing, but are specifically involved in the computations required for accurate, controlled semantic retrieval.

D38 Hemispheric differences in sublexical ambiguity resolution during Chinese word reading

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In Chinese, most of the words are compounds and the constituent character within a compound word can carry different meanings and/or related senses (sublexical ambiguity). This study aims to examine how two hemispheres resolve sublexical ambiguity in reading. Participants read the character-word pairs (centrally presented single character and then a lateralized word) and indicated the semantic relatedness between the word and the first meaning of the character. The number of meaning corresponding to the first character was manipulated. We found that with RVF/LH presentation, words with

ambiguous first character elicited a more negative N400 than unambiguous ones. However, there was no sublexical ambiguity effect with the LVF/ RH presentation. The fact that expectancy-related effects on N400 arise only after presentation to the LH is consistent with theories that posit a specialized role for the LH in using language context information to predict features of upcoming words (the PARLO framework; Federmeier, 2007). For characters that have one meaning (a fairly constraint context), the meaning of the first character of the upcoming word is highly predictable. In contrast, for characters that have multiples meanings (a weak constraining context), it's less predictable for the meaning of the upcoming words. Therefore, more negative N400s elicited for words with multiple meanings could be found in the RVF/LH presentation. On the other hand, the RH is less sensitive to the contextual constraint. And thus, the RH is not affected by the number of meanings associated with the first character.

Motor Control, Speech Production, Sensorimotor Integration

D40 Semantic competition during word production is supported by the domain-general multiple-demand system

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To speak, people must interact with a set of linguistic representations (concepts, words, sounds) using processing mechanisms (response activation and selection) that may either be language-specific or be shared with non-linguistic domains, such as action selection during the production of motor movements. Prior neuroimaging and patient studies have revealed that the left inferior frontal gyrus (LIFG) is sensitive to semantic difficulty during picture naming (e.g., Harvey & Schnur, 2015; Riès et al., 2014; Schnur et al., 2009). However, the LIFG is known for its structural and functional heterogeneity, and recent fMRI work has shown that two distinct large-scale brain networks – the specialized language system (e.g., Fedorenko et al., 2011) and the domain-general multiple-demand (MD) system (Duncan, 2010) – co-exist in close proximity within this cortical region, with variable locations across individuals (Fedorenko et al., 2012). It is thus impossible to determine, based on simply observing activation somewhere within the LIFG, which of these two systems supports semantic competition during lexical access. Here, we used a functional localization approach to do so. The regions of the fronto-temporal language system (8 regions in the left hemisphere covering the lateral frontal and temporo-parietal cortices; Fedorenko et al., 2010) and the domain-general fronto-parietal MD system (9 regions bilaterally, covering lateral frontal and parietal cortices; Duncan, 2010; Fedorenko et al., 2013) were defined in each subject individually (n=14) using functional "localizers": a contrast between sentence and nonword sequence reading, and a harder vs. an easier spatial working memory task, respectively (both tasks have been extensively validated in prior work). In the critical task, participants performed a blocked cyclic naming task, covertly naming pictures and reading words that were either presented in semantically blocked conditions (car, motorcycle, truck…) or semantically mixed conditions (car, onion, desk…). Responses were then examined in the individually-defined language and MD functional regions of interest. Across hemispheres, MD regions were sensitive to the difficulty of word retrieval during production, showing significantly more activation to blocked pictures than mixed pictures, $p = .02$. In contrast, language regions showed no difference, $p = .29$ (numerically trending toward more activation to mixed pictures). This difference in sensitivity between systems (MD vs. language) was significant, $p = .03$. In contrast, both language and MD regions showed significantly less activation to blocked words than mixed words, ps $< .01$, and different effects of blocking on activation for pictures vs. words, ps $< .01$. Although prior research has shown that parts of the LIFG are sensitive to the semantic blocking manipulation, our results indicate that semantic competition during word production is exclusively resolved by the brain regions of the bilateral domain-general MD system (including regions in the parietal cortices and the right hemisphere) – and thus, by extension, only those parts of the LIFG that subserve domain-general processes. This pattern is consistent with both behavioral (Kleinman, 2013; Piai et al., 2014; Schnur & Martin, 2012) and neural (Thompson-Schill et al., 2005) accounts in which semantic processing recruits mechanisms that serve a domain-general regulatory control function.

D41 ERP investigation of semantic facilitation in picture naming

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A plethora of studies used the picture-word interference (PWI) paradigm to investigate lexical-semantic context effects on picture naming in healthy subjects (see Mahon et al., 2007, for a review). Typical results on reaction times (RT) show semantic interference emerging with categorical primes, but semantic facilitation with associative primes (Costa et al., 2005). Some studies also reported facilitation for categorical primes with long negative SOA (Alario, 2001; Glaser & Düngelhoff, 1984). Here we investigated the time-window of semantic categorical and associative facilitation in a PWI task with primes presented with negative SOAs. Two groups of French-speaking young adults underwent a picture naming task with word primes in 3 conditions : associative, categorical or unrelated (e.g. the target picture « airplane » was preceded either by « flight », « helicopter » or « string » respectively).

One group was presented with auditory word primes and the other group with written primes. Behavioural analyses showed a main effect of condition on production latencies for both groups (auditory and visual primes): naming latencies were shorter with categorical primes as compared to unrelated primes and even shorter with associative primes as compared to categorical primes. ERPs were carried out on evoked potential amplitudes at each electrode and time point over the whole period of word production on stimulus-aligned and response-aligned ERPs using non-parametric (bootstrapping) procedures. Relative to unrelated primes, both the categorical and associate conditions modulated ERPs in a late time-window (around 350ms post picture onset). Using a PWI paradigm with negative SOAs, we observed that both written and auditory categorical and associative primes speeded up picture naming as compared to unrelated primes. The late time-window of ERP modulation is rather in line with the response exclusion hypothesis which locates semantic interference and facilitation effects at a post-lexical processing stage (Janssen et al., 2008; Mahon et al., 2007). References Alario, F. X. (2001). Aspects sémantiques de l'accès au lexique au cours de la production de parole [Semantic aspects of lexical access during word production], 53, 741–764. Costa, A., Alario, F. X., & Caramazza, A. (2005). On the categorical nature of the semantic interference effect in the picture-word interference paradigm. Psychonomic Bulletin & Review, 12(1), 125–131. Glaser, W. R., & Düngelhoff, F. J. (1984). The time course of picture-word interference. Journal of Experimental Psychology. Human Perception and Performance, 10(5), 640–654. Janssen, N., Schirm, W., Mahon, B. Z., & Caramazza, A. (2008). Semantic interference in a delayed naming task: Evidence for the response exclusion hypothesis. Journal of Experimental Psychology: Learning, Memory, and Cognition, 34(1), 249–256. Mahon, B. Z., Costa, A., Peterson, R., Vargas, K. A., & Caramazza, A. (2007). Lexical selection is not by competition: A reinterpretation of semantic interference and facilitation effects in the picture-word interference paradigm. Journal of Experimental Psychology: Learning, Memory, and Cognition, 33(3), 503–535.

D42 Incremental activation of semantic representations in sentence production: an fMRI study

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Embodiment of language has attracted much research in recent years. There is an increasing amount of evidence suggesting that concrete nouns and verbs are grounded in sensory and motor systems in the brain that represent previous sensory or motor experience. Evidence comes from fMRI studies on single word or picture processing. Likewise, sentence compre-hension paradigms have been investigated successfully. However, it is yet an open issue whether, and how, this grounding also applies to the production of spoken sentences. Are semantic representations in language production embodied? When we intend an utterance like "The car is left to the tree" – is an embodied representation of "tree" already active when we begin to speak, or is it only activated incrementally as speaking continues? In order to address this question in the present fMRI study, we made use of the picture-word interference paradigm (PWI), a well-established tool in the realm of sentence production. The utterance format was always "The X is left/right to the Y", with X and Y being slots for the names of two target pictures presented on the screen. In addition, a written distractor word appeared above or below the pictures. It was either semantically related to the first noun (e.g. MOTOR related to "car" in the example) or the second noun (e.g. AXE related to "tree"), or unrelated to both (e.g. INK). The semantic relationship of distractor word and target picture name had an influence on the speech latencies: some subjects responded more quickly, others more slowly to distractors semantically related to the first noun (REL1) in comparison to unrelated (UNREL) distractors. For the analysis of the fMRI data, we considered the speech latencies as indicators of the relative influence of the semantics of the distractor word on sentence production in the following way. Since some subjects showed semantic facilitation while others showed inhibition, we used the speech latencies as regressors of interest, thus testing how the amplitude of the hemodynamic response in each of the three conditions was modulated by the sentence production effort. There were three core findings. First, in line with the literature the overall speech latencies were related to activation in the speech motor system, including bilateral insula, and the cerebellum. Second, differential modulations for REL1>UNREL were found in the posterior part of the anterior and middle cingulate cortex and the cuneus, a network discussed in the literature for perceptual/sensory semantics, and in the left insula. Third, effects for REL2>UNREL were weaker and only confined to the cuneus. Together, behavioral and fMRI data suggest incrementality in the activation of semantic representations during speaking. When starting to speak, there are strong effects for sensory representation of the first object/noun. In contrast, representations for words to be produced later in the sentence are at that point only beginning to get activated. Thus, the data might be taken to suggest that embodiment of concrete nouns during

speaking is no all-or-nothing phenomenon but underlies a temporal dynamics driven by the incremental planning of the utterance.

D43 Can we reliably measure language lateralization? *Lisa Bruckert[1], Dorothy V. M. Bishop[1], Kate E. Watkins[1]; [1]Department of Experimental Psychology, University of Oxford*

It is well known that language processing depends on specialized areas in the left side of the brain. As much as 92-96% of the right-handed population predominantly engages the left hemisphere during speech (Knecht et al. 2000). A popular view is that developmental language disorders result from a poorly lateralized brain, but evidence in support of this has been weak and inconsistent. In addition, individuals with 'atypical' lateralization (right or bilateral) appear to have no difficulties acquiring language. Here, we present findings from a combined functional transcranial Doppler ultrasound (FTCD) and MRI study that that examines both the relationship between distinct laterality measures as well as differences in brain function of people with typical and atypical language lateralization. The cerebral blood flow velocity (CBFV) during a word-generation task was assessed using FTCD in a large number of native English speakers with no history of speech or language impairment (N=180). Lateralization was determined by comparing the CBF in the left and right middle cerebral arteries. The magnitude of the difference between the CBFV in the left and right arteries and the reliability of this difference was used to classify participants as showing left or right lateralization for language or bilateral processing. Eleven participants with atypical lateralization (5 right and 6 bilateral; mean 24.9 years; SD 5.8 years, 7 male and 4 left-handed) were identified using this method and scanned using MRI along with eleven typically lateralized controls matched for age, gender and handedness (left lateralized; mean 24.4 years; SD 4.8 years, 7 male and 3 left-handed). Here, we present data from an FMRI word generation task that was as similar as possible to the FTCD task. Participants were asked to covertly generate words starting with different letters. In the typically lateralized group, this task robustly activated extensive portions of the left inferior frontal gyrus extending to the anterior insula, the preSMA, the dorsal striatum and anterior cerebellum bilaterally. The LI toolbox (Wilke & Lidzba, 2007) was used to calculate indices (LI) for activity in the frontal lobes. Participants were considered left- or right-lateralized if the LI fell outside the range -0.2 to +0.2; LIs falling within this range resulted in a classification of bilateral. Using MRI, two participants were classified as right lateralized and one as bilateral, which was concordant with their classification based on FTCD. However, the remaining three right lateralized and five bilateral participants in the atypical group were classified as left lateralized using MRI. The LIs derived using MRI and FTCD were significantly positively correlated (N=22, rho=.58, p=0.005). Our data confirm a positive relation between laterality indices obtained by FTCD and FMRI, but concordance for categorically defined laterality was less good than previously reported (Deppe et al 2000). In particular, some individuals categorised as bilateral on FTCD had left-lateralized language on FMRI. Further investigations will determine the reproducibility of these assessments and their reliability relative to other measures of laterality. Keywords: Cerebral lateralization, Functional transcranial Doppler ultrasound (FTCD), Functional magnetic resonance imaging (FMRI), Language

D44 A combined tDCS-eye tracking investigation of the neural correlates of confrontation naming: investigating the necessity of the anterior temporal lobe vs. the temporo-parietal junction *Sameer Ashaie[1], Jamie Reilly[2], Bonnie M. Zuckerman[2], Richard J. Binney[2]; [1]Speech-Language-Hearing Sciences, CUNY Graduate Center, 365 Fifth Avenue, New York City, NY 10016, USA, [2]Eleanor M. Saffran Center for Cognitive Neuroscience, Department of Communication Sciences and Disorders, Temple University, Philadelphia, PA 19122, USA*

Contemporary neurocognitive models of object naming emphasize dominance of anterior ventral-pathway peri-Slyvian structures including the anterior temporal lobe (ATL) and ventrolateral prefrontal cortex. The role of structures of the temporo-parietal junction (TPJ) in object naming are less clear but feature in models of semantic cognition. We assess the necessity of each of these two regions for confrontation naming performance using transcranial direct current stimulation (tDCS). Effects of non-invasive brain stimulation techniques are often very small when measured by reaction times and accuracy. Therefore we also made a novel attempt to measure these effects using potentially more sensitive eye-tracking measures. 12 neurologically healthy native English speakers ranging in ages 18-25 took part in the study. Behavioral testing and concurrent eye-tracking were recorded prior to and following 20 minutes of 2mA off-line bilateral cathodal tDCS. The study employed a fully counter-balanced repeated-measures design including three sessions held on separate days, each with a different active stimulation site; ATL, TPJ or a control site over motor cortex in the dorsal precentral gyrus (MC). Participants completed a confrontation naming task responding to line drawings of objects. A control task, 6-digit number reading, was also completed for purposes of ruling out non-specific effects of tDCS on performance levels. There was no effect of tDCS on behavioral measures at any of the stimulation sites for either the naming or control task. Analyses of eye-tracking data revealed an effect consistent with a role of the ATL, but not the TPJ, in confrontation naming. Using an a priori defined area of interest (AOI) for each stimulus, we assessed a number of measures including the duration of the first fixation on the AOI and also 'total fixation time' (a sum of durations of all fixations on the AOI). A two way repeated measures

ANOVA revealed a Significant interaction of tDCS (pre- versus post-stimulation) and Stimulation Site (ATL, TPJ, MC) for total fixation time. Post-hoc comparisons confirmed increased fixation duration following tDCS over the ATL. A statistical trend was also observed for this interaction effect on the duration of the first fixation, again confirmed by post-hoc comparisons as increased by stimulation of the ATL only. The analysis of eye-tracking measures for number reading revealed no significant interaction. There was a statistical trend for a main effect of tDCS on the duration of the first fixation, such that this duration was shortened following stimulation, irrespective of the cortical site. Our results confirm a role of ATL in confrontation naming. Conversely, we found no evidence to support a role of the TPJ. This is consistent with models of semantic memory and semantically-driven lexical access that propose a dominance of anterior temporal and ventrolateral frontal regions. Our study also demonstrates the potential for combined tDCS-eyetracking studies as a tool to investigate the neural basis of higher-level cognition (e.g., language or semantic cognition), providing more sensitivity to effects of altered neural excitability that may be relatively small and missed when assessed via relatively coarse behavioral measures alone.

D45 Task dynamics of sensorimotor learning and control in speech production.

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Sensorimotor activities such as speech require both the ability to self-correct and to develop new sensorimotor correspondences, through sensorimotor control and learning mechanisms. The neural networks underlying these mechanisms may be probed using real-time altered auditory feedback during speech production. Sensorimotor learning is associated with altered responses to predictable and sustained feedback perturbation. However, during the initial phase of a sustained feedback perturbation, control mechanisms must be present as the perturbation will only become predictable over time. During magnetoencephalographic recording, participants underwent a speech production task in which they read aloud a CVC word containing the English vowel /ɛ/. Speech output was captured via a microphone, and the first formant was shifted upwards ~ 30%. The perturbed auditory feedback was fed back to the participants via inserted earphones with minimal delay. The task consisted of a baseline phase, followed by a "hold" phase with maximum, sustained auditory perturbation. MEG recordings were preprocessed to remove artifacts related to electrical (60 Hz) and physiological noise (eye movements, heartbeats) and then epoched into trials centered around the vowel onset in the auditory feedback. MEG signal recordings were projected into source space using a whitened and depth-weighted minimum-norm estimates algorithm with each participant's cortical surface. Recordings were then filtered between 4 and 40Hz to remove potential artifacts due to articulator motion during speech. The source maps were averaged within each condition and participant, z-scored relative to each trial's baseline, projected into standard space (using the Colin27 MNI brain) and spatially smoothed. A number of classical speech motor brain areas were chosen as initial regions of interest including primary and secondary auditory cortex, sensorimotor cortex, premotor cortex and the inferior frontal gyrus. Additional cortical regions (parietal cortex, hippocampus and prefrontal cortex) hypothesized to be involved in sensorimotor learning and memory were also used included as regions of interest. Source models for average evoked fields were estimated and a wavelet analysis of each source waveform was calculated for individual trials and averaged in order to characterize the contributions of different frequency ranges. Our initial findings identify the interaction of activation in sensorimotor brain regions during speech production. Under conditions of sensorimotor adaptation, changes in connectivity strength and the recruitment of additional brain regions and frequency bands underscore the dynamics of the short-term learning process.

D46 Voluntary imitation of fundamental frequency and vocal tract length in human speech – a multimodal investigation using functional and real-time anatomical MRI.

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Introduction: The human voice is a highly flexible channel for the expression of linguistic, emotional and social information. Perceptually, fundamental frequency (F0; closely related to pitch) and formant spacing (an index of vocal tract length; VTL) are important cues for the extraction of indexical characteristics such as sex and body size. Behavioural research has further shown that talkers instinctively modulate these cues to emulate various physical and social attributes in the voice and speech (Cartei et al., 2012; Hughes et al., 2014). The current study is the first combined acoustic, articulatory and neurobiological investigation of these paralinguistic aspects of vocal behavior. Methods: Twenty-two adult native speakers of British English (9 male) took part in a behavioural experiment. Self-produced tokens of the monosyllables "bead", "bard" and "booed" (chosen to sample native monophthongs varying in place of articulation) were recorded from each participant. These were used to create subject-specific arrays of synthetic target voices varying in F0 and VTL, in 1-syllable steps, and arranged along two primary axes: one biologically typical axis ranging from lower F0s and longer VTLs to higher F0s and shorter VTLs (i.e. ranging from adult male voices to adult females and children), and one less typical axis ranging from lower F0s and shorter VTLs to higher F0s and longer VTLs. In a behavioural task,

participants heard items from each monosyllable array, in fully randomized order, and were asked to imitate the speech as closely as possible. In a follow-up study, real-time anatomical MRI (rtMRI) of the vocal tract allowed us to measure the dynamics (at 8 fps) of VTL modulation as well as the functional correlates of perception and imitation using fMRI. Results and Conclusion: Acoustic analyses of imitations in the behavioural experiment showed that talkers produced significant changes following a linear trend in F0 and VTL, along both axes, but that F0 was better differentiated than VTL (particularly for atypical targets). Initial rtMRI results showed voluntary raising and lowering of the larynx to imitate varying perceived VTLs – in-scanner rtMRI and acoustic data will be used to probe individual differences in the functional correlates of task performance within auditory and somatomotor networks of the brain. Overall, these results suggest that naïve participants can voluntarily modulate the configuration of the vocal system via both extrinsic and intrinsic muscles of the larynx, in order to simulate the acoustic characteristics of different talkers. Focused analyses of the fMRI data will explore the neural correlates of individual differences in this skill, where we predict involvement of the left frontal operculum and inferior parietal cortex (after work on individual differences in phonetic talent: Golestani & Zatorre, 2004; Reiterer et al., 2011).

Orthographic Processing, Writing, Spelling

D47 Early Visual Brain Responses During Reading Reflect the Length of Words that are Predictable but Never Seen

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Research has suggested that language comprehension is predictive (Delong, Urbach & Kutas 2005, Ehrlich & Rayner 1981, Kamide, Altmann & Haywood 2003), but only recently has work begun to rigorously explore the mechanisms by which such prediction occurs. An important, unanswered question is whether readers pre-activate visual features of upcoming words, lexical-semantic or syntactic knowledge, or some combination of these representations. To examine whether readers pre-activate visual word-form features, we recorded EEG as 26 people read sentences containing strong semantic support for a specific word (cloze > 85%), as in "The crying baby kept her parents awake all NIGHT…". The length of these predictable words was manipulated, with half the words being short (range 3-6 characters, mean = 4.5; mean cloze = 95.0%) and half being long (range 7-14 characters, mean 8.9; mean cloze = 94.9%). Words were presented one word at a time with SOA = 600 ms and accompanied by vertical bars just above and below the word's mid-point. In half the sentences, the semantically supported critical word was omitted from presentation, leaving only the vertical bars (missing word condition). Overall, there were fifty highly constraining sentences in each of these conditions: long word present; short word present; long word missing; short word missing. Based on previous results, we predicted that early visual responses to words reflected in the occipital-temporal P1 ERP would increase with word length (Hauk & Pulvermuller 2003). Furthermore, we hypothesized that predictions of the visual word-form would be imposed when the anticipated form is not presented, causing P1 effects of length for missing words. After each sentence, participants indicated whether a word was missing and attempted to name any missing words aloud. Participants correctly identified the intended missing word in 90% of opportunities. Only trials with correct behavioral responses were analyzed. Epochs of EEG activity for all subjects were concatenated and subjected to a group-level Independent Component Analysis (ICA) to identify brain activity related to early visual processing. Two independent components were identified from visual inspection with clear left and right occipital-temporal concentrations in their electrode-space projections and time courses tracking the occipital-temporal P1-N2 scalp ERP complex. We analyzed activity of these components in a window of 120-160 ms post-stimulus-onset, which surrounded the P1 peak. A continuous analysis revealed that the right posterior component showed increasing activation with character length for both present and missing stimuli (blank p=.022, present=.007). The left posterior component showed the same relationship for missing stimuli only (blank p=.006; present p=.3). Analysis of the P1 component in the scalp ERP showed similar results, with increasing P1 amplitude in right posterior channels for present stimuli (p=.023) and left posterior channels for missing stimuli (p=.028). These effects of lexically-specific features on brain activity in the absence of any bottom-up input provide some of the strongest available evidence that language processing mechanisms are predictive. Furthermore, the results show that the predictions readers make include very low-level visual characteristics of anticipated words.

D48 Levels of representation during single word reading: Evidence from representation similarity analysis

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Multiple levels of representation are involved in reading words: visual representations of letter shape, orthographic representations of letter identity and order, phonological representations of the word's pronunciation, and semantic representations of its meaning. Previous neuroimaging studies have identified a network of regions recruited during word reading, including ventral occipital-temporal regions. However, there is still uncertainty about what information is represented in these regions. In this study, we apply use a multivoxel pattern analysis technique for analyzing fMRI data – representational similarity analysis – to decode the type of information being represented in different brain regions when individuals read words. Consider how the word DOUGH relates to the words

TOUGH, SEW and BREAD. DOUGH is related to TOUGH visually and orthographically, to SEW phonologically, and to BREAD semantically. Similarity among the patterns of neural response to different written words can be used to determine where in the brain each type of information is represented. Regions that respond similarly to DOUGH and TOUGH, but not to BREAD or SEW represent orthographic or visual information, while locations that respond similarly to DOUGH and BREAD, but not SEW or TOUGH contain representations of semantic information. Critical stimuli consistent of 35 written words, presented once per run over the course of twelve runs. Four theoretically predicted similarity matrices comparing each of the 35 words to every other word were computed based on theories of Visual, Orthographic, Phonological and Semantic representation. Twelve English-speaking participants were instructed read these words, pressing a button each time a proper names was presented, while a whole brain scans were acquired on a Siemens TRIO 3T scanner (Voxel size: 3.375×3.375×4mm; TR = 2.0secs). After pre-processing, a general linear model was applied to obtain a β-map for each of the thirty-five words. Using both whole-brain searchlight and anatomical defined regions of interest, brain-based similarity matrices were constructed to determine how similar the distributed patterns of neural activity for each word was to each other word. Strong correlations between brain-based similarity measures and the four theoretical predicted similarity matrices indicate the type of information represented in each region. Group level results of the searchlight analysis reveal multiple levels of representation associated with reading these words along the ventral occipital-temporal lobe. Similarity in the patterns of response to individual words in occipital regions correlates with the visual similarity matrix, but not the semantic, phonological or orthographic similarity matrices. Patterns of activity in portions of the anterior temporal lobe correlate only with the semantic similarity matrix while patterns of activity in the left midfusiform gyrus correlate only with orthographic similarity. This latter result is confirmed with the anatomical ROI analysis, which shows that the pattern of activity across the entire left fusiform gyrus correlates significantly with orthographic similarity, but not with other types of similarity. Taken together, these results provide unique insights into the neural instantiation of different levels of representation in written word processing, and can help adjudicate between competing hypotheses of the neural bases of reading.

D49 Modality Specific Lexico-Semantic Encoding for Visual & Auditory Language *Erik Kaestner[1], Ksenija Marinkovic[2], Daniel Friedman[4], Patricia Dugan[4], Orrin Devinsky[4], Sydney Cash[3], Thomas Thesen[4], Eric Halgren[1]; [1]University of California, San Diego, [2]California State University, San Diego, [3]Massachusetts General Hospital, [4]New York University*

Theories of visual word encoding propose that in experienced readers visual words access meaning via either a 'direct' visual route or an 'indirect' route through phonological recoding and the auditory language network (Frost, 1998). Models often represent this dual-route theory with separate lexicons for visual and auditory words (Coltheart et al., 2001; Diependaele et al., 2010). Indeed, a recent study demonstrated ventral-temporal sensitivity to visual word semantic differences within 150-200ms, likely too quick for indirect-route input (Chan et al., 2011). However, extra-cranial measures have found overlapping visual and auditory lexico-semantic effects beginning at ~250ms in the anterior temporal and inferior frontal regions, suggesting some overlapping lexico-semantic representations (Marinkovic et al., 2003). Here we seek to test the degree to which visual and auditory words access lexico-semantic meaning in separate cortical regions. Intracranial clinical electrodes covering large areas of lateral cortex were recorded while 15 patients performed a visual and/or auditory semantic decision task (9 both, 3 visual only, 3 auditory only). The visual task consisted of 400 words (200 novel, 10 repeated 20 times each). The auditory task consisted of 800 words (400 novel, 10 repeated 40 times). Delayed repetition of words (delays of ~60s in these tasks) has a similar N400 effect as semantic congruity, and was used as a marker for lexico-semantic effects. Analysis focused on high-gamma amplitude (HGA) and local-field potentials (LFP). HGA was calculated by bandpassing the LFP from 70-170 Hz and using a Hilbert transform. HGA & LFP were baseline corrected (-300-to-0ms) and 20Hz low-pass filtered. T-tests were run between novel and repeated word trials and corrected for multiple comparisons with false-discovery rate (Benjamini et al., 1995). LFP results: 27 electrodes (10% of active electrodes) in the visual modality and 43 electrodes (18%) in the auditory modality were identified as differentially active to novel versus repeated words at <500ms. Visual-responsive electrodes mainly clustered around the ventral and inferior-temporal cortex. Auditory-responsive electrodes mainly clustered in perisylvian and antero-lateral temporal areas. Three patients had overlapping effects in the ventral-temporal region and one patient in the perisylvian region. HGP results: 9 electrodes (11% of active electrodes) in the visual modality and 41 electrodes (31%) in the auditory modality demonstrated increased activity for novel words at <500ms. Visual-responsive electrodes mainly clustered around the ventral and inferior-temporal cortex. Auditory-responsive electrodes mainly clustered around perisylvian areas. One patient had overlapping effects in the inferior frontal gyrus and one had an overlapping electrode in the perisylvian area. Our data demonstrate that each language modality has separate areas proximal to their primary sensory cortex sensitive to long-range repetition effects. Overlapping sensitivity was found in the inferior frontal gyrus and ventral temporal areas, supporting previous findings (Marinkovic et al., 2003; Chan et al., 2011). However, only two patients were found to have visual

lexico-semantic sensitivity before 500ms in perisylvian areas suggesting these areas do not typically contribute to first-pass lexico-semantic processing. This research strongly supports the direct route but calls into question the role of phonological recoding and the indirect-route in visual lexico-semantic access.

D50 Consistency of Phonological-Orthographic Binding: Electrophysiological Correlates of Feedforward and Feedback Consistency in Chinese

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Unidirectional mappings between orthography to phonology have been shown to impact on lexical retrieval during reading (Glushko, 1979). For instance, words with higher degrees of feed-forward consistency (i.e. consistent pronunciation among words sharing the same orthographic body) facilitated reading in alphabetic scripts (e.g. Davies & Weekes, 2005; Lacruz & Folk, 2004; Stone et al., 1997; Ziegler, et al., 1997) and morphosyllabic scripts such as Chinese (e.g. Hsu et al., 2009; Leung, et al., 2011). The recurrent theory proposed by Stone et al. (1997) on the other hand argues that bidirectional activation of orthography and phonology occurs during reading. Yet whether words with low feedback consistency (i.e. many ways of spelling a particular pronunciation) may induce greater competition and delay lexical retrieval have lead to inconclusive results (e.g. Bolger et al., 2008; Massaro & Jesse, 2005; Peerman et al., 1998). Given that previous feedback consistency studies were constrained to alphabetic scripts (e.g. English and French), and that Chinese is a deep orthography with irregular and arbitrary print-to-sound mappings and sound-to-print mappings as homophony is pervasive, we propose that investigating such effects in Chinese may help resolve whether feedback consistency impacts on reading, An event-related potential (ERP) study using a homophone judgment task was employed with native Chinese speakers. Target characters varied in token feed-forward consistency (FF consistent vs. FF inconsistent) and feedback consistency (FB consistent vs. FB inconsistent), whilst controlling for stroke, frequency, orthographic neighbourhood size, phonological regularity, and ratio of homographic homophones. FF consistent characters included characters with a consistency token value ≥ 0.6 whereas FF inconsistent characters were ≤ 0.3. FB consistent characters had 1-3 homophones, while FB inconsistent characters had 4-8 homophones, excluding itself. Electrophysiological results showed that both FF and FB consistency influenced the occipital N170 and frontal P200 components, but in opposite directions. More specifically, for FF consistency, enhanced N170 and P200 were found for FF consistent characters, indicating that greater phonological similarity shared amongst orthographic neighbours elicited greater facilitative activation. Whereas for FB consistency, inconsistent characters elicited enhanced N170 and P200, suggesting that when more orthographic alternatives map onto a given pronunciation, greater neural resources may be required to activate multiple corresponding orthographic representations. Furthermore, only FB consistency effects were found a the frontal-central N400 component with greater evoked negativity for FB consistent characters. As FB consistent characters have fewer orthographic competitors, it is suggested that these competitors may share a stronger weighted connection and require greater lateral inhibition amongst the candidate competitors and lead to more effortful N400 activation during lexical-semantic retrieval. Weaker and more distributed connections among multiple candidate competitors in FB inconsistent characters, on the other hand, may result in less interference and a reduced N400. Overall, evidence of feedforward and feedback consistency effects lends support to the recurrent theory where bidirectional flow of activation occurs during word recognition. Evidence of FB consistency also motivates modifications to Chinese word recognition models that only propose unidirectional mappings from orthography to phonology (e.g. Perfetti, et al., 2005; Taft et al., 2006).

D51 Different Levels of Sub-lexical Representation in Reading Chinese: The Effects of Logographeme and Radical Independence

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Chinese character recognition studies have consistently shown that complex characters are automatically decomposed into sub-lexical components referred to as radicals during reading and writing. However, it is not clear how the orthographic sub-system is able to differentiate when the 口 in a character such as 呵 should be activated as a radical for the left side unit, but only makes up a constituent for the right radical 可 which also embeds a 口 within the radical. Rather, studies of writing errors of Chinese children and aphasic patients have postulated that logographemes, a smaller sub-lexical unit than the radical, are the core units of representation (e.g. Law & Leung, 2000). Logographemes refer to a series of stroke patterns that are productive (exist in many characters) and appear to be smaller sub-lexical units than radicals. As such, the character 呵 would consist of three logographemes where two are 口 and one is 丁. To assess whether logographemes are encoded during character recognition, two experiments were conducted using a lexical decision task in conjunction with event-related potential (ERP) measures. In Exp1, real characters varied factorially by character frequency (high vs. low) and logographeme independence (independent vs. non-independent). Independence was defined as whether or not the logographeme could exist as a real character. Given that logographemes can have 'double identities' and also be considered as a radical such as the 口 on the left side of 呵, Exp2 aimed investigate whether logographemes representations are qualitatively different from radical representations. Pseudocharacters were used that factorially varied by radical-level independence (independent vs. non-independent radicals) and

logorapheme-level independence (independent vs. non-independent logographemes). Electrophysiological results in Exp1 showed a significant P100 sensitivity to logographeme independence in which non-independent logographemes elicited a greater positivity than non-freestanding logographemes in real characters. Interestingly in Exp2, when participants encounter pseudocharactes, radical independence effects dominate the right hemisphere P100 component whereby smaller positivity was elicited for pseudocharacters with independent radicals, followed by greater negativity at the N170 component. Logographeme independence effects were only identified at the right hemisphere N170, and showed a different pattern to radicals where non-independent logographemes evoked greater negativity than independent logographemes. For both experiments, no significant effects were found at the P200 and N400 components. Overall, the two studies demonstrate that logographemes are processed early during the visual and orthographic analysis stages, and logographemes that can exist as real characters recruit less neuronal resources and are more readily accessed during early visual encoding. Furthermore, the different timecourse of logographeme independence effects across the two studies may suggest that activation of logographemes depend on the type of characters encountered, with more automatic analytical-like processes during real word recognition but in a holistic-to-analytical manner when identifying pseudocharacters. Lastly, logographeme representations are likely to be independent from radical representation as the effects of radical and logographeme independence effects were shown to be in opposite directions at the N170, and show different timecourse of activation. The findings challenge Chinese character recognition models that do not assume a logographeme representational level.

D52 The different effects of Semantic and Phonetic Radicals in Chinese Phonogram Recognition: Evidence from ERPs *Yan Wu[1], Xieshun Wang[1], Simin Zhao[1]; [1]Department of Psychology, Northeast Normal University*

The majority of Chinese characters are compound characters, and around 80% of the compound characters are phonograms which are comprised of a semantic radical and a phonetic radical. The semantic radical usually implies the meaning of the phonogram (e.g., 桐, tong2: tung, whose semantic radical is 木, mu4: wood), and the phonetic radical offers a phonological clue for the pronunciation of its host phonogram (e.g., 桐, tong2: tung, whose phonetic radical is 同,tong2: together / same). Since the semantic and phonetic radicals have different functional values, some researchers turned to investigate the issue whether their distinctive functions would generate different processing patterns during the phonogram recognition. However, regretfully, current results are confusing, with some studies reporting that the effect of the phonetic radicals were earlier and stronger than that of semantic radicals, however, others assuming that the semantic radicals played a predominant role. Therefore, the present study was conducted to explore the effects of semantic and phonetic radicals during the phonogram recognition, especially focusing on the relative importance of them. Two kinds of radical frequencies were manipulated: semantic radical frequency and phonetic radical frequency. Different from prior research, both semantic and phonetic radicals are standalone characters in the present study in order to make sure some confusing variables such as the pronunciation and the other lexical information are kept consistent between the two types of radicals. Behavioral results (Experiment 1) revealed only phonetic radical frequency could influence the processing of phonogram, the reaction time of phonograms containing high-frequency phonetic radicals was longer and error rate was higher than those containing low-frequency phonetic radicals. However, ERP results (Experiment 2) showed that both semantic radicals and phonetic radicals could play a role in Chinese phonogram recognition. High-frequency phonetic radicals elicited a smaller P200 during 200-300ms time window and a larger N400 around 350-500ms time window as compared to the low-frequency ones. By contrast, the high-frequency semantic radicals elicited a smaller N400 during the time window of 350-450ms than did the low-frequency ones. The present results indicated that both semantic and phonetic radicals could be activated and play a role in Chinese phonograms recognition. But the effect of phonetic radicals was found to be earlier as it was firstly reflected by P200 effects which a component was proved to indicate the sub-lexical orthographic processing. However, both semantic and phonetic radicals could influence the semantic extraction of its host phonograms, as reflected by the N400 effects. Such results were interpreted in terms of the prosperities of semantic and phonetic radicals in Chinese orthographic system.

D53 Word Superiority and Memorial Inferiority for Cursive Handwriting *Anthony Barnhart[1], Stephen Goldinger[2]; [1]Carthage College, [2]Arizona State University*

Barnhart and Goldinger (2010; 2013) reported that various "top-down" effects in lexical access (e.g., word frequency effects) were magnified when people read handwritten cursive words, relative to computer-generated print. We suggested that, when letter-level input is degraded, the perceptual system adjusts with greater lexical feedback. This hypothesis creates a puzzle when considering the classic word-superiority (WS) paradigm, wherein letter strings are briefly flashed then masked, and participants are required to report a single letter appearing somewhere within the stimulus. Under these conditions, people typically identify individual letters more quickly and accurately when they are presented within words than within nonwords (or even presented in isolation). Discovery of the WS effect spurred the development of connectionist models that allowed top-down activity to bootstrap activation at lower processing levels (activity that would be absent for nonwords). In the context of

handwriting, one might expect items to create large WS effects, as word-level influences would dominate weak letter-level activity. Alternatively, one might expect handwritten items to create small WS effects, as the letter-level input may not sufficiently activate words. Across four experiments, we observed clear WS effects with handwritten items, of exactly the same magnitude as the effect with printed items. We also observed a powerful phenomenological effect of "form blindness." Episodic accounts of lexical organization suggest that people would encode some of the seemingly irrelevant surface features of handwritten items within an episodic memory trace, as seems to be the case with voices in speech perception. However, people often could not report whether letter strings were handwritten or printed, even if probed immediately after seeing them. Furthermore, participants were apt to erroneously report that cursive words had been presented in print. This form blindness seems antithetical to episodic accounts of lexical organization, instead supporting abstractionist notions where variant surface features are filtered out. However, these findings are difficult to accommodate within dominant models of word recognition. We suggest that the outcomes are most easily understood within a resonance account of word recognition (see Becker, Goldinger, & Stone, 2006), wherein recognition happens in a cascaded fashion with encoding of surface features happening only after resonances have been established between bottom-up and top-down processing of features, letters, letter combinations, and finally whole words. The brief, masked presentations in the WS paradigm disallow the establishment of higher-order resonances, but would allow feedback to give rise to the WS effect.

D54 Early encoding of radical position legality in Chinese character reading: An ERP study

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In the alphabetic writing system, the identity and order of letters in a word have long been studied as important factors in reading. An analogous question in Chinese is how readers identify sublexical orthographic components called radicals and represent their positional information. Previous studies using behavioural measures have obtained mixed findings (Taft, Zhu, and Peng, 1999; Tsang & Chen, 2009; Yeh & Li, 2002). A recent ERP study by Su et al. (2012) manipulated radical position dominance, defined as the proportion and frequency of characters containing a radical in a particular position relative to all characters containing the radical, and found that target characters containing a primed radical in a dominant position showed smaller N170 but enhanced N400 components compared to characters with radicals in a subordinate position. In this study, we isolated effects of radical position dominance by creating four types of pseudo-characters varying in the constituent radicals' legality and degree of position dominance (Unique, Dominant, Subordinate, and Illegal). Twenty native Chinese readers performed a character detection task where real characters (17% of trials) were identified among pseudo-characters, with concurrent ERP recording. Pseudo-characters with radicals in dominant positions (Unique and Dominant) elicited significantly more errors than pseudo-characters with radicals in subordinate or illegal positions (Subordinate and Illegal). This might be attributed to the higher visual familiarity for radicals appearing in dominant positions, which lowered the threshold for false alarms. For ERP data, Illegal items were reliably distinguished from other pseudo-character items within 100ms, with larger P100 amplitudes at left posterior electrodes. The difference was largest between Unique and Illegal items, and no statistical difference was found among the other pseudo-character conditions. At the N170, Illegal items elicited a significantly smaller negativity than Unique items at occipital sites. Again, the pseudo-character conditions in legal radical positions did not differ among themselves. No effect was found in the N400 time window. The early P100 effect suggested that radical position legality was detected at the initial stage of visual processing and might be similar to the orthographic typicality effects reported for English stimuli where atypical pseudowords like amyss elicited a larger P100 than typical pseudowords like abiss (Hauk et al., 2006). The N170 has been associated with radical-level orthographic processing in Chinese (Lin et al., 2011) and our findings converged with previous reports in showing that radical position legality was reflected in this component. While there were stronger effects for Unique than Dominant and Subordinate items, in general our pattern of finding indicated that radical dominance did not have a large impact in character processing, provided that they appeared in a legal position. Together, these findings revealed the early ERP components that underpinned radical position coding and further specified that its representation appeared to be "all or none" in nature.

D55 Spatial and temporal dynamics of homophone density and phonetic consistency effects in writing Chinese characters: an MEG study

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Previous studies of alphabetic writing systems have demonstrated that orthographic consistency (whether a rime could be spelled in multiple ways) affects auditory word recognition and suggested that knowledge of orthography influences the spoken word recognition. Two different views have been proposed to explain the orthographic consistency effect. One is the phonological restructuring view, which claims that orthographic properties of words may restructure preexisting phonological representations during literacy acquisition. The orthographic effect may arise within the speech network that processes phonological information in the left inferior frontal gyrus (IFG), insula, superior temporal gyrus (STG, BA22) and supramarginal gyrus (SMG,

BA40). The other one is the orthographic co-activation view, which assumes that orthography is activated online during spoken word recognition. The orthographic effect may arise from brain regions for processing orthographic information (i.e. temporo-occipital visual cortex), in addition to the speech network. This study aims to use magnetoencephalography (MEG) to investigate the temporal and spatial dynamics of the orthographic consistency effect and O-to-P consistency effect in writing Chinese characters with dictation, and to resolve the debate between the orthographic co-activation and phonological restructuring views. Participations were asked to perform the writing to dictation task for 108 monosyllabic Chinese spoken words. These candidates for orthographic outputs were divided into four conditions based on their O-to-P consistency (High/Low, measured by phonetic consistency, the reliability of a phonetic radical in providing the whole character's phonological clue) and homophone density (High/Low, measured as the number of characters sharing exactly the same pronunciation). The averaged dynamic statistical parametric maps (dSPM) of the homophone density effect revealed significant activities first in the left insula (433-548 ms) and STG (494-546 ms), and then spread to the left temporo-occipital visual cortex such as left inferior parietal gyrus (545- 614 ms) and left lingual gyrus (743- 842 ms). These findings support the co-activation of orthographic codes in spoken word processing. Besides, the O-to-P consistency effect revealed a later activation in the left IFG (555-597 ms), STG (666-752 ms) and SMG (788-850 ms), and modulated the homophone density effects. To be more specific, the homophone density effects were found in writing low O-P consistent characters in left IFG, SMG, inferior temporal gyrus, inferior parietal gyrus and fusiform (580-850 ms). The second-order feedback consistency effect as O-to-P consistency in the auditory modality supports the reverberation between orthography and phonology in spoken word recognition.

D56 ERP reveals radical processing in Chinese character recognition:Evidence from semantic categorization

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In written Chinese, over 80% of characters are compounds, in which independent constituents called radicals can be considered as the sub-lexical units. Some radicals can appear at different positions within a character. For instance, the radical 口 can appear on the left of 听 (listen), on the right of 知 (know), at the top of 呆 (stupid), or at the bottom of 杏 (apricot). Actually, prior studies confirmed the effects of radical position in Chinese character recognition. The primary concern in present study on radical processing is whether radicals are represented with or without position in the Chinese lexicon (i.e., position-specific or position-general, respectively). In the current study, both position-general radical frequency (GRF) and position-specific radical frequency (SRF) were varied when ERPs were recorded and a semantic categorization task was employed. Two types of radical information were manipulated: the number of characters containing a specific radical irrespective of position (i.e., frequency as a position-general radical) and the number of characters containing a specific radical at a particular position (i.e., frequency as a position-specific radical). The results showed that the effects of position-specific and position-general radical frequency were both related to P200 and N400. Characters of low radical frequency evoked larger P200 and smaller N400 than their high frequency counterparts. Moreover, there was no difference between the peak latency of the two P200 effects. However, our previous research has shown that position-specific rather than position-general radicals produced earlier and more enduring ERP effects on lexical decisions. We thus conclude that both position-general and position-specific radicals are activated and processed in Chinese character recognition, but the time course of different types of radical processing may be modulated by task demands.

D57 The influence of bottom-up and top-down information on the activation of orthographic, phonological and semantic representations during reading

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Reading is a multimodal activity. Several studies provided evidence suggesting that processing written words automatically activates not only orthographic representations but also phonological and semantic ones. This observation could be explained, for instance, by connectionist models claiming that the presentation of an orthographic pattern as input initiates the spread of activation via weighted connections throughout the network in which orthography is linked to phonological and semantic information. Here we used functional magnetic resonance imaging to examine how the activity of different brain areas involved in orthographic, phonological and semantic processing is influenced by bottom-up and top-down factors. Stimuli were sequences of words embedded in a continuous stream of blank screens and masks. Words' visibility, a bottom-up factor, was manipulated by parametrically adjusting the duration of the blank screens that separated the words and the masks (whose duration remained constant). This led to four levels of visibility, ranging from subliminal (blank duration = 0 ms) to clearly visible (blank duration = 50 ms). Participants were required to perform three tasks: a) symbol detection, b) rime detection and c) animal name

detection, emphasizing respectively visual, phonological and semantic processes. This constituted the top-down manipulation. A global network of word processing was obtained in each task by contrasting masked word trials with pure masks trials. We found overlapping brain areas in the three tasks, including the left inferior occipital cortex (OCC), left fusiform gyrus (FUS), left inferior frontal gyrus pars opercularis (IFG oper), left inferior frontal gyrus triangularis (IFG tri), left precentral cortex (PreC), left insula and bilateral supplementary motor area (SMA). Two main activation patterns were observed within the network. First, the activity within the left OCC and FUS increased with level of visibility but was not modulated by task. Second, the activity within the frontal network that constitutes "high-level" language regions was modulated by the interaction between level of visibility and task. Precisely, in the IFG tri, IFG oper, PreC and SMA, the effect of visibility was stronger in the semantic compared to visual task. The same pattern of activation was found in the IFG tri when the semantic was compared to phonological task. A difference between the effects of visibility observed in the phonological and visual task was found in the PreC. Our finding suggests that the influence of bottom-up and top-down information on the activation of different brain areas in the reading network depends on the role of each area in the on-going cognitive process. In the present experimental setup, exposure to written words automatically activated orthographic, phonological and semantic information. However, the strength of activation depended on task and regions of interest. While the activation of the areas involved in orthographic processing remained constant across tasks, the activations of areas involved in phonological and semantic processing varied with task demands.

D58 Network coherence in the resting state: Differences between orthographic networks and evolutionarily older networks

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Written language is an evolutionarily recent human invention, and therefore the characteristics of orthographic processing networks may differ from those of "older" cognitive functions (Dehaene, 2005). While reading and spelling have been examined extensively with task-based neuroimaging (e.g., Cohen et al., 2000; Beeson et al., 2003), these networks have scarcely been examined with resting-state fMRI (RS-fMRI) (but see Koyama et al., 2010; Vogel et al., 2012). Furthermore, there has been no systematic comparison of RS connectivity for orthographic networks (reading and spelling) and other cognitive functions. In this work, we show that understanding the characteristics of orthographic processing networks at rest provides new insights into the fundamental relationships between these and other networks. In this study, we examined the network relationships for different cognitive functions: reading (RdN), spelling (SpN), spoken-language comprehension (LN), dorsal attention (DAN), default-mode (DMN) and sensorimotor (SMN), comparing the within- versus across-network coherence of the RS activity of key nodes of these networks. Within-network coherence corresponded to the average RS correlation between the regions-of-interest (ROIs) of the same network, whereas across-network coherence corresponded to the average RS correlation of the ROIs of a given network with those of a different network. Network ROIs were identified from published meta-analyses for each cognitive function. For the RdN, we performed a cluster analysis of five published meta-analyses of reading, identifying 9 consistent ROIs. In total we examined 52 ROIs in 6 networks (7-10 ROIs per network). Methods. Participants were 8 neuro-typical adults (4 male, mean age 52.9). Each participant underwent 2 consecutive resting-state scans (7:10 each). RS-fMRI data were analyzed using the REST toolbox (Song et al., 2011), and each participant's BOLD signal time-series for the two scans were concatenated to create one time-series of 350 data-points. For each ROI, the average BOLD signal was computed across all voxels in a 3mm-radius sphere centered on the pre-defined coordinates. The correlation between the time-series of every pair of ROIs was calculated, and the average absolute correlations were compared for every pair of networks using a linear mixed-effects model in R (Bates et al., 2013). Results. Evolutionarily older networks (DMN, DAN, SMN, LN) showed generally high within-network coherence, and greater within versus across-network coherence. In contrast, the RdN and SpN showed relatively low internal coherence, and a mixed-pattern of connectivity with other networks, with some across-network coherence values being no different or even greater than the within-network values. In addition, although the LN showed greater internal coherence than the orthographic networks, unlike the DMN, DAN, and SMN it also showed cross-network RS coherence with the orthographic networks that was almost as strong as its internal coherence. Overall, the results indicate that both evolutionary age and functional relationship may affect the degree of RS connectivity between functional brain networks. Orthographic processing may not have had the time to develop the neural connectivity and functional coherence of evolutionarily "older" networks.

Phonology, Phonological Working Memory

D59 Why 'inpossible' is 'umproblematic': the perception of alternating prefixes

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Introduction. The specific pronunciation any word varies widely between speakers, situations, and even linguistic contexts. Though variation is the norm, deviations from canonical pronunciations come in a variety of forms. When frequently encountered, the listener may treat

these forms as expected variation, particularly when driven by common coarticulatory processes or grounded in accent or speech style. Previous work has shown these forms rarely disrupt lexical access (Cole, 1973) and do not generate an N400 during on-line processing (Sebastian-Gallés et al., 2006). Alternatively, unfamiliar variations may be treated as speech errors, particularly if they violate phonotactic constraints on the language. Phonotactically illegal stimuli have previously been shown to generate an N400 in visual (Ziegler, 1997) and auditory (O'Rourke & Holcomb, 2002) domains. I present data which shows that contrary to these broad generalizations, certain unfamiliar deviations can be treated as expected variation, even when phonotactic constraints are violated. Methods. In an ERP lexical decision experiment, subjects (N=28) were asked to identify mispronounced words which began with 'in-' or 'un-' prefixes. Crucially, these prefixes naturally exhibit divergent patterns of variation: in casual speech, 'un-' optionally assimilates before labial stems (e.g., 'umproblematic') whereas assimilation of 'in-' (e.g., 'improper') is obligatory regardless of speech style. Artificial variation was introduced by changing the final nasal in half of the stimulus items. These non-standard nasal segments were distributed in one of four categories: (1) UM+labial (e.g., 'umproblematic'), a frequently encountered but optional coarticulatory assimilation; (2) UM+coronal ('umdeniable'), an unfamiliar and phonotactically illegal sequence; (3) IN+labial ('inprecise') and (4) IM+coronal ('imtolerant'), both of which unfamiliar and phonotactically illegal sequences in a prefix that otherwise participates in obligatory assimilation. Results. ERP results show UM+coronal items trigger a strong N400 response in left anterior electrodes, as would be expected given the phonotactic violations in the stimuli. The UM+labial items do not trigger an N400, supporting it idea that frequently encountered items are treated not as speech errors, but rather as variations of canonical forms. Surprisingly, both IN+labial and IM+coronal forms also fail to elicit an N400 response, despite the fact that these forms are both unfamiliar and contain phonotactic violations equivalent to the UM+coronal forms. Conclusion. The data suggests that prefixes which obligatorily alternate are given different treatment than those which only optionally alternate. This is consistent with the notion that obligatory alternation results in underspecified lexical forms (Inkelas, 1995). Here, the final nasal of 'in-' lacks place features because the obligatory alternation renders these features perfectly predictable based on the stem. On the other hand, 'un-' maintains its coronal specification because it only optionally assimilates. This pattern of results presents a challenge to a number of models of lexical access, such as exemplar-based theories, which do not distinguish sources of variation in perception. This data also provides counterevidence to the FUL model of underspecification (Lahiri & Reetz, 2002), which does not recognize obligatory alternation as a trigger for underspecification.

D60 ERP evidence of implicit and explicit phonological rule learning

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INTRODUCTION: In an artificial language learning study, Moreton (2012) showed that adult English speakers can learn a phonological pattern in which the consonants in CVCV words matched or mismatched in voicing. After brief exposure to words exemplifying the rule (e.g., [dugi], [tika]), participants distinguished novel words that fit the rule (e.g., [gidu]) from those that violated it (e.g., [kidu]). However, decisions about novel words could be made by analogy to learned words or by generalizing abstract rules. Further, phonological learning in both natural and artificial languages is almost always implicit. Are important distinctions between phonological learning and other types of pattern learning (e.g., visual objects) driven by whether learning is implicit or explicit? Two ERP experiments addressed these issues. METHODS: Following Moreton (2012), participants (Exp1: n=24; Exp2: n=18) were exposed to 16 CVCV words, all of which fit the same pattern: the consonants matched in voicing, or the consonants mismatched in voicing. Exposure to the pattern was given in five blocks of 80 trials each. In Exp1, participants were asked to learn the meanings of these words through a word-picture matching task. In Exp2, participants were told to explicitly learn which consonants could co-occur. After each exposure block, participants used a 4-point scale to rate the likelihood that words belonged to the language they were learning (Exp1) or fit the same explicit pattern they were learning (Exp2). Test items included words that had been presented during the exposure block, novel words that fit the phonological pattern (Novel-Fit), and novel words that did not fit the phonological pattern (Novel-Violate). RESULTS: Repetition of words across the five exposure blocks resulted in an attenuation of the negativity that was measured 230-500 ms after word onset. In Exp1, this pattern is consistent with an N400 that decreased in magnitude as participants learned the words. The more anterior distribution of the exposure effect in Exp2 suggests a decrease in the phonological mapping negativity (PMN) as participants explicitly learned the pattern. In Exp1, participants rated novel words that fit the phonological pattern as more likely to be in the language they were learning (Novel-Fit: M=2.71±0.29; Novel-Violate: M=2.21±0.26). The difference in ratings for the explicitly learned pattern in Exp2 was even larger (Novel-Fit: M=3.65±0.30; Novel-Violate: M=1.74±0.57). Critically, in Exp1, Novel-Violate words elicited a larger late positive component (LPC) than Novel-Fit words between 600-1000 ms over posterior regions. The same comparison in Exp2 also showed a late positivity, but it differed in timing (1000-1400 ms) and distribution (anterior) from that observed in Exp1. CONCLUSIONS: Evidence of an LPC that is similar to what is observed in response to violations of syntactic rules in natural languages and harmonic structures in

music suggests that even newly learned phonological patterns from an artificial language can be represented as abstract rules in the brain. Further, those abstract representations are distinct for implicitly and explicitly learned patterns, indicating that the type of learning that occurs is a critical factor differentiating between phonological learning and other types of pattern learning.

D61 Non-perceptual regions support phonological short-term memory: evidence for a buffer account *Qiuhai Yue[1], Randi C. Martin[1], A. Cris Hamilton[1]; [1]Rice University, Houston, TX, 77251, USA*

Short-term memory (STM) is the capacity for holding a small amount of information for a short period of time when the input stimulus is absent. Recently, the buffer vs. embedded processes accounts of STM have been under debate. The buffer account proposes that there are buffers dedicated to the short-term retention of different types of information (e.g., Baddeley, 2001; Martin et al., 1999). In contrast, the embedded processes account argues that STM consists of transient activation of long-term memory (LTM) representations for that information (Cowan, 2001). In line with the embedded processes approach, some have claimed that STM for speech information (i.e., phonological information) depends on persisting activation in the left superior temporal region that supports speech perception (e.g., Ravizza et al., 2011). However, most studies addressing this issue have used visually presented stimuli making it unclear whether subjects relied on phonological retention. Also, these previous studies have seldom addressed perception and STM in the same subjects and thus it is unclear whether the activated regions are in fact speech perception regions. The present study tested these two theoretical alternatives and addressed prior limitations by using auditory presentation and assessing perception and STM for the same healthy subjects with functional magnetic resonance imaging (fMRI) approach. Specifically, we used an immediate discrimination task to tap speech perception and a delayed recognition task for phonological STM. Also, in both tasks, we manipulated the type of stimuli (verbal: nonwords vs. nonverbal: chords) and in the memory task manipulated load (3-items vs. 1-item). Regions involved in STM were predicted to be sensitive to the load manipulation. With this design, we examined whether brain regions involved in phonological STM maintenance would extend beyond those involved in speech perception. Contrary to the predictions of the embedded processes approach, in the speech perception region (e.g., left superior temporal gyrus, defined independently by the perception task), neither sustained activation (relative to the fixation baseline) nor memory load effect was observed during the maintenance stage of the STM task. In contrast, consistent with the buffer approach, the effect of memory load during the maintenance stage of the STM task activated a set of dorsal parieto-frontal regions, including a left inferior parietal region (i.e., supramarginal gyrus), which has been assumed to be a neural substrate for phonological buffer previously on the basis of patient lesion data. In addition, the buffer account assumes that STM buffers are connected to LTM representations so that activated representations of phonological information from LTM can be transferred to and kept active in the phonological buffer. Thus, neural activation in the temporal perceptual region should co-vary with the parieto-frontal maintenance regions. Consistent with this prediction, a context-dependent correlation (i.e., generalized psychophysiological interaction) analysis showed that, as memory load increased, the perceptual temporal region became more strongly connected with the parietal region involved in maintenance. Taken together, the findings support a buffer account for phonological STM in which regions in the left parietal lobe serve as a buffer for maintaining speech representations.

D62 Attentive Versus Pre-attentive Neural Processing of Allophony and Phonemic Contrast *Joseph CY Lau[1], Patrick CM Wong[1,2]; [1]The Chinese University of Hong Kong, [2]Northwestern University*

Contemporary models of neuro-phonological processing have mainly focused on two endpoints of speech processing. On one end, it focuses on how acoustic signals are mapped onto speech categories (e.g. by drawing on their articulatory features). On the other end, it examines the neural pathway that connects combinations of speech sounds with lexical meaning. However, these models largely ignore the role of phonological grammar, which systematically governs how speech sounds are combined into units preceeding words such as sound clusters (e.g., 'pl' in 'play'), syllables (e.g. 'ob' and 'ject' in 'object') and stress templates (e.g. OBject 'n.' v.s. obJECT 'v.'). The present study aims at evaluating the neurocognitive implementation of phonological grammar by testing how phonemes and allophones, two basic levels of abstraction, manifest neurocognitively in speech processing. Linguistic theory postulates that the phoneme is the smallest linguistic unit that contrasts lexical meanings: (e.g./ t/&/d/ in 'teen' v.s. 'dean'). Allophones are realisations of a phoneme into different phonetic categories according to phonological context (e.g. unaspirated 'p'[p] vs aspirated 'p'[p^h] in English depending on whether a preceding consonant exists: 'Pin' (aspirated) v.s. 'spin' (unaspirated)). Behaviourally, the psycholinguistic realities of phonemes and allophones have been attested. Here, we hypothesise that the processing of levels of phonological abstraction (from allophones to phonemes and beyond) follows a hierarchy of cortical processing such that a more basic phonological unit (e.g., allophone) would be processed pre-attentively, whereas a higher level phonological unit (e.g., phoneme) would be processed both pre-attentively and attentively. Seventeen native Cantonese speakers participated in MMN and P300 experiments. Auditory stimuli consisted of Cantonese vowels [o,ɵ,œ] which afforded both allophonic distinction([o~ɵ]) and phonemic contrast([o~œ]). An oddball paradigm consisting of 70%

of standard [ɵ]trials, 15% of [o]trials, and 15% of [œ]trials was presented in both experiments. For P300 experiment, 500 trails were pseudo-randomly presented (1200ms inter-stimulus-interval 'ISI'). Participants were instructed to respond to sounds different from a recurring one. For MMN experiment, 800 trails were pseudo-randomly presented (800ms ISI). Participants were instructed to ignore the sounds. EEGs were recorded (Sampling rate:1kHz) from Fz, F3 and F4 for the MMN experiment, and from Fz, Cz and Pz for the P300 experiment (ground: FPz; reference: M1). Filtering (band-pass: 0.1-30Hz), artefact rejection (window:±50μV), epoching (window:-100 to +799ms), and re-referencing (to M2) were performed offline as ERPs were computed. P300 responses were quantified by picking the positive peak amplitudes and latencies between 250-450ms. For MMN, ERPs evoked by the standard stimulus were subtracted from those evoked by the two deviant stimuli respectively. Responses were then quantified by selecting the negative peak amplitudes and latencies between 100-300ms. Results show that preattentive processing elicited a significantly earlier MMN response for allophonic than phonemic distinction as predicted. Contrary to our hypothesis, attentive processing elicited a significantly larger P300 response for allophonic than phonemic distinction. These results are among the first to pinpoint the neurocognitive architecture of phonological abstraction. How abstraction may interact with acoustic properties to arrive at successful neuro-phonological processing will be discussed.

D63 Voicing Underspecification in English Fricatives

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BACKGROUND: Phonological underspecification theory states that lexical representations in long-term memory contain only a subset of the phonological features needed for pronunciation (Dresher, 2009). This view has received recent support from acquisition studies (Fikkert & Levelt, 2008) and event-related potential studies (Eulitz & Lahiri, 2004; Lahiri & Reetz, 2010). Phillips et al (2000) argue that a varying-standard MMN paradigm (vMMN, where the standards vary within a category) can be used to probe phonological representations. Furthermore, Eulitz and Lahiri (2004) suggest that, in a vMMN paradigm, the MMN indexes the comparison of a phonetic oddball to the phonological representation of the standard in memory. They predict that a standard stream containing a phoneme specified for a feature followed by a contrastingly specified phonetic deviant results in a strong MMN, while a standard stream containing an underspecified phoneme followed by any phonetic deviant elicits a much weaker (if any) MMN response. We examined these predictions with two MMN studies of the /s/-/z/ contrast in English. It has been argued that voiceless fricatives are linked to the feature [-voice] in lexical representations, while voiced fricatives are underspecified for voicing (Iverson & Salmons, 1995). The Eulitz and Lahiri model predicts an asymmetric MMN response for the phonemes /s/ and /z/ in the vMMN paradigm. The predictions were confirmed - an asymmetric MMN response was observed for the phonemes /s/ and /z/ in the vMMN paradigm (Experiment 1); furthermore, this asymmetry cannot be reduced to phonetic properties of the sounds themselves (Experiment 2). EXPERIMENT 1: A vMMN paradigm was used. 4 tokens each of /sa/ and /za/ . 20 right-handed subjects participated (age 19-32, 9 female), who all reported normal hearing and English as a first language. The stimuli for the experiment were all naturally produced. Portions of them were spliced out at zero-crossings to make them roughly equal in duration (~560ms). In two time-windows (a) 250-350ms, (b) 450-700ms, there was a significant MMN for the phonetic oddball [za] (when compared to its own standard), but not for the phonetic oddball [sa] (when compared to its own standard). EXPERIMENT 2: A single standard (phonetic) MMN (sMMN) paradigm was used, where the MMN response of a phonetic oddball token is compared to the phonetic representation of the standard token. 1 token each of /sa/ and /za/ (selected from Experiment 1). 23 new right-handed subjects participated (age 18-24, 17 female), who all reported normal hearing and English as a first language. In the time-window 250-350ms, we found an asymmetric MMN for the phonetic deviant [za] as in Experiment 1. But in (a) 450-700ms and (b) 700-800ms, both phonetic deviants had clear MMN responses. DISCUSSION: Our results follow the predictions of underspecification theory; the vMMN paradigm elicited an MMN response for [za] as a deviant, but not [sa] as a deviant. Furthermore, the results cannot be reduced to phonetic differences between stimuli, since in the sMMN paradigm, an MMN response was observed for both deviant categories. The results suggest that phonemic representations are indeed sparsely represented, i.e., underspecified.

D64 Neural basis of conflict resolution in encoding and retrieval interference

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Introduction: Recent evidence points to retrieval interference from semantic distractors as a primary source of difficulty during thematic integration, while interference from phonological distractors plays a role only at encoding (Kush et al., 2015; Van Dyke & McElree, 2006). The current study examined the neurological basis of these effects. Method: Following previous work, which examined interference effects using a dual-task paradigm, we asked 28 participants (age 16-25) to perform a four-part task during MRI scanning. Tasks were: i) learn a list of three words; ii) read a sentence containing an object-cleft construction; iii) answer a question about the sentence; iv) recall the memory words. The manipulation of interest occurred during sentence reading. Four conditions were presented; conditions (a) & (b) examine

retrieval interference from semantic distractors held in the memory list who can (a) or cannot (b) serve as objects for the manipulated main verb. Conditions (c) & (d) examine encoding interference from phonological distractors that match (c) or do not match (d) the displaced filler in the gapped constructions. a) Memory words: ROOF-SINK-PIPE Sentence: It was the raft that the guy who drank the hot coffee fixed in two days. b) same as condition (a) but replace "fixed" with "sailed." c) Memory words: GRAFT-SHAFT-LAUGHED Sentence: same as in condition (b) d) Memory words: same as condition (c) Sentence: It was the boat that the guy who drank the hot coffee sailed in two days. Results: Data were analyzed using an event-related fMRI design that focused on the locus of retrieval interference (fixed vs. sailed) or encoding interference (raft vs. boat). Semantic distractors produced retrieval interference during integration of the clefted object at the verb, manifested as increased activation in posterior regions above and below the Sylvian fissure. Phonological distractors produced encoding interference when processing the filler, eliciting activation in the inferior frontal gyrus (BA 44/45). A conjunction analysis of both types of interference showed significant overlap in the left superior frontal gyrus (BA 46; DLPFC). We interpret this activation as associated with resolution of verbal conflict (Nee et al, 2007). An independent ROI analysis of subdivisions within the left lateral prefrontal cortex revealed that only encoding interference was associated with significant activation in BAs 47 and 44/45, while both encoding and retrieval interference were significantly active within DLPFC. Additionally, retrieval interference led to significant activation within the rostral caudal cingulate zone and anterior cingulate cortex, regions associated with outcome evaluation (Jahn et al, 2014) while encoding interference did not. Conclusion: Both encoding and retrieval interference recruited a common area of DLPFC, whereas only encoding interference was associated with significant activity within the inferior frontal gyrus area. These results suggest that the DLPFC responds to resolution of verbal conflict regardless of the type of interference that is processed. Inferior frontal areas show greater specificity to phonologically-based encoding interference, while medial regions are associated with selection of the necessary object in order to complete filler-gap dependency.

Syntax, Morphology

D65 Cortical Entrainment to Constituent Structure in Language Acquisition

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All human languages are hierarchically structured: sentences consist of phrases, which consist of words and syllables. While speech contains acoustic correlates to syllable structure, it lacks cues uniquely delimiting higher-level units (phrases and sentences). Recent evidence suggests that mental representations of phrasal and sentential units are nevertheless observed online, as neural activity entrained to the phrasal and sentential rhythms of speech. Ding, Melloni, Zhang, Tian, and Poeppel (submitted) recorded MEG while Chinese or English speakers listened to Chinese and English materials consisting of (i) unstructured sequences of monosyllabic words, (ii) sequences of multi-word phrases, and (iii) sentences containing multiple multi-word phrases. Neural responses at the syllabic rate were observed regardless of language background for all materials. Neural responses at the phrasal rate (ii) or the phrasal and sentential rates (iii) were observed only when participants understood the stimulus language. Follow-up experiments confirmed the independence of neural entrainment from acoustic properties and phrase/sentence length in words, providing a possible mechanism for online structure building. The knowledge underlying entrainment to hierarchical linguistic structure is at least partly language-specific, hence acquired from exposure. How and when does neural tracking of constituent structure emerge during language acquisition? We asked this question using a miniature language with the base syntax ABCDEF, where each letter is a form class category with 2-4 monosyllabic words. Sentences of type ABCDEF comprise 5% of the input. In the rest of the input, pairs of adjacent words from the base structure have been moved, repeated, or deleted. In the experimental condition, transformations apply to phrases [AB/CD/EF], creating high within-phrase and low between-phrase transitional probabilities. In the control condition, transformations apply to any adjacent word pair, creating flat transitional probabilities across words. Thompson and Newport (2007, Language Learning and Development) demonstrated that adults learning the experimental language rapidly acquire its phrase structure, distinguishing two-word sequences that form a phrase (e.g., AB) from those that span a phrase boundary (e.g., BC) after only 20 minutes. As expected, subjects learning the control language did not acquire any phrase structure even after several days. These results suggest that experimental subjects formed representations of higher-level constituents, whereas controls did not. Here we asked whether and how learners' emerging knowledge of constituent structure manifests as neural entrainment to that structure. We measured cortical activity with MEG while participants listened to the phrase-structure or control language. The neural response at the syllabic rate was observed for both languages, as expected. Crucially, the neural response at the phrasal rate was substantially larger for the phrase-structure language than its control after just 6 minutes. Furthermore, the neural response at the phrasal rate is phase locked to the stimulus phrasal structure in the experimental language. Additional exposure to the experimental language augmented the phrasal but not the syllabic response, reflecting increasing knowledge of the phrase-structure rules. Cortical

entrainment to constituent structure emerges rapidly in language learning, perhaps even before behavioral evidence of these representations. These findings suggest a possible role for cortical entrainment in the acquisition of hierarchical linguistic structure.

D66 Parsing in the monolingual and bilingual brain: ERP evidence of automatic simultaneous access to morphosyntactic information in L1 and L2

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In today's world, multilingualism is the norm rather than the exception. The human ability to understand and speak more than one language has therefore become an important topic of investigation in cognitive neuroscience. A key issue in mastering any language is acquiring grammatical and morphosyntactic rules in order to understand and produce discourse correctly. Previous studies suggest that native speakers possess automatic access to memory traces of morphosyntactic elements (Shtyrov et al., 2003, JOCN; Bakker et al., 2013, NeuroImage; Leminen et al., 2013, Cortex), i.e. morphosyntactic structures are rapidly processed in the human neocortex even without listeners' focused attention. It remains unknown, however, whether automatic neural morphosyntactic mechanisms work in a similar way in native speakers and highly proficient bilinguals. This was investigated here in (1) a group of sequential Finnish-English bilinguals (L1 Finnish speakers who started learning English before the age of nine, and use it in their daily lives), and (2) monolingual speakers of English. The two adult groups (aged 18-40) were presented with an acoustically balanced set of Finnish and English words consisting of (1) real inflected words with plural suffixes '–s' (English) and '–t' (Finnish) e.g., cakes, kanat ('chickens'); (2) novel complex words consisting of real stems and combined with suffixes from the opposite languages (e.g., cake-*t, kana-*s), and (3) as a control, novel complex words consisting of phonologically similar pseudoword stems and real suffixes of both languages (*pake-t, *pana-s, *pake-s, *pana-t). We recorded high resolution EEG in a passive listening paradigm. The ERP pattern in the monolingual group showed a stronger activation for real English inflected words with the corresponding inflectional suffix (e.g., cakes) than for Finnish inflected words. This corroborates earlier findings with similar experimental paradigms and suggests automatic access to lexical and grammatical units in L1. Similar, although smaller responses were found in monolinguals for English pseudo-stems with plural marker '-s', e.g., *pakes. Crucially, this pattern was not found in monolinguals for Finnish plural suffix attached to English stems. This suggests that inflectional parsing takes place for both real words and unknown complex pseudowords (although to a different degree) as long as they contain suffixes that conform to the native language morphological patterns. In contrast, bilingual speakers exhibited an unbiased ERP response towards complex words in both languages, indicating a similar skill level of morphological parsing in both L1 and L2. These responses were characterized by similar ERP amplitudes and response patterns across the different morphosyntactic conditions across languages. These results suggest that bilingual learners are capable of automatically accessing morphosyntactic information in both languages interchangeably and exhibit an overlap of morphological processing strategies, whether it be in L1 or L2. These results are in line with a view on bilingual grammatical processing where children who have later exposure of L2 input (even up to the age of 9) may process grammatical information like native speakers (e.g., Hernandez et al., 2005, TrendsCog.Sci.).

D67 Finding agreement: An on-line study of gender processing, in adults and children

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INTRODUCTION: Acquisition of ADJ(ective) gender agreement (masculine-feminine) in French is mastered later than DET(erminer) agreement (Royle & Valois 2010) due to irregular morphology. However, cognitive processes underlying gender acquisition have rarely been addressed (Royle & Courteau 2014). Few ERP studies focus on ADJ-noun agreement and most study morphologically transparent languages in the written modality (Molinaro et al 2011). Agreement errors typically elicit a (Left) Anterior Negativity (LAN) or an N400, followed by a later positivity (P600). In order to understand the cognitive mechanisms underlying agreement, we investigated ERP markers of agreement processing in adults, and whether these are influenced by task. Second, we studied developmental cognitive profiles for agreement in chidren? METHOD: (CORR)ect auditory sentences using vocabulary acquired by age 3 were used. These were cross-spliced to create incorrect conditions: (ADJ)ective agreement, (DET)erminer agreement errors as well as visual-(SEM)antic errors, by presenting incongruent images (e.g., a green shoe) with correct sentences (a green hat). EEGs were recorded with 32 electrodes on two groups: 15 adults, with two task conditions: acceptability judgment (n=8), and no task (n=7), and 40 children (aged 5 to 9). We predicted the SEM condition would elicit an N400 in adults, the DET and ADJ conditions would elicit a biphasic LAN-P600 (Molinaro et al 2011), with the P600 reduced in the absence of a task (Sassenhagen et al 2014). In children, we predicted similar responses for the SEM and DET conditions, but different responses for the ADJ condition (an N400 instead

of a LAN) (Clahsen et al 2007). RESULTS: In adults, SEM incongruencies elicited an N400, and DET/ADJ agreement errors a biphasic LAN-P600. The P600 amplitude was increased with task. In children SEM incongruencies, elicited a later, left-lateralized N400 (400-600ms). DET errors elicited a very late (onset: 1000ms) positivity at parietal sites. The ERPs to ADJ errors were qualitatively different from adults as we observed a LAN + N400 pattern. CONCLUSION: Children elicited patterns similar to but slower than adults for words (SEM) and structures (DET) they master behaviorally. For structures still being acquired (ADJ), children seem to rely more on lexical retrieval (N400) than adults (LAN-P600). Task effects in adults confirm that the P600 is subject to experimental manipulations, while the LAN is not yet stable across error types in children. In order to better understand developmental stages of agreement acquisition, further analyses will involve comparisons between age groups. MATERIALS (1) CORR: _Je vois un soulier vert sur la table_ I see a shoe green.MASC on the table 'I see a green shoe on the table'; (2) ADJ: _Je vois un soulier *verte sur la table_ I see a shoe.MASC green.FEM on the table; (3) DET: _Je vois une *soulier vert sur la table_ I see a.FEM shoe. MASC green on the table; (4) SEM: _Je vois un ?chapeau vert sur la table_ 'I see a green HAT on the table'.

D68 Dissociating scrambling from topicalization for activations in the grammar centers: An fMRI study in Kaqchikel Maya

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Most languages grammatically allow some word orders, and such changes in word order can be explained by several types of movement. One type of movement is scrambling, where a phrase is extracted from the original position in a verb phrase and moves to a structurally higher position outside the verb phrase. Another type of movement is topicalization, in which a subject/object outside a verb phrase moves to a still higher position. To dissociate the effects of scrambling and topicalization, a language that grammatically allows four different word orders [i.e., ±scrambling and ±topicalization] should be targeted. In the present study, we targeted Kaqchikel, a Mayan language spoken in Guatemala. In Kaqchikel, the syntactically canonical word order is VOS (verb-object-subject), and at least three noncanonical word orders are grammatically allowed (i.e., SVO, VSO, and OVS). Among the four possible word orders, the VSO and OVS word orders include scrambling, whereas SVO and OVS involve topicalization. We hypothesize that scrambling induces higher syntactic loads than topicalization, because an object deeply embedded in the verb phrase is extracted and moved during scrambling, while topicalization always occurs outside the verb phrase. Another advantage of targeting such an exotic language as Kaqchikel is to validate the universality of the cortical language areas. We recruited eight right-handed Kaqchikel speakers (aged 22–38), who actually used the knowledge of head-marking in Kaqchikel. We used a picture-sentence matching task, in which the participants listened to a Kaqchikel sentence and judged whether the action depicted in a picture matched the meaning of the sentence. A picture-color matching task was used as a control. We used 3.0 T MRI system (GE Healthcare), and analyzed the fMRI data with fixed-effects analyses. To control task difficulty among the conditions, the accuracy was used as a nuisance variable for each participants. The reaction times for +scrambling were significantly longer than those for −scrambling ($p < .006$), while the accuracy for OVS was significantly lower than that for the other word orders ($p < .002$). The main effect of scrambling showed significant activation in the left inferior frontal gyrus (F3op/F3t), lateral premotor cortex (LPMC), pre-supplementary motor area, posterior superior/middle temporal gyri, right insula, and right cerebellum (corrected $p < .05$). The main effect of topicalization did not show any significant activation (corrected $p > .6$). One-way ANOVAs for signal changes in these regions showed the main effect of word orders among the four conditions ($p < .008$). To examine the effect of scrambling against canonicity and topicalization, we compared each of +scrambling conditions with canonical word order (VOS), as well as with topicalization control (SVO). We found consistent localized activation in the L. F3op.F3t and L. LPMC alone, which have been proposed as the grammar centers. We conclude that activations in these regions are elicited by scrambling, indicating that the grammar centers are selectively involved in such a universal aspect of syntactic processing.

D69 Short Self Paced Listening Times in Syntactic Comprehension: Implications for Deficits

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Sixty one people with aphasia (pwa) and forty one matched controls were tested for the ability to understand sentences that required the ability to assign particular syntactic structures. Participants paced themselves word-by-word through twenty examples of eleven spoken sentence types and indicated which of two pictures corresponded to the meaning of each sentence. Sentences were developed in pairs such that comprehension of the experimental version of a pair required an aspect of syntactic processing not required in the corresponding baseline sentence. The need for the syntactic operations required only in the experimental version was triggered at a "critical word" in the experimental sentence. Listening times for critical words in experimental sentences were compared to those for corresponding words in the corresponding baseline sentences. In most pwa whose corrected self paced listening times were faster than normal, accuracy was below normal or at or below chance. In these pwa, the faster-than-normal listening times at critical words in experimental sentences could be due to either an intrinsic pathology of the parser/interpreter that limits the time

it operates or to a choice between balancing time spent in incremental processing and memory load that leads to more errors than normal. The first of these possibilities is the counterpart of slowed syntactic processing. The second possible mechanism is related to how the control system regulates parsing and interpretation, a mechanism that has some similarity to what has been suggested in the case of lexical processing disturbances in vascular aphasia. Six pwa whose listening times were faster than normal in one sentence type had accuracy that was also below normal on that sentence type. The structures in which these abnormally fast listening times and accuracy were found showed double dissociations and none were found only in the most demanding sentence type (object relatives), arguing that the pathological mechanism that produced these behaviors is not resource reduction. These data therefore are consistent with structure specific deficits. It appears that a pathological truncation of parsing and interpretation, or a poor choice between processing and storage, applied when a particular structure was encountered. These same six pwa had chance performance on at least one other sentence type where listening times for critical words were normal or higher than normal. This indicates that they have other deficits that affected other structures. To our knowledge, this is the first time the possibility that different pathological mechanisms can lead to abnormally low accuracy on different sentence types within individual pwa has been suggested. We are able to draw this conclusion because on-line behaviors differed in different sentence types on which accuracy is below normal in individual pwa, being faster than normal in one sentence type with below normal accuracy and normal or higher than normal in others. The present results point to the need to examine on-line data to know whether a pwa has more than one deficit at the level of mechanisms. Examination of accuracy and RT to end-of-sentence responses alone cannot tell us whether this is the case.

D70 Abstract Linguistic Structure Correlates with Anterior Temporal Activity during Naturalistic Comprehension

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Introduction Accounts of sentence comprehension catalog the network of regions involved but do not detail the information flowing through this network (Poeppel, 2012). A key debate centers on the level of syntactic detail used by the brain. Proposals range from those based on word-to-word dependencies or "good enough" structures, to those based on abstract hierarchical grammars motivated by linguistic theory (Lewis & Phillips, 2015; cf. Chomsky 1965). Neurolinguistic studies have generally relied on classic "violation" paradigms that are only indirectly related to natural language tasks (e.g. Frank et al., 2015). Using data from a passive story-listening task which evokes "every-day" language comprehension, we test proposals by quantifying the cognitive states that they imply. We evaluate model fit against fMRI-recorded brain activity. Methods Eleven participants listened to 12 minutes of Alice in Wonderland while undergoing scanning. BOLD signals from regions of interest were modeled with linguistic predictors derived from the text of the story (cf. Brennan et al., 2012). Four regions were localized per subject using functional and anatomical criteria: left and right anterior temporal lobes (LATL, RATL), left inferior frontal gyrus (LIFG), and left posterior temporal lobe (LPTL). Each region has been implicated in sentence processing, though their functional roles are debated (e.g. Friederici & Gierhan, 2013). Predictors come from models that assign varying amounts of syntactic detail: (S1) Bigram and trigram Markov models that use only word-to-word dependencies, (S2) a context-free hierarchical grammar that incorporates constituent structure but not abstractions like movement (Marcus et al., 1993), and (S3) a minimalist grammar that allows for movement and derives X-bar trees with empty categories (Stabler, 1997, Sportiche et al., 2013). Word-by-word parser states were linked with fMRI data via two complexity metrics: (i) The "surprisal" of a particular word given its syntactic left-context (Hale 2001), and (ii) the number of syntactic nodes enumerated via either a bottom-up or top-down strategy (Miller & Chomsky, 1963). Complexity estimates were aligned with the offset of each word, convolved with a hemodynamic response function, orthogonalized against low-level covariates, and resampled to 0.5 Hz. Mixed-effects linear models joining each syntactic predictor with low-level lexical, prosodic, and physiological covariates were fit against ROI signals. Likelihood ratio tests were used to evaluated the independent contribution of each model. Results Controlling for lexical and prosodic factors, surprisal from the non-hierarchical Markov models predicts signal in all four ROIs (LATL, $\chi2(1)=39.33$, $p<.001$; RATL, $\chi2(1)=24.15$, $p<.001$; LIFG, $\chi2(1) = 18.09$, $p< 001$; LPTL, $\chi2(1) = 25.42$, $p<.001$). Surprisal from a context free grammar, which is hierarchical, improves model fits in LATL ($\chi2(1)=25.29$, $p<.001$) and LPTL ($\chi2(1)=25.74$, $p<.001$). At the highest level of syntactic detail, node counts from minimalist grammars further improve model fits in LATL and RATL ($\chi2(1)=5.68$, $p<.05$; $\chi2(1)=6.42$, $p<.05$). Conclusion These results suggest that the anterior temporal lobes are involved in processing abstract hierarchical representations during every-day language comprehension.

D71 Early EEG indices of syntactic expectation reflect both linear and hierarchical dependencies

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Introduction: Rapidly deployed predictions about upcoming words and phrases are key to efficient language comprehension (e.g. Federmeier, 2007; Hagoort & Indefrey

2014). This study tests what sort of information guides these expectations. In the domain of syntax, stimuli that deviate from an expected word category elicit an early left anterior negativity (ELAN) between .1 and .3 s after stimulus onset (Friederici et al., 1993). This component reflects an error signal generated to deviations from the predicted visual or auditory form (Dikker et al., 2009; 2010). While some studies have shown rapid sensitivity to expectations that reflect hierarchical structure (e.g. Xiang et al., 2012), others suggest that only superficial word-to-word dependencies matter (Frank et al., 2015; cf. Willems et al., 2015). This debate connects with whether everyday language processing requires the brain to compute detailed syntactic representations, or whether superficial "good enough" representations are sufficient. Using electroencephalography and a passive story-listening task, we test whether early EEG signals are sensitive to expectations based on word-to-word and/or hierarchical dependencies. Methods: 19 participants listened to a 12 m segment of Alice in Wonderland and completed a short comprehension questionnaire. EEG data were collected at 500 Hz with 61 active electrodes in an equidistant montage and referenced to linked mastoids. Impedances were kept below 25 kOhms. Data were filtered from 0.5-40 Hz, epoched from -.1-1 s around the onset of each word, and baseline corrected. Epochs with artifacts were visually identified and rejected; eye-movements and cardiac signals were removed using ICA. Single-trial averages from .1-.3 s for 11 left anterior electrodes were analyzed. Word-by-word expectations given the syntactic left-context were estimated using the log-reciprocal of the probability of the next word. This is "surprisal" in the sense of Hale (2001). Probabilities were derived from three language models, all defined over parts-of-speech: bigram (1) and trigram (2) Markov Models fit using OpenGRM on the text of the entire story (chapter headings removed); (3) a context-free grammar using the EarleyX parser (Luong et al., 2013) whose rules came from Stanford parser output applied to the entire story (Klein & Manning, 2003). Surprisal values from each model were mean-centered and fit against the single-trial EEG data using mixed-effects regression with control predictors for stimulus order, word length, word frequency, and random intercepts for subjects. Likelihood ratio tests between nested models was used to evaluate the contribution from higher order predictors. Results and Conclusion: ELAN activity was significantly modulated by word-to-word bigram surprisal ($\chi2(1)=289.43$, $p<.001$). Trigram surprisals did not further improve model fit ($p > .1$). Surprisals from a context-free grammar significantly improved upon a model with bigram, trigram, and control predictors ($\chi2(1)=6.48$, $p<.05$). Re-analysis with function words excluded returned similar results. These findings show that early indices of syntactic expectations reflect hierarchical dependencies in addition to word-to-word dependencies.

D72 Neural mechanisms of passive sentence processing: univariate versus multivariate pattern analysis (MVPA)

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Introduction: Many neuroimaging studies of complex sentence processing have examined object (versus subject) relative structures, with findings showing left IFG and posterior perisylvian activation (see Thompson & Kielar, 2014, for review). However, few studies have examined passive sentence processing, with mixed and less robust activation compared to object movement structures (Caplan et al., 2007; Mack et al., 2013; Hirotani et al., 2011; Wilson et al., 2010). These findings may relate to differences between object relatives and passives; the former involve movement from an embedded to a higher clause, whereas the latter involve a main clause only. Hence, linguistic differences between passive and active sentences are arguably more fine-grained than those between object and subject movement structures and such studies may require more fine-grained neuroimaging analysis procedures, such as multivariate pattern analysis (MVPA). The present fMRI study examined passive (versus active) sentence processing and used both standard univariate (GLM) and multivariate pattern analysis (MVPA) methods. Method: Thirteen healthy participants performed a plausibility judgment task in a 3T scanner, using passive and active sentences (n=40 each) (e.g. The piano was played in the sky), presented in blocks interspersed with a control pitch discrimination task (8 each), with plausibility judged by button press. Univariate GLM analysis averaged passive and active blocks across runs and activation contrasts were performed. For MVPA, GLM-derived data for each experimental block were compared to the average of all control blocks. Contrast files were used to train a support vector machine algorithm, with classification accuracy tested on the whole brain and in five ROIs. Results: No significant activation for passive>active sentences was found using univariate analysis, whereas, MVPA resulted in above-chance classification accuracy at the whole brain level (.048) in the left hemisphere (.046) as well as within a subset of language areas (left IFG, STG, insula, p=.037), with accuracy driven by correct classification of passive sentences (p=.01). Classification accuracy was at chance in right hemisphere ROIs and in occipital and fusiform regions, bilaterally. Conclusion: MVPA showed differences in neural processing for passive versus active sentences, where standard univariate analysis did not. These findings indicate that machine-learning algorithms are useful for examining neural patterns associated with complex sentence processing. References Caplan, D., Waters, G., Kennedy, D., Alpert, N. . . . & Reddy, A. (2007).

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D73 ERP Effects of Scrambling in Korean *MyungKwan Park[1], Euiyon Cho[1], Wonil Chung[1]; [1]Dongguk University*

This paper examines effects of scrambling either a subject or object associated with 'floating' numeral classifiers (FNCs) in Korean by using the event-related potentials (ERP) paradigm. The experimental materials consisted of 360 sets of 6 items, which vary in terms of (i) the grammatical role ((S)ubject vs. (O)bject) that FNCs associate with, (ii) the type of Case/particle marker on FNCs (Case-less vs. (N)om/(A)cc Case-marked vs. (F)ocus-particle-marked), and (iii) the presence/absence of subject or object scrambling, as schematically represented below. i) S-related Case-less FNC: [park-in dog-Nom bread-Acc 2-FNC ate] I heard. ii) S-related N-marked FNC: [park-in dog-Nom bread-Acc 2-FNC-Nom ate] I heard. iii) S-related F-marked FNC: [park-in dog-Nom bread-Acc 2-FNC-Foc ate] I heard. iv) O-related Case-less FNC: [park-in bread-Acc dog-Nom 3-FNC ate] I heard. v) O-related A-marked FNC: [park-in bread-Acc dog-Nom 3-FNC-Acc ate] I heard. vi) O-related F-marked FNC: [park-in bread-Acc dog-Nom 3-FNC-Foc ate] I heard. Using the materials, we investigated the following three questions. First, is there a difference between effects of in-situ and scrambling options on FNCs? Second, is there a contrast between in-situ and scrambled objects? Third, is there a distinction between subjects in object-scrambling and object-in-situ sentences? We found that, first, Case-less FNCs in sentences involving subject or object scrambling elicited P600 in comparison to the corresponding ones in sentences without such scrambling, whereas Case-marked FNCs in the former case are ERP-wise not significantly different from the corresponding ones in the latter case. By contrast, focus-particle-marked FNCs in sentences involving scrambling elicited P600 for subject or N400 for object in comparison to the corresponding ones in sentences without scrambling. We attribute the P600 effects here to a second-pass, revised integration process that now attempts to correctly link the Case-less/F-marked FNC to the relatively more 'distant' scrambled subject or object associated with it.

D74 Honorific (Mis)Match with a Null Subject in Korean: An ERP Study *Euiyon Cho[1], MyungKwan Park[1], Wonil Chung[1]; [1]Dongguk University*

This paper used event-related potentials (ERPs) to measure electrophysiological effects of honorific predicate agreement with null subjects in Korean sentence structures. Particularly, the experiment was designed to examine three questions. First, is it possible to establish long-distance agreement of the honorific-(non)marked predicate with null subjects that take a non-local antecedent? Second, how do Korean native speakers process such long-distance agreement in a non-matched condition as well as in a matched condition? Third, is there a difference between mismatch of a 'respectful' null subject with a non-honorific marked predicate form and mismatch of a non-'respectful' null subject with a honorific-marked predicate form? Twenty-one undergraduate students participated in this experiment. They were native Korean students. Materials consist of two sets of 90 sentence triplets, as shown below: (1) Experiment 1 (a: pro, b: violation, c: control) a. chelswu-ka yaksok-ul cikhinun kes-ul pokose, sensayng-nim-un [pro acwu Chelswu-Nom promise-Acc keep thing-Acc see, teacher-Top very sengsilha-(si)-ta-ko] sayngkakhayssta. sincere-Hor-Decl-Subor thought 'After he saw Chelswu make a promise, the teacher thought pro(=Chelswu) was sincere.' c. chelswu-ka yaksok-ul cikhinun kes-ul pokose, sensayng-nim-un [chelswu-ka acwu sengsilha-(si)-ta-ko] sayngkakhayssta. (2) Experiment 2 (a: pro, b: violation, c: control) a/b. sensayng-nim-i swuhak-ul kaluchi-si-nun kes-ul pokose, chelswu-nun teacher-Nom math-Acc teach-Hor-Nm thing-Acc see, Chelswu-Top [pro yelcengcek-i-(si)-ta-ko] sayngkakhayssta. passionate-Hor-Decl-Subor thought 'After he saw the teacher teach a math class, Chelswu thought pro(=the teacher) was passionate'. c. sensayng-nim-i swuhak-ul kaluchi-si-nun kes-ul pokose, chelswu-nun [sensayng-nim-i maywu yelcengcek-i-(si)-ta-ko] sayngkakhayssta. The mean sensicality judgment for each condition was as follows: as for the example (1), (a), 3.2; (b), 1.8; (c), 3.6; as for the example (2), (a), 3.3; (b), 2.8; (c), 3.7 (ranging from 1, not acceptable, to 4, very acceptable). There was a main effect among sentence types (in Ex (1), $p<0.001$; in Ex (2), $p<0.001$). ERPs to null subject-honorific predicate mismatches in (1b) elicited a bi-phasic, LAN-P600 response. In contrast, ERPs to null subject-honorific predicate mismatches in (2b) elicited a mono-phasic, LAN response. Relative to each sentence (c), (1a) revealed a marginal effect, whereas (2a) revealed a significant effect. These results show that mismatches of respectful null subjects with the non-honorific-marked predicate form induce weaker effects than mismatches of non-respectful null subjects with the honorific-marked predicate form.

D75 No association of genetic variants of FOXP2 and BOLD response during sentence processing *Julia Udden[1,2], Annika Hulten[1,2], Katerina S. Kucera[1], Arianna Vino[1], Simon E. Fisher[1,2], Peter Hagoort[1,2]; [1]Max Planck Institute for Psycholinguistics, Nijmegen, the Netherlands.,*

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The human language faculty is subject to environmental and multifactorial genetic influences of great complexity. Mutations disrupting the FOXP2 gene cause a rare monogenic speech and language disorder. However, the potential association between common FOXP2 polymorphisms and individual variability in the healthy population has been seldom explored. One previous functional MRI study reported an association of polymorphisms and BOLD response in frontal and temporal cortices during sentence processing, in a sample of 94 healthy subjects [1]. Two FOXP2 SNPs, rs6980093 and rs7784315, were associated with variations of activation in the left frontal cortex. The present study tested whether these findings would replicate, using a larger sample of 200 healthy participants. A power calculation established that our sample size would ensure 80% power to detect the strong effect sizes (Cohen's d = 1.0) reported in [1], as well as more moderate effect sizes (d = 0.7), if present. We also used substantially more sentences than in the original study [1], in order to measure a robust individual BOLD response to sentence processing. The analytic approach was restricted to ensure maximal power. The link between the two specific FOXP2 SNPs (rs6980093 and rs7784315) and the activity in BA44 and the precentral gyrus, respectively, was not replicated in the present study. In fact, using a Bayesian statistical framework to compare each FOXP2 association reported as significant in [1] with their corresponding null hypothesis (no effect of genotype or an effect in the opposite direction) we provide moderate evidence (Bayes Factor > 3) for the null hypothesis. Our results contribute to a skeptical view on the sizes of the effects that single common polymorphisms in FOXP2 might have on functional phenotypes of sentence processing. The only large scale study in the literature, which used a sample of 1300 participants, found no associations between the two FOXP2 polymorphisms we tested and structural measures of grey matter volume, as assessed with voxel based morphometry [2]. A recent (N = 216) behavioural study on speech category learning suggested an association between individual difference on learning accuracy and learning rate and the rs6980093 SNP, but did not assess neuroimaging correlates [3]. Summing up the data from different studies including the current one, there does not appear to be strong evidence that common variation in FOXP2 in the healthy population is associated with either functional or structural endophenotypes. FOXP2 remains an interesting entry point to the complex multifactorial genetic underpinnings of disorders of speech and language. However, the current study emphasizes the need for independent replication when associations of single genes or polymorphisms and individual variation in functional measures in the healthy population are reported. Replication studies, increased sample sizes and sophisticated phenotyping are all necessary components to ensure a sensible continuation of brain imaging genetics studies with a focus on language and communication.

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Poster Session E

Friday, October 16, 5:30 – 7:30 pm, French and Walton Rooms

Animal Communication

E1 Mapping genes implicated in speech and language phenotypes in the bat brain

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Bats are able to employ an astonishingly complex vocal repertoire for navigating their environment and conveying social information. Some bat species also show evidence for vocal learning, the ability to acquire and reproduce sounds through vocal imitation, a paramount requirement of the acquisition of spoken language. The presence of this extremely rare ability, shared with humans and only a handful of other species (some birds, elephants, pinnipeds and cetaceans), recommends bats as a model not only for vocal communication, but also for the evolution and development of spoken language. However, despite their obvious potential for the study of vocal communication, bats remain severely understudied at a molecular level. A crucial step for addressing this gap and laying the groundwork for future investigation is an understanding of the neurogenetic structure of the bat brain. Studying gene expression patterns can give insight into neuronal and circuit organization and the contribution of genes to the development and function of those circuits. To this end we have comprehensively mapped the expression of selected genes implicated in speech and language phenotypes in humans (including FOXP2 and CNTNAP2) in the bat brain. Such neurogenetic mapping further allows a comparative approach with other species, including humans. We compared bat brain expression patterns with those observed in the human brain and found a high degree of similarity. This highlights the feasibility for using bats to investigate neurogenetic mechanisms underlying vocal behaviours that may be relevant for speech and language phenotypes. We have further performed genome-wide expression profiling in specific brain regions and this, together with the detailed mapping of individual genes, is helping us to build a molecular picture of the neurogenetic organization of the bat brain - an important step in establishing bats as a tractable model for investigating mammalian communication.

Language Development, Plasticity, Multilingualism

E2 Fiber pathways supporting early literacy in young children *Iris Broce[1], Natalie Baez[1], Luis Cabrera[1], Gretter Hernandez[1], Anthony Dick[1]; [1]Florida International University, Miami, FL*

Several intrahemispheric fiber pathways are proposed to support development of early literacy, although few studies have been conducted in young children. Two fiber pathways—the inferior longitudinal fasciculus (ILF) and the arcuate fasciculus (AF)—have been related to early literacy skill, but often the results are mixed. For example, some studies report that the ILF plays a role in early literacy (Yeatman et al., 2012; Epelbaum et al., 2008) and others report that it does not (Mandonnet et al., 2007; Saygin et al., 2013). The AF is more often related to early literacy (Saygin et al., 2013; Yeatman et al., 2011; 2012). Other fiber pathways, such as the inferior fronto-occipital fasciculus (IFOF) and re-discovered vertical occipital fasciculus (VOF), which connect temporo-frontal and temporo-parietal regions respectively, are candidates for supporting these skills. However, the integrity of these pathways has not been related to early literacy in young children. In general, the characterization of the fiber pathways supporting early literacy remains ambiguous. The present study aims to make progress on this front by examining these fiber pathways in school-aged children (5-8 years old) who are learning to read. Participants: Nineteen children (9 females, 10 males; age range = 5-8 years, M age = 6.8 years, SD = 1.1 years) were scanned using diffusion-tensor imaging (DTI; 15 directions; b = 900; 0.938 mm x 0.938 mm x 2 mm). Procedure: We manually identified and computed fractional anisotropy (FA) of the ILF, the AF and its components, the IFOF, and the VOF (Catani & Thiebaut de Schotten, 2008; 2012; Takemura et al., 2015; Yeatman et al., 2013; 2014; FA threshold = 0.20; fiber angles < 45°). Literacy was assessed using the Word Attack (decoding skill), and Sound Awareness/Sound Blending subtests (phonological awareness) of the W-J III Diagnostic Reading Battery. Controlling for age in months, non-verbal IQ, sex, and whole brain FA, we related white matter integrity of these pathways to literacy using robust linear models. Results: When the whole AF was considered as a single pathway, FA of the left AF predicted phonological awareness (WJ III Sound Awareness/Sound Blending; b = .77, p < .001). However, these results did not hold up when the segments were considered separately. In contrast, both left and right ILF, and right IFOF, predicted early literacy (the bilateral ILF predicted decoding and phonological awareness; b = .38, p < .05 and .63, p < .01; the right IFOF predicted decoding; b = .37, p < .05). An association between phonological awareness and left VOF only approached significance (p = .07). Conclusions: Contrary to previous work (e.g., Saygin et al., 2013), the findings suggest that the ILF is an important fiber pathway for early literacy skill in young children. The evidence of bilateral involvement in early literacy (especially of the ventral ILF and IFOF pathways) suggests that left-lateralization of reading may emerge over development along with the brain networks supporting speech and language. The findings also have important implications for mapping the white matter connectivity supporting these skills during development.

E3 Risky readers? Event-related brain potentials reveal age-related changes in the recruitment of parafoveal visual attention in reading. *Brennan Payne[1], Mallory C. Stites[2], Kara D. Federmeier[1]; [1]University of Illinois at Urbana-Champaign, [2]SUNY Binghamton*

The risky reader hypothesis posits that older adults rely more heavily on parafoveal vision to compensate for age-related slowing. However, little research has investigated whether older adults show qualitatively different recruitment of visual attention during reading. The measurement of event-related potentials (ERPs) allows tracking of visual attention and language processes and has been used fruitfully to understand age-related change in language more generally. However, nearly all research on the electrophysiology of aging and visual language processing has utilized single word presentation, excluding the assessment of parafoveal processing during reading. In the current study, ERPs were used to track the time course of parafoveal processing during reading in older adults, using a bilateral flanker RSVP paradigm (central words flanked 2° bilaterally by preceding and following words). Participants read high-constraint sentences in which a target word (N) was expected, unexpected but plausible, or anomalous. When N was central, the right flanker (N+1) was an invalid (non-word) or valid preview. N+1 was valid when it appeared centrally. Like younger adults (YA), older adults (OA) show evidence for a graded N400 effect when word N appeared in parafoveal vision: anomalous parafoveal words elicited the largest N400, followed by unexpected and then expected words. However, in contrast to YA, only OA show this graded effect a second time when word N appears foveally. These findings suggest that OA are sensitive to parafoveal semantic information like the young, but may not be able to rapidly use that information to facilitate subsequent processing. Age-related changes in visual working memory may be one mechanism responsible for this pattern of findings. While YAs are able to maintain an active representation of the same word across parafoveal and foveal visual inputs, older adults fail to maintain these representations, such that each triad is treated as a novel stimulus. In this way, the semantic status of parafoveally-represented words operates independently from the same words presented in foveal vision, despite older adults allocating attention to parafoveal processing. Additional analyses revealed age-related changes in parafoveal word recognition (detection of parafoveal non-words) and effects of foveal expectancy on parafoveal processing. These findings suggested age differences in

the degree to which visual information is processed in a serial versus parallel manner during reading: YA show evidence consistent with a serial shift of covert attention to parafoveal words that is graded by foveal expectancy. However, older adults show very early appreciation of parafoveal word status, by 200ms (on the occipital P2), consistent with a risky reader model in suggesting a more diffuse visual attentional window. In conclusion, we found that ERPs provide an excellent tool for examining age-related changes in covert parafoveal processing in real time, in ways that other neuroimaging (e.g., fMRI) and behavioral techniques (e.g., eye-tracking) cannot accommodate. Our results suggest that developmental changes in visuospatial attention during reading cannot be understood simply as age-related preservation or impairment in parafoveal processing. Rather, aging results in changes in the dynamic tradeoff between foveal and parafoveal visual processing during reading.

E4 Age of acquisition of the second language modulates structural and functional dynamics in bilingual reading

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Neuropsychological and neuroimaging research have extensively demonstrated the involvement of left-lateralized perisylvian regions in reading processes. Using resting-state functional connectivity, it has been showed that intra-hemispheric connectivity patterns for left and right inferior frontal gyrus (IFG) subregions (pars opercularis, triangularis and orbitalis) differ as a function of hemisphere, confirming the predominant left-lateralization of language-related functions and the division of labor typically attributed to these IFG subregions in previous studies (Xiang et al., 2010). However, recent evidence has showed that, compared to monolinguals, bilingual readers exhibit a weaker left-lateralized pattern of regional activations and a more extensive engagement of left perisylvian and right-hemisphere homologous regions (Park et al., 2012). To date, no neuroimaging studies on bilingualism have specifically examined 1) to what extent right homologous IFG subregions are involved in reading processes, 2) the left-right inter-hemispheric functional connectivity among them, and 3) the factors that modulated their structural and functional dynamics. The present fMRI seeks to investigate these questions, as a function of age-of-acquisition (AoA) of the second language (L2), the language used to read (L1versus L2), and reading task demands (perceptual versus semantic). Thirty-six right-handed bilinguals with Spanish as their L1, who learned Basque as their L2 before age 3 (early bilinguals; n = 18) or after age 6 (late bilinguals; n = 18), participated. Participants in both groups were matched in age, high proficiency in L1 and L2, and had similar daily exposition to their L1 and L2. In the scanner, they performed two separate go/no-go tasks in their L1 and L2 during which they were asked to press a button when they saw a colored letter within a given string (i.e., perceptual-task) or when they saw an animal word (i.e., semantic-task). Region of interest analyses revealed a similar recruitment of left and right language-related regions in both early and late bilinguals except for the left and right triangularis. As compared to late bilinguals, early bilinguals exhibited a different pattern of left triangularis engagement in the interaction between task and language effects . Similarly, early bilinguals showed a more selective recruitment for word versus pseudoword reading in right triangularis. Moreover, functional connectivity analyses confirmed a tighter coactivation among left and right triangularis in early but not in late bilinguals for reading in L1 relative to reading in L2. Importantly, structural analysis revealed increased cortical thinning in left triangularis for early relative to late bilinguals. Finally, enhanced functional activation for L2-L1 language effects in the left triangularis predicted cortical thinning in their right triangularis counterpart only in early bilinguals. Altogether, these findings provide strong converging evidence of structural and functional changes between left and right triangularis as a function of AoA of the L2.

E5 How does L1 influence L2 processing in the brain? Evidence from Korean-English and Chinese-English bilinguals

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Many previous studies with neuroimaging methods have attempted to examine what factors shape brain activation in one's L2 processing, and provided evidence for the role of some critical factors, such as age of acquisition (Wartenburger et al., 2003), language exposure (Mei et al., 2015) or proficiency (Cao et al., 2013). However, not many neuroimaging studies have demonstrated that L1 mechanisms and skills constrain how L2 is learned in the brain, although behavioral studies suggest that the distance between L1 and L2 influences how L2 is acquired (Bassetti, 2008; Wang, Koda, & Perfetti, 2003). The current study compared two bilingual groups, Korean-English and Chinese-English on their L2 processing. We hypothesize that L1 influences L2 processing and because both Korean and English are alphabetic writing system, there is a greater similarity between L1 and L2 in the Korean-English bilinguals than the Chinese-English bilinguals. During functional magnetic resonance imaging (fMRI) scanning, participants were asked to make a rhyming judgment on visually presented words in their L1 and L2. The Korean participants did Korean rhyming (KK) and English rhyming (KE) tasks, while the Chinese participants did Chinese rhyming (CC) and English rhyming (CE) tasks. The English rhyming task was identical in the two groups. The proficiency on English between Korean-English and Chinese-English bilinguals was also matched. The results demonstrated that the brain activation for KE and KK was more similar than that for CE and CC, suggesting greater assimilation in KE than in CE. KE showed greater

activation in the left IFG than KK, and no region was greater for KK than KE. CE showed greater activation than CC in right IFG, left postcentral gyrus, and right postcentral gyrus, and CC showed more activation than CE in right MOG. A comparison of KE and CE revealed that KE showed more activation than CE in the right IFG and IPL. A comparison between KK and CC showed greater activation in KK than in CC at the same right IFG, which is direct evidence of L1 influence on L2. In addition, we found a significant positive correlation between brain activation in the right IFG and Word Attack scores (a pseudoword reading measure) only in KE, but not in CE, suggesting this region plays an important role in KE but not CE. When L1 and L2 are similar, there is a greater similarity in brain activation than when L1 and L2 are different. Regions that are important in L1 processing are also more involved in L2 processing. In summary, the results of the current study suggest that L1 shapes the neural network for L2 reading.

E6 An ERP study of sublexical phonological access in L2 Chinese character reading

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Introduction The present study examined online access to orthographic and phonological representations of Chinese characters in L2 Chinese readers who are proficient in spoken Cantonese and have constant exposure to both the English and Chinese scripts in their daily life. We recruited L2 Chinese learners with a reading level of Grade 4 in Chinese. The requirement of a minimum reading level of Primary 4 was motivated by previous findings of developing L1 Chinese readers that effects of regularity were observed as early as Primary 1, while effects of consistency only emerged in Primary 4 and among pupils with high reading abilities (see Chen, Shu, Wu, & Anderson, 2003, for a review). Effects of regularity and consistency and their interaction were revealed by brain activities reflected in the N170, P200, N400, and LPC components. Method Eighteen right-handed healthy native English speakers (12 female) aged 15 - 29 years (M = 19.9, SD = 3.5) participated in the study. All participants acquired written Chinese as L2 after age 5. The stimuli were 160 real phonograms and 160 pseudo-characters created in accordance with orthographic rules. They were equally divided into four conditions by manipulating consistency (consistent vs. inconsistent) and regularity (regular vs. irregular). The L2 Chinese participants took part in a lexical decision (LD) task followed by a delayed naming (DN) task, in which behavioral and EEG data were recorded. Results and Conclusion Regular characters were named significantly more accurately than irregular characters ($F(1,17) = 61.95$, $p < .001$), but consistency did not have an effect on naming accuracy. In the LD task, real characters were responded to significantly more quickly than pseudo-characters ($t(17) = 3.10$, $p = .007$). There were main effects of task in the N170 (110-190ms), P200 (190-270ms), and LPC (500-800ms) time windows, where DN elicited greater N170 and P200 but reduced LPC ($p < .05$). L2 Chinese readers showed more negative N170 for Regular than Irregular characters but no effect of consistency in this time window. Effects of Regularity and Consistency interacted with each other in P200 where Regular-Inconsistent characters were more positive than Irregular-Inconsistent characters ($p = .047$), in N400 where Regular-Consistent and Irregular-Inconsistent characters were both more negative than Irregular-Consistent characters ($p = .021$ and $p = .033$, respectively), and in LPC where Irregular-Consistent characters were more positive than both Regular-Consistent and Irregular-Inconsistent characters ($p = .020$ and $p = .019$ respectively). Lexiality effects were found only in N400, with pseudo-characters more negative than real characters. In summary, our ERP results showed that non-native Chinese readers exhibited distinctive regularity and consistency effects, albeit somewhat delayed, resembling the pattern of these effects observed of L1 Chinese (Yum et al., 2014). The findings suggest assimilation as well as accommodation of the reading network in learning to read a typologically distinct orthographic system as a second language (Perfetti et al., 2007).

E7 Anodal tDCS over left temporo-parietal cortex modulates working memory capacity in sentence processing

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"The rat the cat the dog bit chased escaped." Previous studies provide evidence that the processing of hierarchical syntactic structures involves a network including the inferior frontal gyrus and temporo-parietal regions (Friederici 2011) as two key players. It requires syntactic hierarchy building as well as both general verbal working memory capacities, preferentially relying on TP-regions (Meyer et al. 2012), and more syntax-specific working memory domains, preferentially relying on IFG structures (Makuuchi et al. 2009). To disentangle the specific contribution of each subsystem, we developed stimulus material that contrasts syntactic complexity and the working memory aspects. Current studies suggest that tDCS over language-related brain areas modulates linguistic abilities both in healthy individuals and in patients with impaired language abilities (Monti et al.2013). The goal of our project is to use our material in facilitation (tDCS study) and impairment (lesion study) to allow ascribing causal roles of the above brain areas to these three aspects of syntax processing. Methods 20 healthy subjects and 19 patients with left hemispheric stroke performed an auditory sentence–picture-matching task. In healthy subjects, anodal tDCS was applied over left IFG or TP-cortex. Both reaction times and error rates were recorded. The stimulus set consists of 132 German transitive sentences. It has a 2x3-factorial design tapping argument order (A: subject- vs. B: object-first) and

depth of syntactic embedding (0: no, 1: single, 2: double embedding; see figures). Results Anodal tDCS over TP-areas explicitly improved the accuracy of responses significantly: F(2, 36) = 4.827, p = .014. Disregarding stimulation, as a function of both (i) level of embedding and (ii) topicalization, we find highly significant effects in terms of increasing reaction times (embedding: F(2,32) = 46.610, p= .000; topicalization: F(1,16) = 25.003,p = .000) as well as decreased accuracy (embedding: F(2,32) = 20.826, p= .000; topicalization: F(1,16) = 10.559, p = .005). Factors do not interact. The first analyses of patient data show a large variability of performance suggesting a specific deficit pattern depending on lesion site. Conclusion 1. Facilitating tDCS over temporo-parietal areas, compared with IFG and sham stimulation, explicitly improves verbal working-memory performance. 2. Reaction times and accuracy significantly change as a function of factor levels for both factors, reflecting the impact of embedding depth as well as non-canonical sentence order on sentence processing. 3. Interestingly, these factors do not interact, suggesting partially independent factorial influence on syntactic processing. Friederici, A (2011). The brain basis of language processing: From structure to function. Physiol Rev 91(4): 1357–1392. Makuuchi M, Bahlmann J, Anwander A, Friederici, A (2009). Segregating the core computational faculty of human language from working memory. PNAS 106(20): 8362–8367. Meyer L, Obleser J, Anwander A, Friederici A (2012). Linking ordering in Broca's area to storage in left temporo-parietal regions: The case of sentence processing, Neuroimage 62(3): 1987–1998. Monti A, Ferrucci R, Fumagalli M, Mameli F, Cogiamanian F, Ardolino G, Priori A (2013). Transcranial direct current stimulation (tDCS) and language. J Neurol Neurosurg Psychiatry 84: 832–842.

E8 School-aged children consolidate foreign language regularities overnight: behavioral evidence and cortical substrates

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Introduction. Incidental learning of phonological structures through repeated exposure is an important component of foreign-language learning. Children seem to outdo adults as second-language learners, possibly due to a sensitive period [1]. According to a classical hypothesis, the differences in language learning potential could be explained by the development of brain lateralization for language [2]. However, how children differ from adult learners on the neural level is not known. The neural correlates of incidental learning of new phonological forms have been characterized recently in adults using magnetoencephalography (MEG) [3,4]. Left-lateralized learning effects pointed exclusively to item-based learning of individual word forms. The present study addresses the neural correlates of the early stages of phonological learning in school-aged children in a similar paradigm. Methods. Cortical dynamics during perception of novel words were tracked with an Elekta 306-channel whole-head neuromagnetometer in 13 Finnish-speaking children, aged 6–7 years. A separate behavioral experiment assessed repetition accuracy of foreign word forms in children and adults. Participants performed delayed repetition of four-syllable word forms that were presented either four times (80) or only once (80) during the first session, and once again on the second day, along with new word forms. Comparison of novel phonological forms that adhered either to the native (Finnish) or to foreign (Korean) phonotactic system was included to explore whether the effects are related to acquisition of specific phonological forms (in both languages) or more general learning of foreign language regularities. Results. Learning of the repeatedly encountered word forms manifested as improved repetition and reduced superior temporal activation at 600–1200 ms both in children and adults. However, this cortical item-level learning effect was differently lateralized in children (right) than in adults (left). Notably, only children showed generalized learning of the foreign language after overnight consolidation. This was demonstrated as overall improved foreign-language repetition and sustained left temporal responses to foreign language stimuli starting to resemble responses to native language on the second day. Conclusions. The results show that in children, markedly different cortical network populations are recruited for item-level learning of new phonological word forms than in adults. Only children showed evidence of generalized learning of the foreign language regularities after a consolidation period. The differences between age groups in the cortical learning effects may reflect the neural underpinnings of a sensitive period in foreign language acquisition. References 1 DeKeyser R (2012) Age effects in second language learning. In: The Routledge handbook of second language acquisition (Gass S, Mackey A, eds), 442–460. London: Routledge. 2 Lenneberg E (1967) Biological foundations of language. New York: John Wiley and Sons. 3 Nora A, Hultén A, Karvonen L, Kim J-Y, Lehtonen M, Yli-Kaitala H, Service E, Salmelin R (2012) Long-term phonological learning begins at the level of word form. NeuroImage 63:789–799. 4 Nora A, Renvall H, Kim J-Y, Service E & Salmelin R (2015) Distinct effects of memory retrieval and articulatory preparation when learning and accessing new word forms. PLoS One 10(5): e0126652.

E9 Developmental changes in the functional and structural connectivity within brain networks involved in phonological processing

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We investigated concomitant developmental changes in structural and functional connectivity in the neural language networks of Chinese children and adults with DTI and PPI analyses. We investigated functional connectivity in the language network during an auditory rhyming task using PPI between four left hemisphere regions: inferior frontal gyrus (IFG), superior temporal gyrus (STG), inferior parietal lobule (IPL), and middle occipital gyrus (MOG). We examined structural connectivity by using DTI tractography to reconstruct three left-hemisphere tracts associated with language (arcuate fasciculus, inferior longitudinal fasciculus, and inferior fronto-occipital fasciculus). Tractography analysis revealed that the investigated fascicles had differential developmental trajectories that correlated with PPI values. In particular, the arcuate fasciculus showed a steady increase in fractional anisotropy (FA) across age with higher FA in fifth-graders than third-graders and higher FA in adults than in fifth-graders. In contrast, the inferior longitudinal fasciculus and inferior fronto-occipital fasciculus showed relatively late FA increases with higher FA in adults than in children but no difference between third-graders and fifth-graders. PPI analysis revealed only one significant developmental change; which is the increased connectivity from MOG to STG, suggesting greater integration of orthographic information in phonological processing in adults. Correlation analysis between PPI and DTI found that, within children, PPI connectivity from STG to both IPL and IFG were positively correlated with FA in arcuate fasciculus. This suggests that functional connectivity in the anterior language network relies on the development of the underlying arcuate fasciculus in elementary school years. We also found that, within adults, PPI from STG to MOG was positively correlated with FA in inferior longitudinal fasciculus and inferior fronto-occipital fasciculus, and that PPI from MOG to STG was positively correlated with FA in inferior longitudinal fasciculus. It suggests that the late matured long-range fiber tracts play an important role in supporting the posterior language network involving orthographic representations in adults. Finally, we found that FA in inferior longitudinal fasciculus was negatively correlated with PPI from STG to IFG in adults, suggesting that there may be a developmental shift from anterior to posterior language network in phonological processing in Chinese adults; which may be driven by literacy acquisition.

E10 Examining the role of 'auditory cortex' in congenitally deaf adults

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Numerous studies have shown that parts of the brain typically dedicated to auditory processing in hearing people, the superior temporal region, can be used to process input from other modalities when auditory input is absent: in those born deaf. Here we sought to replicate the finding of crossmodal plasticity in those born profoundly deaf in response to visual stimuli. We also addressed two unanswered questions regarding what drives this crossmodal plasticity in typically auditory processing regions. First, even in those born deaf - is the extent of crossmodal plasticity influenced by age of acquisition (AoA) of a visuo-spatial language? One possibility is that crossmodal plasticity is greater in those deaf individuals who learnt a signed language early than those who learnt it late. Second, is activation in auditory regions in response to visual input, modulated by task demands, or simply stimulus driven? We contrasted: deaf native signers of British Sign Language (BSL); hearing native signers of BSL; deaf late learners of BSL and hearing late learners of BSL. All late learners learnt after the age of 11yrs. Inside the scanner where pairs of line drawings were presented, participants were asked to decide whether 1) the pictures were the same or not (visual task), 2) the pictures showed objects from the same semantic categories, 3) a phonological parameter in BSL (location or handshape) was the same or different for the BSL signs used to represent the pictured objects. Behaviourally, participants' responses were less accurate and slower on the phonological task than the semantic or the visual tasks. Therefore, only correct trials were included and reaction times were accounted for in the imaging analyses. A significant group (4) X task (3) interaction was identified in the left superior temporal gyrus (STG) in [-66, -28, 2]. No other regions showed a significant interaction. Follow up analyses showed a clear effect of hearing status, such that deaf participants activated the left STG more than hearing. In relation to the AoA, we found that activation in left STG did not differ significantly between deaf native signers and deaf late learners of BSL; and it did not interact with task. Task requirements however, did influence the level of activation within the left STG. Analysis of deaf from all deaf participants, regardless of the AoA, revealed that activation in the left STG was significantly greater for the phonological task than the visual task; and for the phonological task than the semantic task. There was no significant difference between the semantic task and the visual task. Our results suggest that crossmodal plasticity in auditory association cortices due auditory deprivation is not modulated further by AoA of a visuo-spatial language. However, the data demonstrate that activation in the left STG in deaf participants is influenced by task. The left STG is recruited to a greater extent in those born deaf when the demand for linguistic processing is high (meta-linguistic phonological task) relative to low (semantic or a visual task), even when the same stimuli are presented.

E11 When Language is First Learned in Adulthood: Neural Language Processing is Persistently Atypical

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A challenging question in brain development is whether the predisposition of the left hemisphere, fronto-temporal areas for language has a developmental time window when

language experience is necessary. The question cannot be investigated with the population of hearing speakers because they experience language from birth. However, among the population of deaf signers are individuals who, due to profound hearing loss, experience no spoken language and, due to isolation from other deaf people, experience no sign language during childhood (Mayberry et al, 2011). Previous research has found an atypical right hemisphere locus for language processing when language is first experienced in adolescence (Ferjan-Ramirez et al, 2013). With added experience, neural language processing shifts toward a more left hemisphere locus (Ferjan-Ramirez et al, 2014). This leads to the hypothesis that there are no maturational constraints on the left hemisphere's capacity to process language. Rather, the left hemisphere may simply require language experience of sufficient duration, independent of developmental stage, to process language. We tested the hypothesis with a case study of a right-handed, cognitively intact, adult male who was born profoundly deaf in a rural area of an underdeveloped country where he neither attended school nor learned any spoken or sign language. He first learned sign language at age 21 and has used it for 30 years since then. Using anatomically constrained magnetoencephalography (aMEG; Dale et al, 2000), we studied the adult L1 learner's neural responses with a picture-word priming task. Stimuli were part of the learner's vocabulary and presented as videos immediately following a picture that either matched ("cat-cat") or did not match ("cat-ball") the stimulus sign (300 trials per condition). Twelve deaf native signers and eleven hearing L2 learners of ASL were controls. We also compared his results to those of the two adolescent L1 learners who initially showed right-hemisphere processing followed by a leftward shift with additional language experience. The adult L1 learner performed the task with a degree of accuracy and RTs comparable to that of the control groups. He showed a semantic priming effect that localized to the right superior parietal, anterior occipital, and dorsolateral frontal areas. This neuroprocessing pattern was similar to the one observed in the adolescent L1 learners when they began to learn language. After 18 additional months of language experience, the adolescent L1 learners showed a leftward asymmetry that localized to the left perisylvian and frontal areas specifically for those signs that they responded to with fast RT. Unlike the adolescent learners, however, no such leftward asymmetry was observed in the adult L1 learner regardless of sign RT despite 30 years of language experience. These preliminary results suggest that the leftward hemispheric asymmetry for lexico-semantic processing characteristic of typically developing individuals for spoken or sign language is a developmentally time-sensitive phenomenon contingent upon language experience occurring at some point before adulthood. The extent to which these effects are gradient in nature with respect to the length of time the brain develops without language remains to be investigated

Language Disorders

E12 Connections and selections: A computational investigation of word production in aphasia

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Connectionist models have proven to be a useful tool in studying word production. For example, the Dell et al. (1997) model accounts for speech error types in both healthy and aphasic speakers by simulating a small lexical network. The 3 layer network retrieves information using spreading activation, while the fixed pattern of connections approximates the statistical structure of the English lexicon. The two retrieval steps involve first selecting a word and then selecting the phonemes. Errors can occur during either step because activation decays over time and includes noise. Connection strengths between representational levels (semantic, lexical, phonological) are free parameters that can modulate the spread of activation and simulate a damaged network. In fitting the model to a person's data, connection strengths are estimated from the pattern of picture naming responses by identifying the model parameters that best fit the same pattern, assuming (falsely) homogeneity of items. "Best fit" is determined by simulating many naming attempts at many parameter settings and selecting the setting that best matches the subject's data. While this approach has led to significant insights, identifying only point estimates precludes use of the wide variety of modeling tools developed in probability theory. Here we develop a Bayesian approach, which enables (i) the quantification of uncertainty in parameter estimates due to limited observations, (ii) formal model comparisons, (iii) clear semantic interpretations of statistical constructs, and (iv) proven methods for estimating parameters of complex, hierarchical models. Bayesian methods rely on the model's likelihood function, which gives the probability of each response given a set of parameters. Although it is possible to extend the connectionist model hierarchically to consider item-level effects (one of our goals), it is computationally impractical due to the complexity of the likelihood function. Thus, we reformulated the same lexical retrieval process within a multinomial processing tree model (MPT; Batchelder & Riefer, 1988), estimating the selection probabilities directly rather than estimating the network properties that induce them. The selection probabilities are modeled hierarchically as an interaction of subject ability and item difficulty. We analyzed picture naming responses from 276 aphasic patients, with 175 items each (www.mappd.org; Mirman et al., 2010), using the Bayesian approach. First, we validated the connectionist likelihood function, demonstrating that it's consistent with existing simulation methods, with strong correlations (.98) between point estimates. Then we validated the MPT model's parameters, using stepwise multiple linear regression to identify causal relationships between lexical properties and item difficulties, and between subject abilities and behavioral scores on other psycholinguistic tests. Semantic difficulty is predicted by

taxonomic density, lexical difficulty is predicted by length and frequency, and phonological difficulty is predicted by phonological density. Lexical ability predicts scores on synonymy judgment and picture matching, while phonological ability predicts speech repetition scores. The significant predictors validated our measurements of lexical and phonological processing, for both items and subjects. These results pave the way toward a deeper understanding of word production in aphasia and to new approaches to model-driven lesion-symptom mapping.

E13 Prediction of speech impairment from the damage to grey and white matter in chronic stroke

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INTRODUCTION. Lesion studies, which examine the behavioral impact of localized brain damage, have made significant contributions to neuroscience (Rorden and Karnath, 2004). However, there is a risk that the observed brain-behavior relationships are specific to the studied sample of patients and will not generalize to the population. To prevent this, we used leave-one-patient-out predictive framework, training a multivariate model to estimate the linear relationship between the brain damage and behavioral impairment, to predict the behavioral impairment of the patients who were excluded from the training set. METHODS. Our patients (n=90) had chronic left-hemisphere stroke, and their speech was affected to various degrees, as assessed with the Western Aphasia Battery (WAB; Kertesz, 1982). In this study, we investigated five particular scores derived from the WAB: aphasia quotient (overall aphasia severity), speech fluency, auditory comprehension, speech repetition, and naming. Patients underwent MRI scanning, and a neurologist (LB) determined the extent of each patient's lesion on T2-weighted images. The brain scans were spatially normalized (Rorden et al., 2012) and segmented using an anatomical atlas (Faria et al., 2012) to determine the amount of damage to each brain area. We evaluated the integrity of white-matter tracts using diffusion tensor imaging (DTI) and probabilistic fiber tractography (Bonilha et al., 2014). We computed the linear relationship between brain damage and WAB scores using support vector regression (Smola and Scholkopf, 2003): each WAB score was modeled as a linear weighted sum of either (1) damage to brain areas; or (2) number of fibers connecting the brain areas; or (3) a combination of (1) and (2). We then applied this model to predict the WAB score of the patient who was excluded from the training set on each round. RESULTS. In all of our predictions, we observed a significant ($p < 0.000005$) correlation between the actual and predicted WAB scores. For all but one (speech repetition) WAB score, the best results were achieved when the scores were predicted from a combination of grey-matter damage and white-matter tract integrity (actual-versus-predicted score correlation coefficients were 0.69 for aphasia quotient, 0.75 for fluency, 0.61 for auditory comprehension, and 0.59 for naming). For the repetition score, the best prediction (with a correlation coefficient of 0.64) was obtained from grey-matter damage alone. CONCLUSIONS. Using a predictive framework, we demonstrated that it is possible to predict the speech impairment of out-of-sample patients from their brain damage. Accuracy of prediction increased when the integrity of white-matter tracts was used alongside the grey-matter damage as inputs to the multivariate model, capturing the diaschistic effect of stroke lesions.

E14 Connectome-based symptom mapping identifies structural neural systems that support clinical language performance

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Since the late nineteenth century, observations from patients with brain damage have shed light on the neurobiological substrates of language. A classic dichotomy stipulates that while lesions to Broca's area lead to speech production deficits, damage to Wernicke's area disrupts auditory comprehension. By the same token, the interruption of fibers connecting these two regions impair speech repetition. Evidence accumulated from lesion and neuroimaging studies during the last decades, however, reveals a far more complex picture: substantial overlap exists between the neural systems engaged during speech production and comprehension. Accordingly, newer models stipulate the existence of a functional core that activates for all language processes, and a set of domain-specific neural systems. For some authors, specific patterns of brain activation rely on the kind of information being processed (i.e, semantic, lexical, or syntactic) rather than the modality (e.g. comprehension vs. production). Other contemporary models of speech processing propose dissociable but interacting pathways that interface sensory networks with semantic-conceptual systems, on the one hand, and with motor-articulatory systems, on the other. In light of these findings, whole-brain connectivity analyses of language functioning can provide valuable information to understand the neurobiology of language. In this study, we constructed the individual connectome of 96 patients with chronic (> 6 months) dominant-hemisphere stroke from probabilistic tractography. We measured their clinical language performance based on the four language modalities of the Western Aphasia Battery – Revised (WAB-R): speech fluency, auditory comprehension, speech repetition, and naming. For our analyses, we initially identified the top 10th percentile most reproducible links on the right-hemisphere. This yielded a total of 125 brain connections. We then correlated language performance on these sub-scales with the fiber count of the left-hemisphere homologues of these 125 connections, applying Bonferroni's correction. We found that a number of connections support language performance across all WAB-R sub-tests: inferior frontal gyrus (IFG) opercularis

– precentral gyrus, supramarginal gyrus – angular gyrus, superior temporal gyrus (STG) – middle temporal gyrus (MTG), MTG – inferior temporal gyrus (ITG), angular gyrus – middle occipital gyrus, supramarginal gyrus – putamen, STG – putamen, angular gyrus – posterior STG, and angular gyrus – posterior MTG. A set of connections supported specifically speech fluency [posterior middle frontal gyrus (MFG) – dorsolateral prefrontal cortex, MFG – IFG opercularis, prefrontal cortex – IFG orbitalis, MFG – IFG triangularis, STG – amygdala, hippocampus – thalamus, cerebral peduncle – midbrain, and supramarginal gyrus – post STG], auditory comprehension [STG – pos STG], and naming [MFG – precentral gyrus, precentral gyrus – angular gyrus, superior parietal gyrus – angular gyrus, and putamen – posterior insula]. The 24 ROIs involved in connections that supported performance on the WAB-R areas yielded a normalized small world value (a graph-theory measure of global network integrity) that significantly correlated with overall language clinical performance based on the Aphasia Quotient score of the WAB-R ($r = .37$, $p < .001$). These findings provide valuable evidence to understand the neurobiology of language from a connectome-based approach.

E15 Cortical activation patterns correlate with speech understanding after cochlear implantation *Heather Bortfeld[1], Cristen Olds[2], Luca Pollonini[3], Homer Abaya[2], Jannine Larky[2], Megan Loy[2], Michael Beauchamp[4], John Oghalai[2]; [1]University of California, Merced, [2]Stanford University, [3]University of Houston, [4]Baylor College of Medicine*

Cochlear implants (CIs) are commonly used to treat severe-to-profound sensorineural post-lingual hearing loss when hearing aids are ineffective in helping a patient understand speech. Modern CIs work by splitting the sound frequency spectrum into 12-22 discrete channels, each stimulating a different region of the cochlea. Since auditory neurons are distributed along the tonotopic gradient of the cochlea, sounds of different frequencies thus stimulate different auditory nerve fibers. This is in contrast to normal hearing, where ~4000 channels (i.e. the number of inner hair cells) exist. Nevertheless, most post-lingually deafened patients demonstrate large improvements in speech understanding after cochlear implantation. While speech understanding increases with time, it tends to stabilize by 6-12 months after implantation, with the ultimate level of benefit remaining highly variable and difficult to predict. The reason any given patient ends up having a poor speech perception outcome after cochlear implantation remains unclear. The presumption is that the implant is not able to effectively convey the temporal and frequency characteristics of speech to the auditory nerve. Of course, speech perception occurs within and beyond the auditory cortex, and thus neuroimaging could provide a way to supplement behavioral measures in assessing the ability of the speech information provided by the CI to reach language processing regions of the brain thus helping diagnose the cause of difficulties. However, typical imaging techniques (i.e., fMRI) are difficult to use for this purpose due to the ferromagnetic components in a CI being incompatible with the scanner. However, functional near-infrared spectroscopy (fNIRS) is amenable to neuroimaging in this patient population because it is CI-compatible, safe for repeated testing sessions, and small enough to use in a standard clinic. Therefore, to better understand sources of variability in speech perception outcomes in post-lingually implanted CI users, we used functional near-infrared spectroscopy (fNIRS) to measure responses within the auditory cortex to sound stimuli in deaf adults hearing through cochlear implants and in normal-hearing controls. Our findings show that both controls and implanted participants with good speech perception scores exhibited greater areas of cortical activation in response to natural speech than to unintelligible speech. In contrast, we found that implanted participants with poor speech perception scores had large, indistinguishable cortical responses to all stimuli. Importantly, this pattern of activation was not correlated with auditory threshold, patient age, side of implantation, or time after implantation and turning off the implant reduced cortical activations in all implanted participants. Our findings align with previously-published fNIRS, fMRI, and PET data. Together, our results demonstrate that cortical responses in auditory and parabelt areas, as measured using fNIRS, are consistent with behavioral measures of speech perception. This is an important initial step in demonstrating that fNIRS can serve as an adjunct to behavioral speech perception measures during cochlear implant programming.

E16 Aphasia classification and evolution across various disease etiologies: a quantitative approach *Joline Fan[1], Nina Dronkers[2,3], Maria Luisa Gorno-Tempini[1], Edward Chang[4]; [1]Department of Neurology, University of California, San Francisco, CA, USA, [2]Center for Aphasia and Related Disorders, VA Northern California Health Care System, Martinez, CA, USA, [3]Department of Neurology, University of California, Davis, CA, USA, [4]Department of Neurological Surgery, University of California, San Francisco, CA, USA*

Aphasia describes a disturbance in language comprehension and expression due to injury to the brain. Current methods of evaluating and classifying aphasias are driven by qualitative clinical guidelines, which are time-dependent and may not generalize to all aphasia phenotypes. This study presents a unique, data-driven method to evaluate aphasias by identifying key features that characterize aphasia phenotypes. Rather than using traditional classification methods, we propose a novel way of describing aphasias as a spectrum of language disturbances. Using dimensionality reduction techniques, we identify two fundamental features that explain 86% of the variability in the data of three patient cohorts representing different disease etiologies: primary progressive aphasia (PPA), stroke, and post-neurological surgery aphasia. The first feature is severity, which

places aphasia phenotypes on a spectrum from normal and anomic language dysfunction to global dysfunction. The second feature is a linguistic-specific dimension that encompasses fluency, comprehension, and grammaticality and thereby separates Wernicke's aphasia from Broca's aphasia, as well as agrammatic PPA from semantic PPA. The second feature is thought to relate to the neuroanatomy of the injury. Individual aphasia phenotypes are visualized using plots with axes representing these two features. Interestingly, clusters representing the clinical classification were found to be preserved, demonstrating the viability of this simple method of visualization. Furthermore, we demonstrate that aphasia phenotypes can then be tracked in a quantitative manner over the course of a disease. These novel methods provide an interpretable approach to characterizing aphasia phenotypes across disease etiologies and over time as to quantify a disease trajectory.

E17 Testing Wordle: Development of a Mobile App for Rehabilitation of Aphasia

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Aphasiology research shows that people with acquired language impairment (aphasia) receive far less treatment than they could benefit from. This has motivated development of treatment techniques that can be administered outside of therapy sessions. However, for people with aphasia (PWA) with speech production problems, the absence of a therapist (and therefore feedback on the quality of the PWA's productions) is potentially deleterious to outcomes. To help fill this need, we are developing an Android-based mobile app (Wordle) for treating naming impairment, a ubiquitous deficit in aphasia marked by difficulty retrieving words and /or their constituent sounds. (i.e., phonemes) The app presents pictures of common objects for naming and utilizes Google Voice Recognition (GVR) to provide immediate feedback. If the response is correct, the app moves on to the next trial; if the response is an error the app provides the word or phrase it "thinks" they said. The goal of the current study was to evaluate the fidelity of the GVR component in accepting correct naming responses and rejecting errors in PWA and neurotypical controls; and, to evaluate whether the app's performance is robust across gender and dialect. Eight participants with chronic aphasia from left-hemisphere stroke and 8 race-, gender-, and age-matched controls provided naming responses to 50 common objects twice. The PWA group was a heterogeneous convenience sample including the various cortical syndromes with two PWA with verbal speech apraxia and one with speech dysarthria. A human coder transcribed responses into the International Phonetic Alphabet (IPA) and coded responses as correct (the utterance included 100% of the phonemes of the target word as defined by a standard American English dictionary) or error. The errors were subdivided into lexical errors (wrong word was produced; e.g., blimp instead of helicopter) and phonological errors (right word but wrong sounds; e.g., brimp instead of blimp). In neurotypical speakers, the app accepted on average 87% (SE = 2%) of correct responses and correctly rejected errors 88% (SE = 6%) of the time. Correct acceptance or correct rejection rates did not vary as a function of gender or race (all ps>.10); and, the presence of dialect did not affect the app's performance. In the PWA group, the app accepted on average 80% (SE = 4%) of correct responses and correctly rejected 83% (SE = 4%) of errors. The rate of correct acceptance did not differ significantly between controls and patients, suggesting the voice recognition software is robust against distortions in how phonemes are produced, which is common in PWA. Within the PWA group, there was a reliable increase in the rate of failed rejection for phonological versus lexical errors ($p<.001$). This suggests that the app may give better feedback to PWA with naming impairments marked by difficulty retrieving target words (e.g., Wernicke's, anomic aphasia) rather than sounds (e.g., Broca's, conduction aphasia). Clinical implications and next steps for development are discussed.

E18 Neurodevelopmental Trajectories of Thalamic Volume in Control and Dyslexic Readers

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Neuroimaging research with typical and atypical readers has underscored functional and structural differences within regions supporting cortico-subcortical interactions during reading processes (Preston et al., 2010). Specifically, compared to typical readers, individuals with dyslexia exhibit thalamic hypoactivation associated with phonological deficits in reading tasks (Diaz et al., 2012). Moreover, postmortem studies have evinced the presence of alterations in the medial and lateral geniculate nuclei of the thalamus of dyslexic individuals (Galaburda et al., 1994; Livingstone et al., 1991). This evidence highlights the critical role of this region in language (Johnson & Ojemann, 2000). Nevertheless, to date there is limited evidence of the typical structural maturation of the thalamus over development, which is key to understanding the altered structural and functional patterns observed in this region in individuals with dyslexia. Here we present two developmental studies aimed at 1) investigating the structural correlates of thalamic volume in relation to the performance of readers with dyslexia (n = 26) and age, gender, IQ matched controls (n = 27) on a task that typically discriminates between these groups of readers, and 2) characterizing the typical development of thalamic volumes and their relation with other brain structures in a large cohort of 210 healthy individuals ranging in age from 3.9 to 51.8 years. Our results revealed that left-right thalamic volume asymmetry was positively associated with age in control readers but not in readers with dyslexia, and that this effect was due to a significant decrease with age in the right thalamus. Importantly, simple regression

analysis controlling for age revealed that left-right thalamic volume asymmetry strongly predicted dyslexic readers' accuracy and naming speed across four different conditions of the RAN task (i.e., numbers, letters, colors, and objects). These associations were not observed in control readers. When examining a large cohort of control readers, our results confirmed the positive association between left-right thalamic volume asymmetry and age. Moreover, thalamic asymmetry was associated with corpus callosum volume, which is the main connectivity route across hemispheres between the left and right thalamus. This relationship was not found within dyslexic readers, stressing the differences found in the thalamus between the two groups. Our findings 1) highlight the crucial role of the thalamus in dyslexia, by linking structural differences to this neurological disorder, and 2) show the developmental trajectories of left and right thalamic volumes underscoring their increasing asymmetry over development, probably tied to language-related processes.

E19 Understanding the contribution of FOXP genes in language-related disorders. *Pelagia Deriziotis[1], Arianna Vino[1], Christian Gilissen[2], Henning Frohlich[3], Sarah A Graham[1], Rolph Pfundt[2], Danai Dimitropoulou[1], Han Brunner[2,4], Gudrun Rappold[3], Simon E Fisher[1,5]; [1]Max Planck Institute for Psycholinguistics, Nijmegen, the Netherlands, [2]Radboud Institute for Molecular Life Sciences and Donders Centre for Neuroscience, Radboud University Medical Center, Nijmegen, the Netherlands, [3]Ruprecht-Karls-University, Heidelberg, Germany, [4]Maastricht University Medical Centre, Maastricht, the Netherlands, [5]Donders Institute for Brain, Cognition and Behaviour, Radboud University, Nijmegen, the Netherlands*

It is well-established that brain development depends on the complex interplay between many genes. Nonetheless, there is little known about the genes that underlie the formation of brain circuits related to language. In the last fifteen years or so, advances in genetic technologies have uncovered members of the FOXP family of genes as key players in the development of language-related brain networks. These genes encode transcription factor proteins that regulate when and where other genes are switched on, thus acting as master switches during neurodevelopment. Disruption of the FOXP2 gene causes a severe speech and language disorder characterized by developmental verbal dyspraxia (DVD). Affected individuals have difficulties mastering the orofacial movements required for speech and problems with expressive and receptive language. FOXP2 is expressed in several brain regions, including the cortico-striatal and cortico-cerebellar circuits relevant for language. Investigations in mice carrying FOXP2 mutations that mirror those found in cases of DVD show deficits in motor-skill learning and electrophysiological dysfunction in cortico-striatal circuits. In addition, neuroimaging studies of individuals with FOXP2 mutations reveal structural and functional abnormalities in brain regions related to language, such as the basal ganglia. FOXP1, the most similar gene to FOXP2, is expressed in some of the same regions and new research using mouse models indicates a role for FOXP1 in post-natal striatal development. In the striatum, the FOXP2 and FOXP1 proteins may interact with one another to co-regulate genes, including ones involved in language, such as CNTNAP2. FOXP1 disruptions cause a more severe neurodevelopmental disorder characterized by autism spectrum disorder (ASD), intellectual disability (ID), and moderate to severe language deficits. Here we report three new cases of ID/ASD and language impairment carrying novel FOXP1 mutations. Using assays of protein function, we provide strong evidence that these mutations cause the neurodevelopmental deficits seen in these patients. Strikingly, the three mutations found here, and three others reported previously in cases of ID/ASD, affected the ability of the protein to interact with FOXP2, which may have consequences for the regulation of shared target genes. Therefore, it is possible that dysregulation of such target genes in individuals with FOXP1 or FOXP2 disruptions may relate to the language deficits observed in both groups of patients. In sum, our results show how coupling genomic analyses in patients with language deficits to assays of molecular function can provide insights into the genetic pathways underlying normal development of language-related brain circuits.

E20 Language impairments in traumatic brain injury: A case series *Michelle Hall[1], Lauren Cloutman[1], Anna Woollams[1]; [1]University of Manchester*

Background Cognitive deficits and cortical lesions are common following traumatic brain injury (TBI). As language relies on a complex distributed network and draws on executive control capacities, language impairments would be expected following TBI. White matter connections are known to be important to language function and white matter damage is also commonly seen following TBI, again leading to an expectation of language deficits in this population. However, research into language deficits resulting from TBI is scarce, particularly research into the role that white matter may play. The goal of this case series was to quantify the nature of language deficits in TBI at the cognitive and neural levels. Method Five TBI patients (P1-5; age range 21-48) completed neuropsychological tasks designed to examine general cognition and various aspects of language functioning. Reaction times (RT) were recorded. Anatomical Connectivity Maps (ACMs) were derived from participants' diffusion weighted MRI images which were then normalised into MNI space, smoothed, and compared with a group averaged ACM map, based on age matched control participant data, to identify abnormal voxels using SPM8. Links between behavioural performance and diminished connectivity were then examined. Results P1's performance was worse than matched controls in general cognition, reasoning, visuospatial abilities, semantics and orthographic processing with increased RT. White

matter connections were lower than averaged controls in the corpus callosum, and left external capsule, superior longitudinal fasciculus (SLF), and posterior thalamic radiation. P2 showed increased RT for semantics and was worse in general cognition, reasoning, visuospatial abilities, semantics and orthographic processing. Connections were diminished in the corpus callosum, left internal capsule (IC) and the right frontal lobe. Performance for P3 was impaired on executive functioning and orthographic processing. P3 showed decreased connections in the right inferior frontal gyrus as well as the right SLF and left IC. P4 was impaired on executive tasks and had reduced connections in the corpus callosum, right precuneus, left IC and bilateral anterior corona radiata. P5 performed well across all tasks except for memory tasks which were impaired. Connections in the left mid temporal lobe were particularly low as well as the left hippocampus, fornix, putamen, insula and external capsule. Discussion The results suggest that white matter in the right frontal regions and the corpus callosum may play a role in semantics and orthographic processing as well as visuospatial and executive functioning. These areas may also play a role in speed of functioning. Connections in the left temporal lobe may be involved with executive functions and/or memory, particularly the IC. However, given the small sample size this needs to be explored further. When compared to a structural lesions, it can be seen that white matter lesions are more widespread and numerous than cortical lesions, particularly as P4 had no cortical lesions but had multiple areas of low white matter connection when compared to a group average. This may suggest that lesions in white matter contribute to impairment on cognitive tasks which highlights the need for more complex imaging such as diffusion tensor imaging when considering TBI.

E21 Investigating the integrity of major white matter tracts in aphasia *Maria Ivanova[1], Dmitry Isaev[1], Olga Dragoy[1], Yulia Akinina[1,2], Alexey Petryshevskii[3], Oksana Fedina[3], Nina Dronkers[1,4,5]; [1]National Research University Higher School of Economics, Moscow, Russia, [2]University of Groningen, Groningen, The Netherlands, [3]Center for Speech Pathology and Neurorehabilitation, Moscow, Russia, [4]VA Northern California Health Care System, Martinez, California, USA, [5]University of California, Davis, California, USA*

Historically in the quest for the neural basis of language, most of the emphasis has been placed on the role of specific brain areas. However a growing literature is pointing towards the importance of white matter tracts in understanding the neural mechanisms of language processing and determining the nature of language deficits and recovery patterns in aphasia (Dick, Bernal, & Tremblay, 2014; Forkel et al., 2014). Fractional anisotropy (FA), mean diffusivity (MD), radial diffusivity (RD) and axial diffusivity (AD) extracted from diffusion-weighted scans, together provide comprehensive in-vivo measures of microstructural integrity of white matter tracts. In the current study, we compared the integrity of major white matter tracts in each hemisphere – Arcuate Fasciculus (AF), Superior Frontal-Occipital Fasciculus, Inferior Longitudinal Fasciculus (ILF), Inferior Fronto-Occipital Fasciculus (IFOF), Uncinate Fasciculus and Corpus Callosum – between individuals with aphasia and healthy controls and investigated the relationship between these neural indices and language deficits in aphasia. Thirty-four right-handed individuals with different types of aphasia due to left hemisphere stroke and eleven age-matched controls were scanned with DWI sequence (Siemens Avanto 1.5T, b=1000 s/mm2; 20 directions with two repetitions, 2.7x2.7x2.7 isovoxel). All participants were right-handed and were native speakers of Russian. Raw anatomical and diffusion-weighted data for each participant were preprocessed using the following algorithm: transformation of individual diffusion maps (FA, MD, RD, AD) to T1 space, computation of the transform from T1 to MNI, application of inverse transform from the previous step for the tracts chosen from John Hopkins University White Matter Tractography atlas in MNI space, use of transformed tracts as ROI for extraction of FA, MD, RD and AD values for the whole tract in T1 space. Individuals with aphasia were also assessed with a standardized language test in Russian on subtests targeting comprehension and production at the word and sentence level (Tsvetkova et al., 1981). Individuals with aphasia had significantly lower FA values for left hemisphere tracts and significantly higher values of MD, RD and AD for both left and right hemisphere tracts compared to controls. For the aphasia group all tracts in the left hemisphere had significantly lower mean FA values and significantly higher MD, RD, AD values compared to patients' own tracts in the intact right hemisphere. Language comprehension was found to be related to integrity of the left IFOF and left ILF, while language production was related to integrity of the left AF. Subsequently we determined that different segments of these two tract were differentially related to language production and comprehension in aphasia. For instance, integrity indices of the lower (temporal) portion of the AF were significantly related to comprehension both at the word and sentence level, while integrity of the middle (parietal) portion of the AF was related to production at the word and sentence level. Our findings emphasize the potential importance of fiber pathways in supporting different language functions (Poeppel et al., 2012; Bornkessel-Schlesewsky et al., 2015) and point to the importance of temporal tracts in language processing, in particular comprehension (Turken & Dronkers, 2011).

E22 Right hemisphere gray matter volume in left hemisphere stroke-induced aphasia: A Voxel-Based Morphometry (VBM) study *Sladjana Lukic[1], Xue Wang[2], Todd Parrish[2], David Caplan[3], Swathi Kiran[4], Brenda Rapp[5], Cynthia K. Thompson[1]; [1]Department of Communication Sciences and Disorders, Northwestern University,*

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Introduction: Studies examining structural changes in brain tissue following stroke have focused primarily on chronic hemi-paretic stroke, whereas, no studies have evaluated such changes in chronic aphasia. Motor-impaired patients show increases as well as decreases in cortical thickness in the pre and/or postcentral gyri relative to controls, primarily in the ipsilesional (e.g., Zhang et al. 2014), but also in the contralesional hemisphere (Gauthier et al. 2012), with these findings linked with recovery of function. The present study examined gray matter (GM) volume using VBM in the right-hemisphere (RH) of left-hemisphere (LH) damaged aphasic patients compared to healthy age-matched controls. Additionally, correlations between age and language severity and RH GM volume were undertaken. Method: T1-images from 40 patients (age = 22 – 81, M = 58.9) and 32 controls (age = 24 – 76, M = 57.8) were collected across three research sites [1]. All patients presented with aphasia, based on a uniform set of cross-site language measures, from a single LH stroke. Language severity was measured by WAB-AQ (Kertesz, 2007) and an Overall Language Score (average of six domain-specific scores: spoken and written comprehension and production of words and sentences). MRICron was used to measure lesioned tissue (by slice), lesion location and volume were calculated, and patients were grouped by lesion site: anterior, posterior and mixed. Using T1 images, VBM analysis included: (1) normalization to a controls' template (2) segmentation into GM, white matter, and CSF, using probability maps, (3) modulation of tissue classes, correcting volume change, and (4) 8mm Gaussian kernel smoothing. We examined: (1) between-group differences in GM volume in the RH and selected ROIs (inferior frontal gyrus –Orbitalis, Triangularis, Opercularis (IFG), superior and middle temporal gyri (STG, MTG), supramarginal gyrus (SMG), angular gyrus (AG), and Insula) using T-tests ($p < 0.05$, FWE-corrected), and (2) correlations between GM volume and age and language score. Results: No significant differences in GM volume in the RH or within ROIs were found when patients were compared to controls. However, analyses by stroke group revealed increased GM volume for the mixed-lesion group in the pars orbitalis, STG, and SMG ($p > 0.05$). In addition, older patients showed decreased GM volume in RH frontal and temporal areas. However, no significant correlation between GM volume and language severity was detected. Conclusion: Increases in GM volume in the RH in left-brain-damaged stroke patients was found, but only for those with distributed lesions. These data suggest that contralesional tissue is recruited to support functions previously performed by LH regions, and have important implications for understanding post-stroke reorganization. References Gauthier et al., (2012). Atrophy of spared grey matter tissue predicts poorer motor recovery and rehabilitation response in chronic stroke. Stroke, 43: 453-457. Zhang, J., Meng, L., Qin, W., Liu, N., Shi, F.D. & Yu, C. (2014). Structural Damage and Functional Reorganization in Ipsilesional M1 in Well-Recovered Patients With Subcortical Stroke. Stroke, 45: 788-793. [1]The Center for the Neurobiology of Language Recovery (CNLR; P50DC012283; Thompson), a multisite Clinical Research Center focused on biomarkers of language recovery in aphasia.

E23 Neural Correlates of Impaired Articulation Speed in Aphasia: A Voxel-Based Lesion-Symptom Mapping Study

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Lesions associated with isolated motor speech deficits have been studied in several lesion correlation studies, which have typically used ratings of articulatory agility as the clinical measure of interest. Results from these studies have varied, implicating insular cortex, inferior frontal gyrus, and precentral gyrus. We examined one aspect of speech motor control – articulation speed – in a group of people with left hemisphere stroke. We used voxel-based lesion-symptom mapping (VLSM) to determine brain locations where damage was associated with slowing of speech articulation. Participants were 31 patients (11 women, 20 men; mean age 59 years; mean education 14.4 years) with left hemisphere ischemic stroke. All were at least 180 days post-stroke, native English speakers, and pre-morbidly right-handed. Articulation speed was measured using audio recordings from a 60-item pseudoword repetition task. Pseudowords ranging in length from 1-4 syllables (4-8 phonemes) were presented as pre-recorded audio files, and participants repeated each item as accurately as possible. The duration of each complete utterance was measured and used to calculate phonemes per second (PPS) for each trial, which were then averaged across trials in each participant after removal of extreme outliers. Intra-rater reliability on this measure was very high ($r = .90$). Mean PPS was 6.51 (sd 1.32), range 3.99 to 8.71. PPS was moderately correlated with lesion volume ($r = -.50$, $p = .004$) and with a clinical rating of articulatory agility ($r = .558$, $p = .001$), but not with gender, age, education, or days post onset. High-resolution MRI was obtained in all patients, and lesioned areas were labeled blind to the behavioral data. VLSM was performed using PPS as the dependent variable and lesion volume as a covariate of no interest. Slower speech articulation was associated with damage to a focal region of anterior parietal cortex that included most of the postcentral parietal operculum and extended superiorly along the postcentral sulcus. A small region of posterior insula was also implicated. The parietal region included the opercular areas OP1-4 of Eickhoff et al. (Cerebral Cortex, 2006) and anterior parietal areas PFop and PFt of Caspers et al. (Neuroimage 2006). No frontal or anterior insular regions were associated with articulation speed. The lesions implicated in slowing of speech articulation on this repetition task were in the anterior parietal portion of the

suprasylvian speech production pathway. These regions are associated mainly with high-level somatosensory rather than motor processing. Lesions in this region may impair proprioceptive signals necessary for monitoring and controlling motor output. The lack of frontal involvement is unexpected and suggests the possibility of distinct frontal and anterior parietal speech production deficits. Whereas anterior parietal lesions may primarily reduce articulation speed, posterior frontal lesions may primarily affect articulatory planning (syllabification, sequencing), resulting in slowing of production and frank errors on more complex sequences.

Lexical Semantics

E24 Using neural network models of conceptual representation to understand the stages of visual object processing in the ventral stream

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According to most neurocognitive accounts of semantic processing, concepts' meanings are made up of distributed, overlapping, feature-based representations (Haxby et al. 2001; Cree & McRae 2003; Taylor et al. 2011). In particular, statistical properties of concepts' features, such as how shared or distinctive a feature is across concepts, are posited to play a critical role in how the meaning of a concept is activated (Tyler & Moss 2001; Cree et al. 2006; Clarke et al. 2013). However, the manner in which sensory processing interacts with the activation of distributed semantic representations remains unclear. We addressed this issue in a study using familiar visual objects. We combined a deep convolutional network model of vision (Krizhevsky et al. 2012) with an attractor network model of concept semantics (Cree et al. 2006) where information about object meaning is represented as a pattern of activation across feature units. Consistent with our neurocognitive account (Taylor et al., 2011; Tyler et al. 2013), this model directly maps high-level visual representations onto semantic feature representations, encoding statistical information about semantic features (e.g. feature sharedness/distinctiveness) but also semantic features' relationship to visual information. Within this architecture, and consistent with the timecourse of category and basic-level activations in MEG (Clarke et al., 2015), early stages of semantic processing show stronger activation for visual features and features shared by many objects (e.g. "is long"), compared with distinctive and non-visual features. To investigate the relationship between this visually-grounded semantic model and human object processing, we analysed data from an fMRI study in which 16 participants named pictures of 131 objects (Clarke & Tyler, 2014). We used representational similarity analysis (RSA; Kriegeskorte et al. 2008) and searchlight analysis (Kriegeskorte et al. 2006) to relate distributed patterns of activation in the computational models to distributed patterns of activation in fMRI data. We calculated eight dissimilarity matrices (RDMs) corresponding to the eight layers of the deep convolutional network and 20 RDMs corresponding to the 20 processing stages of the attractor network. These 28 RDMs delineate a trajectory through a space of representational geometries, from pixels to detailed object semantics. Pattern similarity in visual cortex was best explained by layers of the visual convolutional network, consistent with previous results (Khaligh-Razavi & Kriegeskorte 2014, Clarke et al. 2014). However, RDMs corresponding to the early stages of the attractor network, where activation of shared and visual semantic features is strong, better explained pattern similarity in the posterior fusiform. The final stage of the semantic attractor network model, where detailed semantic representations, including both shared and distinctive features, are maximally activated, best explained pattern similarity in bilateral perirhinal cortex (see also Clarke et al., 2014). These results demonstrate how models integrating visual and semantic representations can account for fMRI pattern-information throughout the ventral object processing stream. In particular, the results reveal a posterior-to-anterior gradient in semantic processing in ventral temporal cortex, with general, shared feature information driven by the perceptual input most strongly associated with the posterior fusiform, and later more specific semantic information associated with perirhinal cortex.

E25 Toward a Brain-Based Componential Semantic Representation

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Classical componential theories of lexical semantics define concepts in terms of essential features, but the features in such theories are themselves complex concepts, leaving open the question of what constitutes a primitive feature. Accumulating evidence supports the claim that concept representations are at least partly "embodied" in the perception, action, and other modal neural systems through which concepts are experienced. In this study we explore the possibility of devising a componential model of semantic representation based entirely on such functional divisions in the human brain. We propose a basic set of 65 experiential attributes based on neurobiological considerations, comprising sensory, motor, spatial, temporal, affective, social, and cognitive experiences. Internet crowdsourcing methods were used to obtain ~1 million ratings of the relevance of these attributes to 535 English words (434 nouns, 62 verbs, 39 adjectives). After rejection of 6.7% of the data for failure to pass a correlation-based quality metric, an average of 28.6 complete ratings (i.e., 65-attribute vectors) were available for each word. We explored the underlying structure of the data using a priori category labels and data-driven clustering. Mutual information between attributes was low on average (mean

= .049 bit), indicating a low overall level of redundancy, though some attribute pairs and groups showed higher overlap. Statistically significant differences between concrete object categories (e.g., animals, body parts, people, plants, foods, tools, musical instruments, vehicles) were observed across a large number of attributes. For example, animals, plants, and tools differed significantly ($p < .0001$) on the relevance of color, visual motion, biological motion, speed of motion, shape complexity, presence of a face, presence of body parts, tactile texture, auditory form and pitch, taste, smell, association with head movements, association with upper limb movements, degree of manipulation experience, association with movement along a particular kind of path, association with near personal space, causality associations, association with social interactions, perceived intentionality, association with benefit and harm, pleasantness, association with fear and surprise, association with drive and needs, and association with attentional capture and arousal. K-means and hierarchical cluster analyses were used to explore the similarity structure in the data independent of a priori labels, revealing several novel category distinctions, including a distinction between social places (e.g., office, store, church) and non-social places (e.g., field, forest, lake), between festive (e.g., party, festival, circus) and verbal (e.g., debate, oration, testimony) social events, and between beneficial (e.g., trust, hope, knowledge) and neutral (e.g., hierarchy, sum, paradox) abstract entities. We discuss how such a representation might deal with various longstanding problems in semantic theory, such as feature selection and weighting, and representation of abstract concepts. In contrast to componential models based on verbal features, the proposed representation systematically relates semantic content to large-scale brain networks and biologically plausible accounts of concept acquisition.

E26 The brain differentiates between inclusive and exclusive semantic predictions

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Predictive Coding has been suggested as a general working principle of the brain (Friston 2005) that may also be applicable to language processing (e.g., Kutas et al., 2011; Pickering & Clark, 2014). However, are all predictions of the same kind? Following Kahneman & Twersky (1982), we conceptually distinguish between exclusive predictions - i.e., a top-down prediction that no other than the predicted event(s) will occur next - and inclusive predictions - i.e., an increased propensity of bottom-up systems towards a range of eventually occurring events. We propose that both mechanisms operate in parallel to support language processing. In two experiments, we tested (i) if exclusive vs. inclusive predictions elicit different neural signals, and (ii) if both modulate behavior independently. In previous research (Sassenhagen et al., 2012), in addition to the well-known N400 effect with a graded sensitivity to within- and out-of-category semantic violations, we found an early anterior EEG response that does not differentiate between violation types, but only between expected and unexpected continuations. Experiment 1 (64-channel EEG) tested whether this signal truly reflects exclusive predictions. Subjects heard correct and incorrect words in the context of sentences enumerating both large, open (e.g. animals, furniture) and closed (e.g. olympic medals: gold, silver, and ...; parents: mother and ...) categories. Experiment 2, a novel self-paced reading two-alternative forced choice paradigm, investigated behavioral correlates of the two prediction types. Subjects judged the congruence of each word over the course of similar sentences enumerating both large and small categories. Hypotheses were as follows. While, commensurate with spreading activation, inclusive predictions should be strengthened similarly by unfolding sequences of small/closed and large/open categories, the proportional, word-by-word change in the remaining (predicted) set size is considerably larger for a word from a closed as opposed to an open category (e.g., there is only one remaining option after two olympic medal types, but the number of as yet unseen animals is barely changed). Accordingly, only closed/small categories license exclusive predictions. In Exp. 1, an N400 was elicited by both closed- and open-category violations. An earlier, focused mediodorsal-prefronal ICA component showed no such graded sensitivity (Bayes Factor (H0>H1)>3), responding only to violations of exclusive predictions (closed-category mismatches; Bayes Factor (H1>H0)>3). In Exp. 2, preliminary Hierarchical Drift Diffusion Modeling (Ratcliff, 1978; Wiecki & Frank, 2013) indicated that the rate of information accumulation logarithmically increased with each seen category member (drift rate; 95% HDI excludes 0). In contrast, exclusive predictions modulated the decision threshold parameter (95% HDI excludes 0), such that the remaining category member set size logarithmically predicted the boundary criterion. In conclusion: in its predictive processing of language, the brain relies simultaneously on incremental accumulation of semantic information and on increasingly truncated sets of explicitly predicted candidates for the next event, reflected differently in behavior and neural responses. Our study further demonstrates that application of Drift-Diffusion modeling to sentence processing can differentiate components of processing during language comprehension.

E27 Chinese and English speakers share representations for word-elicited concepts, but semantic models struggle to capture this similarity

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When a speaker of English and a speaker of Chinese read names for an object in their respective languages, similar concepts are evoked by these words and represented in each speaker's brain despite the dissimilarity of the

English and Chinese orthographic stimuli. We find that multi-voxel patterns of functional brain activity elicited by seven concrete nouns matched closely across Chinese and English speakers, enabling neurally-mediated translation. Three semantic models based on behavioral judgments and corpus statistics, however, failed to capture this cross-language similarity. Multi-voxel pattern analyses have enabled cognitive neuroscientists to decode patterns of brain activity for word stimuli and predict functional responses for new words or participants (e.g., Mitchell et al., 2008). Previous decoding studies have found that neural similarity structures for word-elicited concepts are strongly conserved across subjects. We extend similarity-based decoding across languages to match word-elicited activations across groups of Chinese and English speakers by matching the neural similarity structures elicited by translation equivalent words in each language. Semantic models have previously yielded promising results in within-language neural decoding, and we compare three such models for neural translation. Seven translation-equivalent monosyllabic, concrete nouns in English and Chinese were compared in each model. Functional MRI data were acquired from eleven native speakers of each language performing semantic relatedness judgments in the scanner (see Zinszer et al., 2015). Corpus models were constructed based on the method of Mitchell et al. (2008), computing the co-occurrence frequencies of each noun with 25 verbs using the Leeds University query tool for comparable Chinese and English Internet corpora (http://corpus.leeds.ac.uk/internet.html). Behavioral models were obtained from 11 additional native speakers of each language performing two semantic relatedness judgment tasks in their respective languages. For noun-noun (NN) ratings, participants rated every pairwise combination of the seven nouns on a scale of 1-5. For noun-verb (NV) ratings, participants made binary relatedness ratings for every noun with each of the 25 verbs. Similarity structures were estimated for all neural, corpus, and behavioral measures. Neural similarity structures for the English and Chinese speaker groups were highly correlated across languages ($r=0.89$, $p<0.001$). Out of 96 anatomical ROIs, multi-voxel pattern analyses in six ROIs resulted in neural translation with 100% accuracy. The NN and NV behavioral models also strongly correlated across languages ($r=0.85$ and 0.61, respectively, $p<0.01$) but showed no significant correlation with the neural similarity structures. The corpus models in Chinese and English failed to correlate across languages or with the neural similarity structures. We observe that functional brain responses of Chinese and English speakers contain shared information that discriminates between words in both languages but is not adequately explained by any of the semantic models presently described. This information is meaningful because it permits neural translation (decoding across languages), but whatever the source of these cross-language regularities, it is not directly derived from speakers' intuitions about semantic relatedness nor from corpus statistics. Visual or sensorimotor representations may provide better descriptions of this cross-language relationship, and future research could test a multi-modal model's ability to decode word-elicited concepts across languages.

E28 Decoding Conceptual Information from Heteromodal Cortex

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Neuroimaging studies have implicated a network of heteromodal cortical areas in conceptual processing, but the role of this "general semantic network" (GSN) is not well understood. We propose that at least a subset of the GSN contributes to conceptual processing by encoding patterns of co-activation over modality-specific cortices. In other words, these GSN areas may function as convergence-divergence zones, integrating sensory-motor information from multiple modalities during perception/action and coordinating the reactivation of sensory-motor areas during concept retrieval. Alternatively, the GSN could encode exclusively abstract conceptual representations whose informational structure bears no direct relation with sensory-motor representations. We investigated this hypothesis using predictive machine learning on the fMRI data from Fernandino et al. (2015), in which participants performed a concreteness decision task on a set of 900 written English words and 300 pseudowords. In the present study, we predicted fMRI activation patterns for individual words using an encoding semantic model based on the relative relevance of five semantic attributes – all directly related to sensory-motor processes – to the meaning of the word: sound, color, shape, manipulability, and visual motion. The model was trained via multiple regression on a set of 820 words, and tested on a separate set of 80 words. Model performance was evaluated separately in voxels located in the GSN (using a mask generated from the ALE meta-analysis from Binder et al., 2009) and in voxels located in control regions (defined by the contrast pseudoword > word, and consisting mainly of visual, somatosensory, and motor cortical areas). The semantic model was able to successfully decode activation patterns associated with individual words from voxels in the GSN ($p = .004$), but not from voxels in control regions. Follow-up analyses determined that GSN areas in the lateral temporoparietal cortex provided the highest decoding accuracy. Conversely, a different model based on visual word-form attributes (length, neighborhood and bigram statistics) was able to decode neural activity in control areas, particularly from voxels in early visual cortex ($p = .001$), but not from voxels in the GSN. These results demonstrate that semantic information encoded in temporoparietal heteromodal areas during concept retrieval is directly related to sensory-motor attributes of experience, consistent with a role for these areas in coordinating the reactivation of sensory-motor

representations in modality-specific cortices. References: Binder, J. et al. (2009) Cereb. Cortex, 19 (12), pp. 2767-2796 . doi:10.1093/cercor/bhp055 Fernandino, L. et al. (2015). Cereb. Cortex. doi:10.1093/cercor/bhv020

E29 Neural representational profiles of word distributional and sensorimotor properties. *Francesca Carota[1], Hamed Nili[2], Nikolaus Kriegeskorte[3], Friedemann Pulvermueller[4]; [1]Department of Psychology, University of Cambridge, UK, [2]Experimental Psychology Department, University of Oxford, UK, [3]MRC-CBU, Cambridge, UK, [4]Freie Universität, Berlin, Germany*

Lexical semantic processing involves the mapping between abstract/symbolic word forms and their related concepts and attributes, as well as the integration of semantic information into combinations of words giving rise to coherent discourse contexts. We investigated the neurocognitive representations of the semantic relationships between single words denoting different (arm-, face-, leg-related) actions and (animal-, food-, and tool-related) objects, asking whether 1) their statistical distributions in contexts affected the neural computation of their meaning and 2) semantically similar word categories triggered similar brain activity patterns in common brain regions. In a condition-rich fMRI design, participants read 96 words during a typo-detection task. We performed a whole-brain searchlight (5mm sphere radius) using representational similarity analysis (RSA) - sensitive to the qualitative properties of the linguistic inputs - and assessed differences in the multivariate patterns of fMRI responses between word pairs by comparing them with 1) computational linguistic models of latent semantic (LSA) distances between single words, coding for their probabilities to co-occur in similar semantic contexts and 2) behavioural rating models of sensorimotor properties (action-relatedness, imageability, form/colour and valence). We found that the latent semantic distances between words resembled the representational patterns in distributed cortical networks, including bilateral inferior frontal gyrus (BA47), insula, left anterior temporal regions and temporo-parietal regions. Latent semantic distances specific to manipulable tools and to foods were encoded, respectively, in middle and inferior temporal regions relevant to object processing and in insular/ left inferior frontal regions, part of the gustatory cortex. Instead, visual properties dominated partially overlapping inferior temporal regions, left ventrolateral prefrontal cortex, posterior inferior and middle temporal regions typically supporting conceptual object knowledge, and parieto-occipital areas along the dorsal visual pathway. Complementary ROI-based analyses showed that action-relatedness significantly correlated with brain activity patterns elicited by action (but not object) words in inferior frontal and motor regions, whilst visual properties, especially colour-relatedness and imageability, were mostly associated with object (but not action) words in temporal regions. Within the set of object words, food-related nouns exhibited strongest sensitivity to colour-relatedness, imageability and valence. Moreover, action specific properties such as arm-relatedness and face-relatedness correlated with tool and food words, respectively, mirroring the actions that these words afford. On the other hand, LSA distances specific to face-, food-, and tool-related words correlated with shared patterns of activity in bilateral insula, cingulate cortex, anterior temporal regions, IFG (BA 45), right IFG (BA 44-47) and bilateral precentral gyrus. These findings suggest that a widespread fronto-temporo-parietal networks reflect context-based statistical information about how words are used in actual language and might support associative mechanisms for computing inferential representations of lexical meanings, providing a base for vocabulary mastering and text processing in everyday language use. Within this network, qualitatively different distributional and sensory-motor word properties of action and object words are grounded in differentiated sensorimotor circuits, with partial overlaps between object word and visual processing systems and between action words and motor processing systems, indexing the rich sensory, motor-functional and emotional configurations of the actions and objects denoted by words.

E30 The timing of semantic coding in the anterior temporal lobe: temporal representational similarity analysis of electrocorticogram data *Yuanyuan Chen[1], A. Shimotake[2], R. Matsumoto[3], T. Kunieda[4], T. Kikuchi[4], S. Miyamoto[4], H. Fukuyama[5], R. Takahashi[2], A. Ikeda[3], M.A. Lambon Ralph[1]; [1]Neuroscience and Aphasia Research Unit, School of Psychological Sciences, University of Manchester, Manchester, UK, [2]Department of Neurology, Graduate School of Medicine, Kyoto University, Japan, [3]Department of Epilepsy, Movement Disorders and Physiology, Graduate School of Medicine, Kyoto University, Japan, [4]Department of Neurosurgery, Graduate School of Medicine, Kyoto University, Japan, [5]Human Brain Research Center, Graduate School of Medicine, Kyoto University, Japan*

Electrocorticograms (ECoG) provide a unique opportunity to monitor neural activity directly at the cortical surface. Ten patients with subdural electrodes covering ventral and lateral anterior temporal regions (ATL) performed a picture naming task. Temporal representational similarity analysis was used to compare spatio-temporal neural patterns from the ATL surface with pre-defined theoretical models. The results indicate that the neural activity in the ventral subregion of the ATL codes semantic representations from 250 ms after picture onset. The observed activation similarity was not related to the visual similarity of the pictures or the phonological similarity of their names. In keeping with convergent evidence for the importance of the ATL in semantic processing, these results provide the first direct evidence of semantic coding in the ventral ATL.

E31 A computational model of lexical semantic/ episodic knowledge. *Juan Valle-Lisboa[1,2], Camila Zugarramurdi[1], Emilia Fló[1,2], Álvaro Cabana[1]; [1]Facultad de*

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We present a simple computational model of lexical knowledge based on two modules: one using WordNet and the other on the storage of particular events. The objective of this toy model is to realize the hypothesis that lexical knowledge is based both on a semantic and a episodic-like component. The role and content of the lexicon has been recently debated in the psycholinguistic literature. From the point of view of some connectionist and radical pragmatic approaches, meaning is always constructed by integrating cues from different sources, and in that sense the 'meaning' of a word does not exist independently of context. An alternative interpretation is that there is a lexicon of words associated with their meaning, but there is also a memory of the most frequent events where these words are used. The flexibility of meaning evidenced in some experiments could be the result of the interaction between the lexicon and the set of events stored. In order to explore this last alternative we created a model with two components: a WordNet-based lexical store and a set of documents (news stories) related to different types of events; robberies, soccer matches, other sports news, scientific news and political news. The proportion of documents from each topic was varied as a parameter. The model was used to simulate priming experiments. When a word (the prime) is presented to the model, it activates its WordNet synsets and all the documents it appears in. WordNet activation gives a pre-activation to neighboring words as decreasing function of the (graph) distance between the prime and neighboring words. In the event module, the other content words in each document are activated in proportion to the reciprocal of the number of words; that is each documents distributes a fixed amount of activation to each of its words, and the activation of each word is computed adding the activation it receives in all the documents activated. This activation is considered a measure of facilitation. We show that there are instances when word to word priming comes mainly from the semantic space and others that it comes mainly from the events memory. The main task we model is the presence of priming in a context+short SOA condition. We explore the parameter sets to find cases in which only congruent contexts prime event nouns but object noun priming occurs irrespective of context. We vary the decay constant of facilitation in WordNet, the amount of documents in each category, and the relative strength of priming. We found that the conditions are met when a cluster of event related words are strongly represented in the episodes and the common nouns are represented in a wide an unrelated set of documents, rendering their event-activations low. That is, when object nouns are spread over many different types of events, the event knowledge is not relevant, but it is the only one present for event nouns. We propose that there is thus an event memory that alters priming and frequency effects.

Motor Control, Speech Production, Sensorimotor Integration

E32 'Gift of the gab' linked to changes in prefrontal and premotor activity

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Fluent, extemporaneous speech is an ability that can engender respect (and occasionally envy) in social situations. Politicians, priests, and professional comedians all wield this 'gift of the gab' to entertain and persuade audiences to their way of thinking. But what makes one person more fluent than another? The current study aimed to determine whether expert speakers use additional neuronal resources beyond the normal speech production system or whether their brains simply used the normal system more efficiently than typical speakers. Functional magnetic resonance imaging (fMRI) was used to measure brain activity while participants performed a novel speech elicitation task based on the BBC's Just a Minute Radio 4 program: they were asked to speak on a random topic for 30 seconds without hesitation, repetition or deviation (from the topic or from English as we know it). Alternating blocks of counting aloud served as the main control condition to account for the mechanics of producing speech and hearing one's own voice. 20 normal, healthy controls were compared to 18 expert speakers comprised primarily of professional stand-up comedians with extensive experience with improvisatory speech. We found that expert speakers were significantly more fluent than normal volunteers, both during the Just A Minute task as well as outside the scanner during everyday speech production. The imaging results showed that extemporaneous relative to overlearned speech produced significant activity primarily within left fronto-temporal regions including ventral premotor cortex, pre-SMA, and mid-cingulate cortex in both normal and professional speakers; there was no evidence that expert speakers recruited additional brain regions outside the normal system to achieve greater fluency. However, differences in the levels of activity within the speech production system were observed. Notably, activity in the ventral premotor cortex was lower in professional speakers during the production of extemporaneous speech relative to rest, while activity in the left pre-SMA and mid-cingulate gyrus was greater. This pattern is consistent with greater demands on self-monitoring and cognitive control necessary to excel at the Just A Minute task as well as reduced demands in regions important for planning and sequencing of linguistic events. In other words, fluency with extemporaneous speech appears to be a form of verbal expertise that manifests at a neural level as subtle differences in the use of the normal speech production system. Subsequent studies will be necessary to determine whether these differences innately endow a speaker with the 'gift of the gab' or whether they are the consequence of extensive training and practice.

E33 Dynamics of speech encoding processes under increased attentional demand : an ERP study on dual-tasks interference *Raphael Fargier[1], Marina Laganaro[1]; [1]FPSE, University of Geneva, Geneva, Switzerland*

Increased attentional demand has a detrimental effect on speech production. However, there is little information as to whether dual tasks interfere with lexical selection or with phonological encoding or with several encoding processes at once. In this study, we sought to shed a light on which processing stages word production is influenced by concurrent tasks in healthy speakers. For this, we compared performance and Event-Related Potentials (ERPs) during three tasks that varied according to the degree of attentional demand: Picture naming only, picture naming during passive listening to tones and picture naming during a tone discrimination task. In all concurrent tasks, auditory stimuli appeared 150 ms after the onset of the picture on the screen (SOA=+150 ms). In the passive listening condition, participants were requested to name the pictures while ignoring the distractors. In the tone discrimination task, we used a go/no go paradigm so that participants were asked to respond on a button box when they heard one specified tone while continuing to name all the pictures. This allowed us to directly compare word production between the three tasks. Three different sets of pictures matched for pertinent psycholinguistic variables were used and the order of the tasks was counterbalanced across participants. We observed increasing production latencies for tasks with increasing attentional allocation with longest production latencies for the task that involved tone discrimination. Stimulus-aligned ERPs analyses revealed waveform differences on different time-windows : starting around 200 ms after picture onset to 320 ms ; from 3 60 to 400 ms and from 430 to 500 ms. The effects were distributed mostly on central and occipital sites. Crucially, when comparing picture naming during passive listening and picture naming during tone discrimination, differences were found specifically between 400 and 450 ms post picture onset. In contrast, no differences were found on response-aligned ERPs. Spatio-temporal segmentation analyses indicated topographic differences from 200 ms onwards with specific topographic patterns being extended for picture naming during attentional demand compared to picture naming only. Importantly, a topographic pattern specifically observed in dual tasks (from 360 to 430 ms) was more extended when the dual task involved explicit attentional allocation (tone discrimination). While no differences occurred during late time-windows, likely corresponding to phonological-phonetic processes (Indefrey, 2011), the spread earlier modulations are likely reflecting interference with lexical selection and lexical-phonological processes. Altogether, these results support the idea that lexical-phonological but not phonological-phonetic processes are under attentional control. Reference: Indefrey P (2011) The spatial and temporal signatures of word production components: a critical update. Front. Psychology 2:255.

E34 Neural correlates of audiomotor map learning *Megan Thompson[1,2], Alexander Herman[1,2], Dameon Harrell[1], John Houde[1], Srikantan Nagarajan[1]; [1]University of California, San Francisco, [2]University of California, Berkeley*

Typically, sensorimotor learning studies have used visuomotor adaptation or speech adaptation. In this study, we sought to derive more general principles about audiomotor control by examining auditory feedback processing through the use of neuroimaging and a magnetoencephalography imaging (MEGI)-compatible touchpad. Initial study was conducted with non-speech tone stimuli, and we are currently extending this paradigm to speech sounds. Subjects learned a novel audiomotor map task, eventually developing an internal model of auditory feedback triggered in response to locations they touched on the touchpad. Following training, 15 subjects were given a target cue via headphones and attempted to reproduce it by touching the corresponding area on the touchpad and subsequently receiving feedback. 10 out of 15 subjects demonstrated better-than-chance responses, improving upon their initial performance, indicating stable learning. In addition to demonstrating an increased rate of correct responses, evidence for the development of an internal model of auditory expectations was seen in significant MEGI differences in post-learning neural response between correct and incorrect responses. These differences showed efference copy-based suppression in the auditory cortex in correct feedback and error/conflict monitoring in frontal areas in incorrect feedback. Notable high gamma frontal lobe suppression was also found in correct responses compared to when the subject passively listened to tones (n=4). Additionally, some left temporal lobe suppression was seen in typical correct responses with expected auditory feedback compared to "surprise" trials in which, after training, subjects correctly identified the location for the probe tone but received unexpected auditory feedback (n=4). Increased activation in areas responsible for error monitoring in incorrect trials and suppression in sensorimotor areas during correct responses is consistent with efference copy comparison. We are now examining speech stimulus learning and adaptation behavior with this paradigm. By investigating speech and non-speech auditory feedback processing without speech motor feedback, we can elucidate more general auditory-motor control effects.

E35 High gamma modulations of intracerebral recordings during a picture-naming task : A group analysis *Anne-Sophie Dubarry[1,2], Anaïs Llorens[1,2], Agnès Trébuchon[2,3,4], Romain Carron[5], Catherine Liégeois-Chauvel[2,3], Christian Bénar[2,3], F.-Xavier Alario[1]; [1]Aix Marseille Université, CNRS, LPC UMR 7290, [2]INSERM,*

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Introduction Among the tasks used to study language processing, picture naming provides a framework in which word retrieval processes can be thoroughly examined. This experimental paradigm is widely used in clinical research (e.g., [1]) as well as in cognitive research (e.g. [2], [3]) to study the cortical regions and the spatiotemporal dynamics subtending word production. Clinically motivated invasive recordings allow high spatial and temporal resolution study of language processing [4]. Important insights on the neural bases of cognition have come from analysis focused on high gamma activity activity [5]. The goal of the current study was to provide a systematic mapping of the cortical activity involved in picture naming. To compensate for the relatively poor spatial sampling of SEEG, we collated functional patterns of high gamma activity that were objectively similar across several patients. **Methods** We report data recorded from 18 patients with intractable epilepsy implanted for clinical reasons performing a naming task. We labeled the regions of implantation following the anatomical atlas in [8]. Artifact rejection (epileptic spikes), epoch segmentation and baseline correction was performed with the BrainVision Analyzer® software (Brain Products GmbH, Munich, Germany). The rest of the analysis was performed using Matlab (Mathworks, Naticks, MA). Time-frequency decomposition of the bipolar signals was performed using Morlet wavelets between 70 and 150Hz. We computed one-sample Student t-tests at each SEEG contact and each time sample. Significance threshold on the duration of activation was determined for each patient with 95% bootstrap confidence intervals. Within each region that showed significant activity from at least two different patients, we averaged the signals per patient and computed a Pearson's correlation test between the resulting time courses. We report regions for which the mean of these correlations was above a heuristic threshold. **Results** The analysis pipeline revealed significant high gamma activity consistent across patients. The diverse regions that are active can be grouped in three anatomo-functional sets. Regions in the basal posterior part of the brain showed an early activity (100 ms) that was then sustained for hundreds of milliseconds. Somewhat later, another set of regions showed relatively similar activity over spatially distinct areas: basal anterior (ventral) area and temporo-parietal (dorsal) areas. Around the time of articulatory onset, activity was observed on precentral gyrus (premotor area) and on the middle temporal lobe (auditory area). **Conclusions** High gamma reveals an orderly set of activities linking sustained visual processing, with two concurrent streams of activity suggestive of the ventral and dorsal streams for language [9], onto articulatory motor processes. **References** [1] J. DeLeon et al. (2007). Brain, 130, 5, pp. 1408–22. [2] M. Miozzo et al. (2014). Cereb. Cortex. [3] A. Llorens et al. (2014). Brain Lang., 133, pp. 47–58.[4] A. Llorens et al. (2011). Front. Psychology 2:375. doi: 10.3389/fpsyg.2011.00375 [5] J.-P. Lachaux et al. (2012). Prog. Neurobiol. 98, 3, pp. 279–301.[6] J. K. Mai et al. (2008). Atlas of the human brain. Amsterdam: Elsevier/Academic Press. [7] G. Hickok and D. Poeppel (2007). Nature reviews, 8, pp. 393–402.

E36 Tracking double-object naming using the N2pc

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EEG is beginning to shed light on the production of individual syllables and words. Here we used EEG to track the allocation of attention in double-object naming. Previous double-object naming studies have demonstrated that eye movements (overt attention) are closely linked to speech planning processes, providing a window into the coordination of visual information uptake and motor output. Such studies have also suggested that the second named object is sometimes processed before it has been fixated upon. This might be because attention can be allocated to objects covertly, without moving the eyes. The present study investigated whether there is a link between object processing and covert attention, as indexed by lateralized brain activity, and if so, when speakers allocate covert attention to each object. Twenty-four participants named 448 pairs of objects ("dog and chair") while keeping fixation upon a central fixation cross (six additional participants were excluded based on strict eye movement rejection criteria). Two squares, one to the left and one to the right of the fixation cross, flickered continuously; one at 25 Hz and the other at 18.75 Hz, counterbalanced between participants. This elicited steady-state visual evoked potentials (SSVEPs; EEG responses at the frequency of visual flickering), which have been shown to increase in amplitude with attention. After 1600 ms, a green and a red object appeared, superimposed onto the flickering squares. Participants named the green object first and the red object second. To discourage participants from attending to one side of the screen prior to the presentation of the objects, the red and green objects' positions were randomized, such that on half of the trials the naming order was left-to-right and on the other half of the trials the naming order was right-to-left. Importantly, the processing difficulty of the two objects was orthogonally varied by presenting each object in upright orientation or upside-down. Naming errors increased by about 3% when Object 1 or Object 2 was difficult than when it was easy. Correct naming latencies were longer by about 60 ms when Object 1 was difficult than when it was easy. ERPs on correctly named trials were analyzed using cluster-based permutation tests. The N2pc component, known to index lateralized shifts of attention, showed an initial attention shift to Object 1

followed by a shift to Object 2. Object 1 difficulty delayed the shift to Object 2 at around 700-1100 ms, suggesting extended attention to Object 1. More importantly, Object 2 difficulty attenuated the amplitude of the shift to Object 1 at around 200-500 ms. Given that average naming latencies were approximately 1150 ms, this suggests early allocation of attention to Object 2. Time-frequency analyses did not reveal effects of object difficulty on SSVEP amplitude. In sum, the findings show that visual attention as indexed by the N2pc shifted to each object in the order of mention. Moreover, the N2pc suggested an early onset of processing of the second object.

E37 The neural basis of proverb usage in a social context *Kelssy Hitomi dos Santos Kawata[1], Rui Nouchi[1], Motoaki Sugiura[1], Sugiko Hanawa[1], Hyeonjeong Jeong[1], Shigeyuki Ikeda[1], Mizue Suzuki[1], Yukako Sasaki[1], Takayuki Nozawa[1], Keyvan Kashkouli Nejad[1], Ryuta Kawashima[1]; [1]Tohoku University*

Proverbs are primarily a social phenomenon. They are learned through social interaction for social purposes (Honeck 2009). During social interaction, proverbs pervade human dialogue as advice. Their unfailing wisdom throws light on doubt and gives courage in moments of indecision. However, although many studies related to the retrieval process of the proverb can be observed, our understanding of how people come up with these types of expressions is quite limited. We hypothesized that the cognitive processes by which proverbs are produced involves induction and inductive learning (Honeck 2009). Induction involves a number of sub-processes such as mental representation, categorization, inference, analogizing, and problem solving in general. Inductive learning implies that the learner goes beyond the information given to develop some kind of summary of or hypothesis about particular learning experiences. In the present study, we examined the neural mechanism of proverb advice production in communication scene. Forty right-handed healthy native speakers of Japanese (F=14 / M=26; Age= 21.9 ± 2.3) participated in this study. Written informed consent was obtained from all subjects. Based on our preliminary experiments, we selected 80 proverb strips from a book of Japanese proverbs. In our stimuli, a story is made up of two scenes, which contain pictures and sentences that describe a social situation where the protagonist is facing trouble. During the fMRI task, subjects were requested to concentrate on the story by reading the narrative portion of the strip and to pay attention to the story's pictorial content. The answers were requested orally and all subjects participated in all four conditions that included two advice conditions (PA: Proverb Advice and NA: No-proverb Advice) and two situation description conditions (PD: Proverb Description and ND: No-proverb Description). In the advice conditions, the subjects were instructed to use the PA and NA to give advice to the protagonist to avoid or cope with the problem. In the situation description conditions, subjects were instructed to use the PD and ND to describe the situation of the narrative. The total, 80 stimuli, were presented with the event-related fMRI paradigm. The order of the four conditions was counter-balanced across subjects. Statistical analyses were performed with SPM12. Our main interest was giving advice using a proverb (PA), thus we conducted one sample t-test ($p < 0.05$, FWE corrected using cluster size) using contrast (PA > NA + ND + PD) with the following inclusive masks (PA > NA, PA > PD, PA > ND, $p < 0.05$ uncorrected). The data of thirty-four subjects (F=12 / M=22; Age= 22.1 ± 2.4) were analyzed. Significant activation was found in the posterior cingulate gyrus (PCgG), precuneus (Pcu), dorsolateral prefrontal cortex (DLPFC), orbital frontal cortex (OFC) and anterior cingulate cortex (ACgC). Given the known involvement of the PCgG, Pcu, DLPFC, OFC and ACgC in social cognition and social decision-making (Cruyssen et al., 2015; Meeks et al., 2009), our results are therefore consistent with our hypothesis that inductive reasoning is involved in PA.

E38 Functional, acoustic and articulatory outcomes of speech training: a multimodal investigation of native and non-native imitation *Daniel Carey[1], Marc Miquel[2], Bronwen Evans[3], Patti Adank[3], Carolyn McGettigan[1]; [1]Dept. of Psychology, Royal Holloway University of London, [2]Queen Mary University of London & Barts and the London NHS Trust, [3]Dept. of Speech, Hearing & Phonetic Sciences, University College London*

Introduction Flexibility of vocal behaviour is a critical skill in human communication. This flexibility can be placed under strain when acquiring the phonemes of a second language, particularly for adult L2 learners, where native perceptual and articulatory processes may dominate. Yet, to date, relatively little research has explored the articulatory and acoustic outcomes of speech learning in association with functional activation in speech production networks. Here, we used a speech training paradigm combined with fMRI and real-time imaging of the vocal tract (rtMRI) to explore vocal imitation skill. Methods Native speakers of British English were trained to imitate a (native) unrounded front vowel and a (non-native) rounded front vowel prior to scanning. Their performance on imitation of these vowels and a similar untrained pair was then measured during approximately 1 hour of in-scanner imitation. We measured the BOLD response using a rapid-sparse, event-related fMRI protocol (TR: 3.2 s; TA: 1.7 s) in which participants were cued either to 1) listen to or 2) listen to and then imitate native and non-native vowels. Vocal tract dynamics were also measured using a real-time T1-weighted gradient echo sequence (125ms temporal resolution, or 8 fps). Here, participants imitated vowels presented in mini-blocks. Two 60-second real-time runs were collected prior to each of three functional runs (lasting around 12 mins). In-scanner acoustic recordings of speech output were made using a MR-compatible microphone. Results and Discussion Behavioural results showed that acoustic imitations of non-native vowels

were less accurate than for the corresponding native vowels, with considerable individual differences in imitation success related to training. fMRI results showed significantly greater activation in somato-motor cortex, IFG and superior temporal cortex when participants listened in preparation to produce speech, versus either listening without preparation to repeat, or during production itself. Effects of training varied across individuals, and were associated with activation of lateral somato-motor, inferior frontal and cerebellar regions. rtMRI data revealed measurable changes in lip aperture, and some evidence of increased lip protrusion, due to training in lip rounding. Profiles of distance between articulators across the length of the vocal tract also allowed us to identify the articulatory changes related to rounding. Using representational similarity statistics (Kriegeskorte et al., 2008), we then applied a novel analysis approach, by directly comparing rtMRI of vocal tract articulators to fMRI activity during phoneme production. By generating representational similarity matrices to describe the articulation of different vowel categories, we were able to probe the functional fronto-temporal speech production network to identify regions representing the categorical dimensionality of trained and untrained vowels. These results will help to inform an account of vocal imitation as a skill, with respect to acoustic, articulatory and neural indices.

E39 Imitation and language development in deaf and hearing schoolchildren *Emil Holmer[1], Mikael Heimann[2], Mary Rudner[1]; [1]Linnaeus Centre HEAD, Swedish Institute for Disability Research, Department of Behavioural Sciences and Learning, Linköping University, [2]Swedish Institute for Disability Research and Division of Psychology, Department of Behavioural Sciences and Learning, Linköping University*

Introduction: Deaf signing children and hearing children reveal different developmental trajectories in several aspects of neurocognitive functioning; however, comparative studies of imitation across these groups are lacking. Imitation has been suggested to play a part in language and cognitive development, and the ability to imitate indicates multi-modal integration and analysis (e.g., Meltzoff & Williamson, 2013). Thus, understanding the function of imitation in typical and atypical groups is of theoretical interest, but may also have practical implications. Because sign language is gesture based, it is likely that deaf signing children can tap into existing linguistic representations during gesture imitation whereas only motor representations are available for non-signing individuals. Thus, gesture imitation is likely to be supported by different cognitive skills in the signing and non-signing individuals. Importantly, imitation may expose qualities of generic mechanisms in the representational system. Method: Thirteen school-aged deaf users of Swedish Sign Language and 36 hearing non-signing children, at similar levels of non-verbal cognitive ability and word reading skills, performed an experimental imitation task. The task involved spontaneous imitation of a set of manual gestures. Participants performed the task at two occasions, separated by 35 weeks. Tests of non-verbal intelligence, visual working memory, phonological awareness, word reading and reading comprehension were also administered. We investigated the precision of the imitative acts across groups and time, as well as relationships between imitative precision and cognitive and language skills in both groups. Results: A split-plot repeated measures ANOVA demonstrated that deaf signers imitate manual gestures with greater precision than hearing non-signing children. Further, improvement in imitative precision over time was greater for deaf than for hearing participants. Correlational patterns indicated that imitative precision was positively associated with language skills in both groups. Specifically, for deaf children, word reading skills at both assessment points and performance on a sign similarity judgment task at the second assessment were correlated positively with imitative precision. For the hearing participants, positive connections to word reading skills and performance on a rhyme task were observed at the second assessment point. In both groups, a significant connection between imitative precision and reading comprehension was observed at the second assessment point. Conclusion: Our results demonstrate that sign language experience enhances the ability to imitate manual gestures longitudinally. They also show that imitation ability is linked to language skills in the non-manual, speech-related domain. We propose that the precision of imitative acts reflects the quality of linguistic and motor representations and the ability to employ them in language processing.

E40 Language lateralization in right- and left-handed individuals: an fMRI study *Grigory Ignatyev[1], Rosa Vlasova[1,2], Yulia Akinina[1,3], Maria Ivanova[1], Olga Dragoy[1]; [1]National Research University Higher School of Economics, [2]Federal Center of Medicine and Rehabilitation, [3]University of Groningen*

There are a number of neuroimaging studies focusing on handedness and language lateralization. These studies compare mean lateralization indices (LI) between groups (Ramsey, Sommer, Rutten, & Kahn, 2001), present a correlation between LI and handedness quotients (HQ) (Szaflarski et al., 2002), or assess variability of hemisphere dominance within different groups (Pujol, Deus, Losilla, & Capdevila, 1999). The goal of the present study was to measure functional language lateralization in healthy right- and left-handers and to test the following hypotheses: i) whether mean LIs between these groups are different; ii) whether there is a correlation between LI and HQ; and iii) whether there is a higher variability of hemisphere dominance within the group of left-handers. Language-related lateralization of brain activation within the frontal and the temporal lobes were assessed. A block design fMRI paradigm and a sentence completion task were used. Each block consisted of three five-word incomplete sentences with a direct object omitted, e.g. «Yesterday the detective

cautiously unlocked the …». Sequences of meaningless syllables of equal length were used in the control condition. Participants had to read the sentences and syllables aloud and either to complete a sentence with a single word or to repeat the last syllable of the presented sequence. Thirteen healthy subjects (6 right- and 7 left-handed; 7 female; mean age 24 years) were tested. Handedness quotient for each participant was calculated using the Edinburgh Handedness Inventory (Oldfield, 1971). FMRI images were acquired in a 1.5T Siemens Avanto scanner using a sparse-sampling paradigm to minimize scanner noise and to register participants' responses. The data were analyzed in the SPM12 software. Lateralization indices were calculated in the LI toolbox (Wilke & Lidzba, 2007) using t-weighting of voxels and frontal and temporal lobes masks. Two-way ANOVA was performed to compare LIs between the groups and the lobes. No significant difference between the groups was found ($F = 1.8$, $p = .21$), but the main effect of the lobe (frontal vs. temporal) was revealed ($F = 7.2$, $p = .02$), with higher LI within the frontal lobe ($M = .69$, $SD = .31$) compared to the temporal lobe ($M = .34$, $SD = .36$). No significant correlation was found between LI and HQ ($r = .24$, $p = .45$). There was low variability of hemisphere dominance within the group of right-handers (all of them showing left hemisphere dominance, threshold = .25), but the variability increased in the group of left-handers, two of them showing bilateral activation. Thus, the present study failed to find difference between mean LIs in the groups of left- and right-handers, and no correlation between HQ and LI was revealed (likely due to the small sample). However, a significant difference in the variability of hemisphere dominance was found, the group of right-handers having more uniformly left-lateralized activation. Overall higher LIs in the frontal lobe suggest that language lateralization within anterior language regions is universally stronger than in the temporal lobe. Acknowledgement: The study was supported by the Russian Foundation for Basic Research (grant 15-06-08516a).

E41 Direct Cortical Recording of Regions Implicated in Speech Production During Pseudoword Articulation

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To date, many studies have investigated the neural correlates of speech production. Results have implicated multiple cortical regions in articulation, including the superior precentral gyrus of the insula (SPGI; Dronkers, 1996), inferior frontal gyrus pars opercularis (IFGpo; Hillis et al., 2004; Richardson et al., 2012), precentral gyrus (PrCG; Graff-Radford et al., 2014; Basilakos et al., 2015), and post-central gyrus (PoCG; Hickok et al., 2014). Thus, a network of regions is involved in articulation, but questions have arisen regarding regions that are crucial for articulation, and which are involved in a more secondary role. The insula has traditionally been discussed as the primary region for coordinating articulatory movements, with support from lesion data (Dronkers, 1996) and studies that show its response is modulated with increasing articulatory difficulty (Ogar et al., 2006; Baldo et al., 2011). However, more recent studies with post-stroke individuals have provided greater support for the primary role of other regions in speech production. Here, we report findings from direct cortical recordings of two patients who completed an articulation task while undergoing intracranial EEG monitoring for surgical management of epilepsy. Both patients had electrode contacts in areas implicated in speech production. One patient (Patient 2) had depth electrode placement in the left and right anterior insula (AIns), allowing for direct observation of insula activity during articulation. The two patients (both female, ages 25, 36) were implanted with 10-channel stereo-electroencephalographic (sEEG) depth electrodes. Patients completed a pseudoword articulation task, consisting of twelve different bisyllabic pseudowords presented over eight blocks. Stimuli belonged to one of two groups – easy (CVCV) and hard (CCVCCV). A post-implant structural T1-MRI was used to localize electrodes. Normalization of T1 images was completed with the Clinical Toolbox for SPM8. Normalization utilized cost-function masking, where electrode locations were manually drawn on each T1. Contact coordinates were localized with the AAL atlas (Tzourio-Mazoyer et al., 2002). High gamma activity in the following regions of interest were analyzed with an in-house code for Matlab: premotor cortex, PrCG, PoCG, L and R AIns, and IFGpo. The following analyses were completed in 100msec time bins prior to and after the onset of articulation: 1) pseudoword articulation>pseudoword perception; and 2) hard>easy articulation (level of significance set to $p<0.05$). T-tests of high-gamma activation for contacts in the LAIns, RPoCG, and left premotor cortex reveal significant effects for articulation relative to perception. Inspection of the time course of articulation shows that significant differences emerged in the RPoCG and left premotor cortex first, followed by the LAIns. For the hard>easy articulation conditions, the following patterns emerged: the LPoCG, left and right premotor cortex, and RPrCG showed a significant effect of condition, whereas the IFGpo, left and right AIns did not show this effect. This study did not find that the AIns is modulated by articulatory task difficulty; rather, this modulation was found for the premotor, motor and post-central sensory regions. Although our sample size is limited, these results add to the growing body of literature suggesting that articulation is crucially supported by sensorimotor cortical regions.

E42 Syllable is proximate unit of word-form encoding in speech production for Mandarin speakers

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Speaking involves conceptual preparation, lexical access, word-form encoding and articulatory processes. Studies have investigated this stage with the aim to identify functional units that underlie word-form encoding. Recently, the role played by sub-lexical units in this process such as the phoneme, syllable or mora has received much attention. Studies in alphabetic languages (such as English, Dutch) demonstrated that the phoneme (or segments) is a functional unit at the stage of word-form encoding. However, the findings in Chinese, as a non-alphabetic language, were not consistent. You, Zhang, and Verdonschot (2012) found syllable priming effect across word reading and picture naming tasks, and thus support the notion that the syllable is a functional unit for Chinese speakers (see also Chen, Chen, & Dell, 2002; Chen, Lin & Ferrand, 2003). In contrast to these results, two studies reported have found sub-syllabic priming effects (Wong & Chen, 2008, 2009; Qu, Damian & Kazanina, 2012) indicating that the segments also plays a role in Chinese speech production. The present study investigated the proximate unit of word-form encoding in Chinese speech production, and the temporal courses of syllable retrieval and segments retrieval during this stage, by combining behavioral responses and ERP components in masked priming paradigm. The experimental conditions include syllabic overlap, segments overlap and non-overlap between the primes and the targets. Behavioral data showed a significant syllable priming effect, rather than the segmental overlap effect, and are consistent with previous findings from different tasks in Chinese. Consistently, ERP data provide evidence that the syllables but not the segments are proximate unit for Chinese speakers: syllables overlap modulated ERPs from 200 ms to 500 ms after picture onset, whereas no segments modulation effect. However, both syllables overlap and segments overlap modulate ERP components from 500 ms to 600 ms after picture onset. Our findings reveal that the syllables are the proximate unit for Chinese speakers and are retrieved at the early stage of word-form encoding, whereas the segments are retrieved later than the syllables which may involve in the later stage of word-form encoding or phonetic encoding in speech production. The present findings will be discussed in the framework of the Word Encoding by Activation and VERification model and the hypothesis of proximate unit proposed by O'Seaghdha, Chen, and Chen (2010).

E43 Neural Substrates of Sentence Choice *Malathi Thothathiri[1], Michelle Rattinger; [1]George Washington University*

Many languages contain multiple sentence structures (e.g., active versus passive voice) for expressing the same meaning. Speakers can vary their sentence choices depending on a number of factors, including prior statistical experience. In this study, we investigated the neural substrates of sentence choice using a miniature language paradigm and neuroimaging. The miniature language paradigm is a well-established method for controlling the language experience of each participant. The language used in this study contained novel verbs (e.g., pelk) that described transitive actions, and two novel sentence structures. The two structural alternatives both began with the verb and placed either the agent or the patient earlier in the sentence (agent-before-patient: AP, patient-before-agent: PA), similar to the distinction between actives and passives [1]. Each participant completed three training sessions where they watched videos depicting transitive actions, heard a corresponding sentence, and repeated it. During this training phase, we manipulated the statistical association between verbs and structures (verb-bias). Some verbs appeared exclusively in AP order (AP-bias), others exclusively in PA order (PA-bias), and yet others alternated between the two (Alt-bias). After training, participants returned for a behavioral test where they watched and described videos using the miniature language. Importantly, the videos involved new nouns and could not be described using sentences memorized from training. A subset of the participants returned for a final scanning test, where they completed the same task. Different videos were used during the two tests. Results from the behavioral test showed that participants used both AP and PA order with different verbs. However, there was (1) a significant overall preference for AP over PA order consistent with the pattern observed in many languages; and (2) a significant effect of verb-bias such that PA order was used more with PA-bias and Alt-bias than AP-bias verbs. Thus, prior statistical experience facilitated PA order use with specific verbs. Results from the scan test replicated these behavioral findings. We used a sparse-sampling fMRI design. Sentence production activated bilateral superior temporal gyri (STG), bilateral precentral gyri, and visual areas relative to baseline (viewing scrambled videos). This supports a growing number of results showing the involvement of bilateral regions associated with comprehension and extralinguistic processing during production [2]. To determine the neural substrates of producing the less preferred PA order, we contrasted PA minus AP response activation for each verb bias separately. PA>AP response activation was found in bilateral STG, with the strongest effect for Alt-bias, followed by PA-bias, and no effect for AP-bias verbs. Thus, bilateral STG activation varied with language experience: verbs that alternated between AP and PA order during training showed the strongest separation in activation for the two orders suggesting that competitive interactions during training may have tuned these regions. Psychophysiological interaction (PPI) analyses revealed different functional connectivity between speech motor processing (left precentral gyrus) and visual/frontal regions during PA order production with different verbs. These results inform how sentence choices are made in relation to prior language experience. [1] Wonnacott et al. (2008), Cognitive Psychology. [2] Silbert et al. (2014), PNAS.

E44 Talking out of order: does grammatical gender always precede phonology in lexical access?

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Language production requires access to the semantics, syntax and phonology of the words one plans to utter. Some models of language production posit that this information is retrieved in a serial manner proceeding from semantics to syntax to phonology (e.g. Levelt et al., 1999). This serial order has received support from ERP studies using the dual-choice go/no-go paradigm. Analyzing the lateralized readiness potential (LRP), Van Turennout et al. (1998) found evidence that native speakers of Dutch retrieve grammatical gender information before phonological information. Here we ask whether this finding generalizes beyond the specific between-subjects experimental design used by Van Turennout and colleagues. 20 native German speakers performed a covert picture naming task based on that used by Van Turennout et al. Participants made decisions based on the grammatical gender (masculine or neuter) and initial phone (/b/ or /k/) of each depicted noun. One source of information (gender or phonology) determined whether or not to press a button on a response pad, and the other source of information determined which button to press in the case of a go trial (left or right), with response hand and go/no-go task fully counterbalanced across blocks within participants. ERP analysis focused on the N200 component, which has been reliably used to provide an upper-bound estimate of the time at which lexical information is accessed in go/no-go tasks (e.g., Schmitt et al., 2000). Results showed larger N200 amplitudes for no-go versus go trials (an N200 effect), but no significant differences in N200 effect peak latency for go/no-go decisions based on gender compared to phonology ($F(1,19)=0.07$, using a jackknife ANOVA approach: Kiesel et al., 2008). We next examined whether these results might reflect task order by splitting participants into two groups: those who made the go/no-go decision based on phonology first, and those who made the go/no-go decision using gender first. Participants using phonology first showed a large temporal advantage in N200 peak latencies for go/no-go decisions based on gender (M=355ms) compared to phonology (M=421.5ms); participants using gender first showed a small N200 latency difference, with later mean peak latencies for gender-based decisions (M=417.1ms) compared to phonology (M=410.1ms). Results from a two-way ANOVA with go/no-go condition (phonology vs. gender) and group (phonology vs. gender first) revealed a significant interaction between condition and group on peak latency ($F(1,18)=9.96$, $p=0.006$). Separate one-way ANOVAs for each group showed a significant effect of condition in the phonology-first group (jackknife-corrected $F(1,9)=1965.4$, $p<0.001$), but no such effect in the gender-first group (jackknife-corrected $F(1,9)=0.09$), $p=0.77$). Using a within-subjects design, our group mean effects failed to find a temporal advantage for retrieving grammatical gender information over phonology. Instead, this effect was dependent on a particular task ordering. Our results thus suggest that the gender-before-phonology finding is delicate. It is sensitive to task ordering, and therefore may not generalize to all language production contexts. Our results are more consistent with parallel models of lexical access, where relative retrieval latencies are sensitive to task difficulty (e.g., Abdel Rahman & Sommer, 2003).

Orthographic Processing, Writing, Spelling

E45 Braille Reading in the Visual Cortex of Blind Individuals

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Reading words typically recruits a specialized region in the visual ventral stream, the so-called visual word form area (VWFA). In the absence of vision, blind individuals read using a tactile system called Braille. There is some evidence that the VWFA plays analogous roles in Braille reading and visual reading (e.g. Reich et al., 2011). However, visual cortex regions beyond the VWFA also respond to Braille (Sadato et al., 1996). In addition, the visual cortex of blind individuals is recruited during non-visual functions such as sound localization, tactile discrimination, and language processing (Gougoux et al., 2005; Sadato et al., 2002; Bedny et al., 2011). We asked 1) whether responses to Braille are localized to the VWFA or are present throughout the visual cortex, and 2) whether the VWFA responds selectively to Braille or to other non-visual inputs as well. Ten congenitally blind participants took part in an fMRI experiment involving two auditory and three tactile conditions. Participants listened to auditory words (AW), listened to words played backwards (AB), felt Braille words (FBW), felt consonant strings (FCS), or felt tactile shapes made out of Braille dots (FSH). On each trial participant heard or felt six target stimuli followed by a probe. Participants judged whether the probe came from the preceding list. We defined individual functional VWFA ROIs by selecting voxels in the VWFA that responded more to Braille words than shapes using a leave-one-run-out procedure. We find that the VWFA is sensitive to language in both tactile and auditory modalities: it responded more to Braille words than consonant strings and tactile shapes (FBW>FCS>FSH) (M=0.77, SD=0.45; M=0.43, SD=0.47; M= -0.03, SD=0.37, $F(2,8)=10.32$, $p=0.006$) and more to auditory words than auditory backwards speech (AW>AB) (M=0.24, SD=0.34; M=-0.30, SD=0.17; $t(9) = 6.61$, $p = 0.0001$). Critically, the size of difference between Braille words and tactile shapes and auditory words and words played backwards was similar in the VWFA (M=0.80, SD=0.53 for (FBW-FSH) and M=0.55, SD=0.26 for (AW-AB), $t(9) = 1.81$, $p = 0.10$). There was a main effect of lexicality (greater response to auditory and tactile words than shapes and backwards speech, $F(1, 9) = 36.74$, $p < 0.001$), as well as a main effect of input type (greater response to

all tactile than auditory stimuli, $F(1,9) = 23.05$, $p = 0.001$). There was no interaction between lexicality and input type ($F(1,9) = 3.29$, $p = 0.103$), suggesting that the VWFA is similarly sensitive to language in tactile and auditory modalities. This functional profile was consistent across several visual cortex regions outside of the VWFA both on the ventral surfaces and the lateral surface of the occipital lobe. However, responses to both Braille and spoken words were especially pronounced in the canonical VWFA region. The present findings suggest that responses to Braille occur throughout the visual cortex in blindness and peak in the VWFA. However, Braille-responsive regions, such as the VWFA, do not appear to be selective for Braille but are rather sensitive to linguistic information in general across tactile and auditory modalities.

E46 Building a computational basis for the brain response in visual word recognition: A sparse familiarity model for the left ventral occipito-temporal cortex

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The left ventral occipito-temporal cortex (lvOT) is consistently activated in response to visual words and current controversies center around this region. This study, presents a computational model of the lvOT and use benchmark effects from the literature to validate its assumptions. Furthermore, data from a pseudoword-learning paradigm is used to validate the learning assumptions of the model. The sparse implementation of this model is based on two assumptions: First, the shape of the neuronal activity in relation to engagement and proficiency in any task follows an inverted u-shaped function, and second orthographic familiarity of letter strings can be used as an index of engagement and proficiency in visual word recognition tasks. The simulated mean neuronal activity successfully reproduces the brain activation patterns of the lvOT from several benchmark contrasts in published functional neuroimaging studies (e.g. consonant strings < words; pseudohomophones > words). Given that the described model is a reasonable account for a large set of benchmark effects, it can be used to derive predictions for the outcome of new studies, which was realized in the second part. In two pseudoword-learning tasks, one group of pseudowords was familiarized by auditory presentation and a second group of pseudowords by visual presentation. Both learning tasks required the overt vocalization of each auditorily or visually presented pseudoword, and the learning effect was quantified by the decrease in response latencies. Thus, while for visually familiarized pseudowords both visual and auditory information was trained, auditory learning was based purely on auditory information. Thereafter, fMRI data from 39 German normal readers was acquired while participants silently read the learned pseudowords, a group of unlearned pseudowords, and a group of real words (all matched on orthographic similarity). To control if participants read the stimuli catch trails were included. Brain data revealed a large lvOT cluster with reduced activation for auditory learned pseudowords in contrast to words. Visually learned pseudowords also showed reduced activation relative to words, but in a much smaller lvOT cluster. No reliable cluster was found when unlearned pseudowords were contrasted to words (remember orthographic similarity was matched). The data suggest that auditory familiarization results in rather unspecific lvOT learning effects, whereas additional visual information increases the regional specificity of learning effects in lvOT. To evaluate the learning assumption of the sparse familiarity model, we realized three different implementations. One stressed the influence of visually learned information (i.e., stronger weights for visually learned pseudowords in the familiarity estimation), a second stressed the auditory learned auditory information, and a third model implemented equal weights to visual and auditory information. The comparison of model simulations and fMRI data from lvOT showed that the patterns of the equal weights model and the model with stronger auditory weights were represented in the data, while the model that stressed visual information could be falsified. In sum, lvOT activation can be modeled by a sparse computational implementation and the validation of the model's learning assumptions allowed tracking down the origin of the present learning effects to learned auditory information.

E47 Genetic and Environmental Covariation between Cortical Brain Structure (Thickness, Surface Area) and Written Language Ability

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Language ability, cortical thickness and cortical surface area are all strongly influenced by genetic factors. We investigated genetic and environmental covariation between written language ability and cortical structure in regions previously implicated in language function in 526 twins (104 monozygotic twin pairs, 159 dizygotic pairs; mean age = 22.7 ± 3.08 years). Nominally significant phenotypic correlations were found between cortical thickness measures and regular-word spelling performance, as well as between surface area and nonword spelling. In the supramarginal gyri, both thickness and surface area were associated with spelling measures. No significant associations were found between cortical measures and measures of reading nor of print exposure.

Further tests involving the supramarginal gyri indicated that genetic influences on right supramarginal cortical thickness may account for around 7% of variance in regular spelling ability, while genetic influences on supramarginal surface area account for ~3% of variance in nonword spelling. These are the first results indicating a genetic association between cortical structure and variance in written language skill. Larger studies are required to confirm these findings and further investigate the regional and lateral specificity of these associations.

E48 N170 expertise effects differ among skilled and less-skilled adult native English speakers

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Introduction: This study examines the relationship between individual differences in reading skill, orthographic N170 effects, and N170 laterality. Previous studies have reported larger N170s to words and pseudowords versus consonant strings, and increased left lateralization of the N170 (LN170) in early reading development. In the present study we asked whether the N170 would show sensitivity to skill differences among adult native English speakers. Participants performed a lexical decision task, and we manipulated demands on lexical processing by including two types of pseudowords: pseudowords (e.g., hurricene), which are both orthographically and phonology altered from their real-word counterparts, and pseudohomophones (hurricain), which are orthographically altered but phonologically intact. We hypothesized that decoding skill would be correlated with left lateralization of the N170 and with the magnitude of the orthographic N170 effect, which we defined as an increased (more negative) N170 for words versus pseudohomophones. By contrast, we predicted that N170 laterality and orthographic effects would be unrelated to nonverbal reasoning ability. Methods: Participants were 22 right-handed native English-speaking students enrolled at the University of Pittsburgh, with a range of reading and nonverbal skills that is typical of this population. There were three types of experiment stimuli: correctly spelled words (e.g., hurricane), pseudohomophones (eg., hurricain), and pseudowords (eg., hurricene). The targets (correctly-spelled) and the two types of foils were separated into lists, such that corresponding foils and targets were not seen together. The lists were equated for mean word frequency, word length, bigram frequency, and orthographic neighborhood. Participants were asked to make a word-nonword judgment (i.e., a lexical decision) to each stimulus. Stimuli were presented for 350 ms with a 2-second interstimulus interval. We recorded the electroencephalogram (EEG) using a 128-channel net with a vertex reference, data sampled at 250 Hz. The EEG were segmented into 1000 ms epochs, with a 200ms prestimulus baseline. Epochs were cleaned, rereferenced to the average reference and baseline corrected to the pre-stimulus interval. N170 amplitudes were measured using an adaptive mean (± 20ms about the peak) at ten electrodes — 5 on each side of the scalp — clustered around PO7 (Left), or PO8 (Right). LN170 amplitude was defined as the difference in mean amplitude over the left and right clusters. Vocabulary knowledge, reading comprehension, decoding, spelling ability, nonverbal reasoning, and reading experience were measured offline. The relationship between N170 measures and reading scores were evaluated using partial correlations, with nonverbal reasoning as the control variable. Results: Without correcting for multiple comparisons all reported effects had uncorrected p-values that were below .05. Larger LN170 amplitude predicted faster reaction times. Words-pseudohomophone contrasts predicted lower online accuracy: more activation for words vs. pseudohomophones corresponded with higher accuracy. Higher vocabulary scores predicted greater left lateralization of the N170 for all stimulus types, and higher comprehension scores predicted left lateralization for words and pseudohomophones only. Summary & Conclusion: The present study found that reading skill correlated with N170 lateralization in adult native English speakers. This replicates and extends previous ERP studies of N170 effects in early reading development.

E49 A Meta-analysis of Neural Systems for Chinese Characters Processing Driven by Stimulus Properties versus Task Demands

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The convergent and divergent brain areas have been identified for the neural systems of visual word reading across different languages, such as Chinese and English. Regions specific for Chinese character reading are thought as stimulus selective and shaped by language properties. However, this view has been challenged by increasing evidence that showing tasks modulated activities in those regions. Here, using activation likelihood estimate (ALE) technique, we analyzed previous Chinese fMRI studies to examine the stimulus selective versus task demanded regions involving in Chinese characters processing. The foci of two types of contrasts were selected from previous Chinese fMRI studies on character processing from 2000 to 2014. The first contrast was the stimulus contrast intended to identify brain regions sensitive to the quality (e.g. character > pinyin/faces) or quantity (e.g. high vs. low frequency) of the properties for visual characters under the same task. The second contrast was the task contrast that required different cognitive processing, such as the semantic judgment and rhyme judgment. In order to identify the areas constituting the brain network conjointly involved in stimulus or task contrasts, a probabilistic whole-brain map was constructed using the revised algorithm of the activation likelihood estimation (ALE) approach implemented in the Ginger ALE 2.3.3 software package. The results showed that the stimulus contrasts revealed bilateral clusters at superior parietal lobule

and insula, left clusters at Inferior Frontal Gyrus (IFG), Middle Frontal Gyrus (MFG), Angular Gyrus (AG) and Fusiform Gyrus (FFG).Whereas the task contrasts revealed bilateral clusters at superior parietal lobule, insula and IFG, left clusters at MFG and posterior temporal gyrus. The interesting finding is the directly comparison between two types of contrasts. The regions more for stimulus than task contrasts located at left pre-central gyrus, AG, and FFG. Whereas, the regions more for task than stimulus contrasts located at left IFG/MFG, posterior part of superior/middle temporal gyrus, as well as superior frontal gyrus. The present data showed language specific regions in previous studies (MFG for Chinese, and pSTG for English) are driven by task demanded instead of stimulus selectivity. It shed the light on the general neural network of visual words reading both for Chinese and English.

E50 Microstructural white matter differences between 6-year old readers and prereaders

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Background: Recent studies reported white matter microstructural differences between individuals who learned to read as adults and those who remained illiterate. Reading is typically learned during early childhood when brain plasticity is pronounced. We set out to examine whether the ability to read in children is associated with differences in white matter microstructure. We hypothesized that compared to peers who had not yet learned to read, 6-year old readers would demonstrate differences in white matter properties within tracts implicated in decoding. Methods: We conducted diffusion MRI (dMRI) scans and behavioral tests of intelligence, expressive language, phonological awareness (PA) and reading skills in 33 children (mean age=6.2 years, 10 males). Readers (n=22) were defined as those with a standard score greater than the group mean (>110) on pseudoword reading. Children who read ≤1 word on the same task were defined as pre-readers (n=11). 30-direction dMRI and high resolution T1-weighted data were obtained on a 3T scanner. Six bilateral white matter tracts were identified using deterministic tractography: anterior Superior Longitudinal Fasciculus (aSLF), Inferior Longitudinal Fasciculus (ILF), Arcuate Fasciculus (Arc), Forceps Major (FMajor), Corticospinal tract (CST) and Uncinate Fasciculus (UF). We quantified fractional anisotropy (FA) values along the trajectory of each tract. Group differences in behavioral tests and tract FA were examined with independent samples t-tests. Results: Readers and pre-readers did not differ significantly on the basis of socioeconomic status, sex, second language exposure, stage in school, or non-verbal IQ. Readers performed significantly higher on tests of expressive language, PA, and verbal IQ ($p<0.05$). Readers demonstrated significantly higher FA than pre-readers within segments of the left ILF, left aSLF, FMajor, and right UF ($p<0.05$) and significantly lower FA than pre-readers within segments of the right Arc and left and right CST ($p<0.05$). Group differences observed within the left aSLF and right UF remained significant after correcting for multiple comparisons ($p<0.05$, corrected). Conclusions: 6-year old readers had both significantly higher and lower FA than pre-readers in several white matter tracts implicated in reading processes. Such group differences may reflect inherent differences in white matter microstructure or variability in experiences with learning to read. Future longitudinal analyses in this sample will examine whether individual variations in FA observed during the early stages of learning to read are predictive of later reading abilities.

E51 The effect of aging on the brain network for exception word reading aloud

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Cognitive and computational models of reading aloud agree on the existence of two procedures to map the orthography into the phonology of written stimuli: 1) subword processes, in which regular orthography-to-phonology mappings are sequentially employed to read new, unknown words or pseudowords (PW) (e.g., 'atandier'); and 2) idiosyncratic whole-word processes, used to read exception words (EW) with atypical orthography-to-phonology mappings (e.g., 'pint'). Regular words (RW) can be successfully read using both procedures. Recent behavioral findings seem to suggest that older adults may rely more on whole-word processes, while younger adults on subword ones. However, the neural counterpart of this reading mechanism switch in older adults remains unknown. The aim of the present fMRI study was to verify whether the larger reliance on whole-word processing shown in older adults in behavioral studies is reflected by changes in the pattern of brain activation while reading different types of words. To this aim 16 older (9 females, mean age of 67.0 ± 4.5, age range = 60-75 years) and 16 younger (8 females, mean age of 27.5 ± 4.0, age range = 22-33 years) adults performed an overt reading task that included three types of stimuli (n = 60 per condition): 1) EW, that can only be successfully read using whole-word processing; 2) RW, that can be read either by whole-word or subword processes; and 3) PW, that can only be successfully read by the application of subword processes. Behavioral results showed that older adults committed significantly less errors in reading EW compared to younger adults. At the level of brain activation pattern, three main results were observed. Firstly when we compared EW and PW reading, we observed significant activation of the left anterior temporal lobe (ATL) in both young and older adults. This is consistent

with previous neuropsychological and neuroimaging findings showing that the left ATL is implicated in whole-word reading processes. Secondly, when we compared RW and PW reading we observed significant activation of the left ATL in older adults only. This suggests that older adults, differently from younger adults, would activate the whole-word reading network not only for EW reading but also for RW. Thirdly, when we compared EW to RW, significant ATL activation was observed in young adults but not in older adults. This suggests that both EW and RW lead to comparable ATL activation in older adults but not in younger. Altogether these findings reveal that older adults activate brain regions involved in whole-word reading when engaged in both EW and RW reading, while young adults would show comparable networks for both RW and PW reading. This provides for the first time critical neurofunctional evidence in support of the hypothesis that older adults rely more on whole-word processes.

E52 Reduced electrophysiological connectivity during visual word recognition in dyslexic children *Gojko Žarić[1], João M. Correia[1], Gorka Fraga González[2], Jurgen Tijms[3], Maurits W. van der Molen[2], Leo Blomert[1], Milene Bonte[1]; [1]Maastricht University, [2]University of Amsterdam, [3]IWAL Institute*

Reading is a complex cognitive skill subserved by a distributed network of visual and language-related regions. Disruptions of the connections within this network are proposed as a possible cause of reading dysfunction in developmental dyslexia. Here we investigated effective connectivity in the reading network of 9-year-old typically reading children (TR; n=20) and two groups of dyslexic children: severely dysfluent dyslexic (SDD; n=17) and moderately dysfluent dyslexic (MDD; n=18). To this end, we used directed transfer function (DTF) to analyze the electroencephalographic (EEG) signal recorded while the children recognized visual words and meaningless letter-like symbol strings. DTF is a spectral multivariate estimator of EEG activity propagation and based on autoregressive models. Here DTF was performed per subject and random-effect statistics were calculated between groups per condition using Wilcoxon tests per frequency bin (FDR<0.05). Our preliminary analysis indicates an expected propagation from posterior to anterior channels in TR children during both the visual word and symbol string recognition task. Similar results were found in the MDD group with significantly weaker connectivity from left parietal to central and frontal channels than in TRs and SDDs on both tasks. On the other hand, the SDD readers showed significantly weaker propagation from occipital to central and frontal channels on both tasks than both TR and MDD groups. Most interestingly, the SDD group exhibited significantly stronger bilateral anterior to posterior connectivity in both conditions than TR and MDD groups. This pattern of results suggests that the two groups of dyslexic children use two different compensatory mechanisms: MDD readers rely on qualitatively the same connectivity as TRs; while SDD readers more strongly rely on bilateral anterior to posterior connectivity. This differentiation emphasizes the importance of considering differences in severity of reading dysfunction within dyslexic population in addition to group differences between typical and dyslexic readers.

E53 Recovering orthographic knowledge: Contributions of the ventral and dorsal components of the orthographic processing network. *Jeremy Purcell[1], Brenda Rapp[1]; [1]Department of Cognitive Science, Johns Hopkins University, USA*

With regard to the orthographic system, there is a distinction between a ventral orthographic processing stream associated with orthographic word form processing and a dorsal stream associated with attentional/serial aspects of orthographic processing (e.g., Cohen et al. 2008). One source of information about the orthographic processing system is the study of the recovery of spelling abilities in individuals with acquired dysgraphia who have undergone rehabilitation. In this study, we examine the neural changes associated with the recovery of spelling, interpreting the findings within the context of the dual-stream view of orthographic processing. Participants were 5 individuals with chronic dysgraphia subsequent to stroke (time post-stroke at least two years). We identified individualized sets of 40 TRAINING words (25 - 80% letter accuracy). We carried out a CART based treatment (Beeson, 1999) over approximately a 3 month period. Training was completed when at least 90% letter accuracy was achieved for the TRAINING items. To track neural changes associated with spelling training, we performed an fMRI study of spelling (modelled after Rapp and Lipka, 2010) at pre- and post-training time points. The fMRI protocol was designed so that each participant processed the spelling of their individualized sets of TRAINING words during scanning. In this analysis we examined differences in the neural responses to TRAINING words at pre-training as compared to post-training. The neural response to the training items either significantly increased or decreased after training. Cluster-size correction for multiple comparisons ($p < 0.05$) was applied. We generated an overlay of the normalized, unsmoothed, significant single-participant responses. For each participant we identified areas associated with a relative difference in activation from pre to post training for the TRAINING items. 4/5 participants demonstrate a decrease in neural response on the TRAINING items from pre to post training in the left fusiform gyrus. 4/5 participants demonstrate an increase in neural response on the TRAINING items from pre to post training in the left angular gyrus. Unlike the other 4, one participant had damage to the left angular gyrus, but still demonstrated a relative increase in the contra-lesional right angular gyrus. First, we found that an effective spelling intervention in adult acquired dysgraphics leads to both up- and down-regulation of neural responses to training items. Second, we observed that these up- and

down-regulation effects correspond generally to dorsal and ventral orthographic processing streams respectively. Ventrally, in the left fusiform, we identified a consistent effect of down regulation of the neural response to spelling the TRAINING items. This could be due to an initial high demand on the orthographic word form system when the spellings are not easily accessed, but after training the neural response is more efficient, hence lower. More dorsally, the left angular gyrus up-regulation could be associated with attention/working-memory circuitry that has come to play a more prominent role. The observation of these two regions in the recovery of spelling function may reflect two aspects of recovery of orthographic function: one which reflects improved orthographic word form and another which reflects improved serial orthographic processing.

E54 Neural Correlates of Writing: Voxel-based Lesion Analysis of Single-Word and Sentence-Level Writing

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While a large number of lesion and neuroimaging studies in the literature have focused on the neural basis of reading, much less attention has been dedicated to identifying the brain networks associated with writing. Like reading, writing is a relatively recent human invention that had to be built upon pre-existing cognitive and neural structures. Previous work by our group and others has suggested that a distinct brain network underlies writing and that this network only partially overlaps with the network for reading. In the current study, we analyzed lesion and behavioral data from a large cohort of 111 left hemisphere stroke patients using voxel-based lesion symptom mapping (VLSM) to identify the most critical regions in the writing network. Patients were selected based on the following criteria: A single, left hemisphere stroke; pre-morbidly right-handed; English as a first language; chronic phase of stroke (> 6 months); no neurologic or severe psychiatric history; and a minimum 8th grade education. The sample included patients with a wide range of writing performance and aphasia severity (approximately 50% of the patients had mild to no aphasia). Patients were assessed with a series of writing subtests from the Western Aphasia Battery that included both word-level and sentence-level writing. The writing subtests also included different levels of performance demands, such as spontaneous writing (e.g., written picture description), writing to dictation, and copying written material. Scoring was based on accuracy of content only—quality of penmanship and speed were not factored into performance. Permutation testing (1,000 iterations) with alpha = .05 was used to determine a conservative cut-off threshold for what constituted a significant t-value in the VLSM maps. The VLSM analysis of overall writing performance, collapsed across all writing subtests, revealed two major foci: The highest t-value was in the left supramarginal gyrus, near the border of the angular and supramarginal gyri, and a second focus was centered in the left mid-superior temporal gyrus. Other significant voxels were present in the left mid-middle temporal gyrus, superior parietal lobule, and post-central gyrus. The VLSM analyses of individual writing subtests showed that writing to dictation (both word- and sentence-level) was most strongly associated with the focus in the left mid-superior temporal gyrus, although the left inferior parietal focus was still present as well. Similarly, writing a description of a picture (a picnic scene) implicated these same two main foci, with the highest t-value centered in left superior temporal cortex. In contrast, neither of these foci (superior temporal or inferior parietal) was implicated in the VLSM map of the sentence copy subtest (simply copying a written sentence). The only significant voxels that survived thresholding on this subtest corresponded to the geniculocalcarine tract (optic radiation). These findings from a large cohort of unselected left hemisphere patients provide further insight into the brain regions most critical for distinct aspects of writing and offer an important contrast with the more ventral network typically implicated in the closely-related process of reading.

E55 Experimental induction of dyslexia-like reading difficulties in normal readers: Novel insights from MEG

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This magnetoencephalography (MEG) study was run to gain deeper insights into dyslexic reading. Based on two previous studies investigating reading times (Tholen et al., 2011) and fMRI (Heim et al., 2014), we evoked reading difficulties resembling dyslexia-like symptoms in healthy adult readers. Items were modified in two different ways. 1) A phonology-related deficit (GPC) was simulated by using an unfamiliar font, making grapheme-to-phoneme conversion more difficult. 2) A visuo-magnocellular deficit (VIS) was simulated by using moving letters, making the items appear to be "dancing" as reported by dyslexic readers. Previously, Heim et al. (2014) found activation for GPC in the left inferior frontal and parietal cortex resembling effects in real dyslexics, but also involvement of their homologs in the right hemisphere. Likewise, for VIS, left- but also right-hemispheric effects were seen in area MT+ of the magnocellular pathway known to be affected in dyslexia (Jednoróg et al. 2011). The question emerged what role the right hemisphere plays in simulated dyslexic reading, and what the impact might be for real dyslexia. The hypothesis was that of compensatory support by the right hemisphere, implying a later occurrence of effects in the right than in the left hemisphere. Thus, in the present study, we sought to investigate the time course of the

effects with MEG. ource localization was applied to extract the spatio-temporal time courses of activity. RMS values were then calculated voxel-wise for each subject using a sliding window of 100 ms duration with 50 ms overlap between 0-850 ms. SPM8 was used for a random-effects group analysis of the individual data sets normalized into MNI space. Behaviorally, we replicated the earlier findings by Tholen et al. (2011) and Heim et al. (2014). Preliminary MEG analysis from 24 healthy German adult readers revealed effects largely replicating the frontal, parietal and temporo-occipital blobs in Heim et al. (2014). The activation course of frontal and inferior parietal areas in GPC followed the expected pattern, i.e. the left hemisphere was activated first and right homologues followed in a later time window. For VIS, left temporo-occipital effects partly preceded those in the right hemisphere. In accordance with the hypothesis, these findings suggest a compensatory and additional activation by means of right-hemispheric homologs of the reading system in dyslexia. References Heim, S., Weidner, R., von Overheidt, A.C., Tholen, N., Grande, M. & Amunts, K. (2014). Simulating reading difficulties in normal readers: Novel insights into the neurofunctional mechanisms of dyslexia. Brain Structure and Function, 219, 461-71. Jednoróg, K., Marchewka, A., Tacikowski, P., Heim, S., Grabowska A. (2011). Electrophysiological evidence for the magnocellular-dorsal pathway deficit in dyslexia. Developmental Science, 14, 873-880. Tholen, N., Weidner, R., Grande, M., Amunts, K. & Heim, S. (2011). Eliciting dyslexic symptoms in proficient readers by simulating deficits in grapheme-to-phoneme conversion and visuo-magnocellular processing. Dyslexia, 17, 268-281.

E56 Patterns of Orthographic Working Memory Impairments in Acquired Dysgraphia: A Case Series nalysis

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Introduction Studies reporting on the occurrence of orthographic working memory (OWM) impairment in cognitive neuropsychology (CN) appear to be limited. However, a recent study offers some evidence that points to the common occurrence of OWM impairments in clinical populations (Haslam, Kay, Tree, & Barron, 2009). But the evidence offered in this study is also limited to three cases with dementia. Thus, the evidence for common occurrence of OWM impairments awaits, at the least, a case series analysis of several cases. Previous studies of OWM impairments in dysraphias have identified characteristic error profile that included length effect, letter errors, and lack of frequency effects (Buchwald & Rapp, 2009). Additionally, letter errors were more common in the middle of words than in the initial or final positions (Zazio, Cappaso, & Miceli, 2013). As the recent debates on case series investigations in CN imply (Schwartz & Dell, 2010; Rapp, 2011), focused cognitive analysis of OWM impairments might reveal the trends and variations in the patterns of occurrence. The present study reports on OWM impairments in four cases with a history of chronic aphasia and dysgraphia. In addition, this study also discusses the variability in the patterns of OWM impairment and reflects on the previously established profiles of impairments. Method Subjects. Four adults with chronic aphasia have served as the subjects of this study: Subject 1:CBH, a 59-year-old, right-handed female with a medical history of stroke-induced bilateral parietal lobe lesion, Subject 2: JL, a 66-year-old, right-handed female with an ischemic stroke affecting posterior temporo-parietal cortex of the left hemisphere and bilateral white matter atrophy, Subject 3: LK, a 45-year old, right-handed male with a stroke induced infarct involving the left temporal region and a portion of the left frontal cortex, and Subject 4: SE, a 69-year-old right-handed female, with a stroke-induced lesion in the right frontal lobe under the anterior horn of the lateral ventricle and the head of caudate and putamen. Procedure Clinical evaluation included administration of the Boston Diagnostic Aphasia Examination (BDAE). Experimental Tests administered include 1) Johns Hopkins University Dysgraphia Battery and 2) Psycholinguistic Assessment of Language Performance in Aphasia (PALPA), specifically the letter length subtests of Reading and Spelling Tests. Results and Discussion The results revealed the presence of letter length effect in all four patients: LK had 17% correct responses, JL had 30% correct responses, CBH had 79% correct responses, and SE had 87% correct responses. These results clearly support the view of common occurrence of OWM impairments (Haslam, Kay, Tree, & Baron, 2009). However, there was a variable letter position pattern in the four patients (Figure 1). SE, who had the least number of errors, among the four patients, was the only case that had a clear bow-shaped pattern. CBH had more errors in the middle letters but did not show a clear bow-shaped pattern. LK and JL had more errors in the initial letters than in the succeeding ones. These findings warrant further research into the importance of letter position for the characterization of OWM impairment profile.

Phonology, Phonological Working Memory

E57 Individual differences in the neural correlates of reading words and passages

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Single word recognition serves as a building block for text comprehension. It is, however, unclear how the brain in the same individual processes isolated words and connected words in a narrative and how brain activation in reading words and narratives associates with individual difference of reading skills. In the present study, we investigated how individual differences in reading fluency, decoding ability

and comprehension correlated with the brain activation in reading single words and passages. Participants covertly read single words and stories in different sessions of fMRI recording. Outside of the scanner, the participants' reading fluency, phonemic decoding and comprehension were assessed by a) Test of Word Reading Efficiency, b) Comprehensive Test of Phonological Processing and c) Woodcock-Johnson Test of Achievement, respectively. In a simultaneous multiple regression analysis, these three behavioral scores were included as predictors on the whole brain activation. The results showed that the levels of reading fluency negatively correlated with the right inferior temporal gyrus in word reading but did not significantly uniquely correlate with any brain activation in story reading. Phonemic decoding skill positively correlated with the activation of the left inferior frontal gyrus in word reading, and negatively correlated with the activation of the right middle frontal gyrus in story reading. Comprehension skill positively correlated with the right middle temporal gyrus in word reading and positively correlated with the activation of the left anterior superior temporal sulcus and the left middle temporal gyrus in story reading. Moreover, the comprehension ability positively correlated with the activation of the right middle temporal gyrus in both word and story reading. The results suggest that fluent readers are able to recognize words more automatically (Golinkoff & Rosinski, 1976), and that leads to efficient semantic retrieval, and less activation of the right inferior temporal gyrus in word reading. Better phonemic decoding skill involves the left IFG more strongly. Better phonemic decoders may benefit from faster word retrieval and consequently decrease working memory load and the involvement of the right middle frontal gyrus in story reading. People with better comprehension ability may be better at semantic retrieval, reflected in their involvement of the right middle temporal gyrus in both word and story reading. People with better comprehension ability may also be better at semantic integration, supported by the left anterior superior temporal sulcus in story reading. In conclusion, phonemic decoding and comprehension skills support reading isolated words and connected words in narratives. The right middle temporal gyrus commonly predicts the individual difference in reading comprehension for both word recognition and narrative comprehension.

E58 The effects of healthy aging and left hemisphere stroke on statistical language learning

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Sentences in spoken language are a continuous stream of sound, with no reliable acoustic cues marking word boundaries. To identify word boundaries, language learners use an implicit statistical learning mechanism that computes transitional probabilities between syllables. Infants, children, and young adults perform this type of statistical learning, without explicit instructions or feedback. Neuroimaging studies in healthy young adults have suggested that the left inferior frontal gyrus (IFG), left arcuate fasciculus, and bilateral caudate and putamen are involved in speech segmentation via statistical learning. Here we test whether this learning is disrupted by healthy aging or left hemisphere injury. Peñaloza et al. (2014) demonstrated some speech segmentation in individuals with left hemisphere injury, but only weak tests of learning were administered. Participants were 14 healthy college-aged adults (mean age 19.1, 6 male/8 female), 28 healthy older adults (mean age 57.8, 13 male/15 female), and 24 patients in the chronic phase of recovery from left-hemispheric stroke (mean age 59.9, 17 male/7 female). The artificial language (Saffran, Aslin & Newport 1996) uses 12 distinct syllables organized into 4 trisyllabic words, randomly ordered with equal frequencies for the words and their junctures, and concatenated into a continuous speech stream by a synthesizer with no acoustic cues to word boundaries. Participants listened for 10 minutes while performing a monitoring task to ensure they attended to the stream. After exposure, participants completed a 30-item post-test in which they heard a Word, Part-word (trisyllabic sequence that spanned a word boundary), or Non-word (3 familiar syllables in an unfamiliar sequence) and rated "How familiar does this sound?" from 1 (not at all) to 5 (very). Patients also completed a battery of language and cognitive tests. Young controls rated Words (mean rating: 4.17) > Part-words (3.60) > Non-words (2.60); in a within-group repeated measures ANOVA, the main effect of word type ($F(2,26)=27.833$, $p<.001$) and all possible pairwise comparisons were significant. Older controls also showed a significant main effect of word type: Words (3.62) > Part-words (3.38) > Non-words (2.79) with $F(2,54)=13.885$, $p<.001$; however, only pairwise comparisons to Non-words were significant (Word vs. Part-Word approached significance: $p=.067$). Patients' mean ratings: Word (2.84), Part-word (3.01), and Non-word (2.84), did not show a significant main effect ($F<1$, $p=.404$) nor any significant pairwise comparisons. Between-group repeated measures ANOVAs show significant WordType*SubjectType interactions for younger vs. older controls ($F(2,80)=3.77$, $p=.027$) and older controls vs. patients ($F(1.71,85.29)=7.19$, $p=.002$). Preliminary voxel-based lesion symptom mapping analysis suggests that lesions in left IFG are associated with poorer ability to distinguish Words from Part-words. Only young controls showed the robust statistical learning required to distinguish Words from Part-words. Healthy older controls showed sequence recognition (distinguishing Words from Non-words) but somewhat reduced statistical learning. As a group, patients showed no learning, although some individual subjects performed better than others. These findings suggest that speech segmentation ability, like other implicit learning skills, declines during

healthy aging. It is also sensitive to left hemisphere injury, specifically to IFG lesions, supporting prior evidence for the role of left IFG in statistical language learning.

E59 Transdiagnostic neural basis for impaired phonological working memory across reading disability and autism

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Goals: Individuals with reading disability or autism spectrum disorder (ASD) have, respectively, distinct disorders of language and social communication, but often exhibit common impairment in phonological processing. Here we asked whether there is a common transdiagnostic neuroanatomical basis for impaired phonological processing, in particular, phonological working memory, across the diagnoses of reading disability and ASD, or alternatively, whether impaired phonological working memory reflects different neuroanatomical bases in these two disorders. Methods: 64 children (17 girls and 47 boys), ages 5-17 years with reading difficulties, or ASD, or typical development (TD) matched in age, non-verbal IQ and gender participated in the study. Phonological working memory is assessed by a combination of phonological awareness and verbal short-term memory tasks. All five tasks involved the ability to store and manipulate segmented phonological units in short-term memory and immediate access to those phonological representations for speech production. The diffusion-weighted images were acquired on a Siemens Trio 3T MRI scanner with a standard 32-channel phased array head coil. The diffusion-tensor imaging data were processed using TRACULA (Yendiki et al., 2011), which generated probability distributions of major white matter pathways. Results: Compared with TD, both Poor Reader and ASD groups exhibited reduced phonological working memory. Both groups displayed lower fractional anisotropy and higher radial diffusivity in the temporo-parietal part of the left arcuate fasciculus (TP-AF). ASD group additionally exhibited white-matter anomalies at the temporo-occipital part of the right inferior longitudinal fasciculus (TO-ILF). No group difference was found between Poor Readers and ASD. The fractional anisotropy of the left AF and right ILF correlated with ability in phonological working memory across all participants. In particular the microstructural features of the right ILF only correlated with phonological working memory in the two diagnostic groups, but not the typically developing counterparts. The variation in the microstructure of right ILF is not related with a broad measure of social cognition assessed by the Autism Diagnostic Observation Schedule (ADOS, Lord et al., 2000), suggesting the specificity of the link between right ILF and impairment in phonological working memory. Conclusions: We found that decreased phonological working memory in both Poor Reader and ASD groups was associated with common white-matter structural abnormality in left AF and right ILF. These results provide the first evidence for transdiagnostic markers of impaired phonological working memory across poor reader and ASD groups based on both behavioral and anatomical measures, and suggest that at least a subset of common endophenotypes exist between reading disability and ASD. Our findings strongly support a common pathophysiology underpinning of behavioral deficits in different groups of children, consistent with the recent efforts in search of biomarkers to reconceptualize disorders along dimensional features, the RDoC approach to psychiatry (Insel, 2014).

E60 Glutamate and Choline Levels predict Individual Differences in Reading Ability

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Magnetic Resonance Spectroscopy (MRS) is used to acquire noninvasive invivo measures of neurometabolites including N-acetyl-aspartate (NAA), choline (Cho), creatine (Cr), GABA, and glutamate (Glu). Abnormal levels of Cho have been reported in ADHD and Autism, abnormal Cho is hypothesized to reflect abnormal white matter organization and cell membrane turnover (whereas heightened Glu can reflect hyperexcitability). Previous studies of NAA and Cho have identified abnormalities in Cho of RD adults (both overexpression and under expression). The current study examined neurochemistry early in the development of learning to read, which is critical for disentangling whether abnormal metabolite levels are a result of life-long reading experiences or are present even as children are beginning to learn to read. MRS was performed on a 4T scanner to measure GABA, NAA, Cho and Glu (relative to a Creatine baseline) from a posterior occipital region of brain. Data from 75 children, ages 6-10, revealed greater levels of choline and glutamate as an inverse function of reading skill, with greater levels present for poorer readers. Moreover, when a subsample of clinically defined RD (SS < 85% our reading composite) and matched TD readers was pulled out, RD readers had significantly greater levels of choline and glutamate relative to TD readers. The hypothesis that Glu has been associated with hyperexcitability, fits with data suggesting generally noisy neural systems in RD, whereas elevated Cho in RD may reflect excessive connectivity or abnormal myelination. Critically, abnormal levels of these neurotransmitters are present early in reading development in RD readers. Additionally, a subset of these subjects participated in an fMRI experiment in which they read and listened to English words. Using bivariate and multivariate (Partial Least Squares, or PLS) correlation analysis, we investigated whether subjects' metabolite levels were related to

regionally specific neural activation levels (as measured by the MRI Blood-Oxygen-Dependent response) in the brain. Results indicate that lower levels of NAA, choline, and glutamate jointly predict higher activation of brain areas crucial for reading, including the bilateral inferior frontal gyrii; bilateral fusiform gyrii; bilateral angular gyrii/ inferior parietal cortex; and the left-lateralized middle and superior temporal gyrii. This replicates earlier general findings of a negative correlation between glutamate and BOLD activation, and extends them to include related metabolites, specifically within the context of the neural circuit for reading.

E61 How lexical dynamics determine the relative (un) grammaticality of novel wordforms: A Granger analysis of MR-constrained MEG/EEG data

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Introduction: Native speakers have strong, reliable intuitions about the phonological wellformedness (grammaticality) of nonwords. For example, English speakers generally agree that blik is well formed, but bnik and bdik are not. Furthermore, they agree that bnik, though unacceptable, is more acceptable than bdik. The patterning of these judgments is captured in linguistic theory by gradient abstract rules or constraints. Alternate analyses suggest that gradient phonological acceptability reflects the relative featural overlap between nonsense items and phonological representations stored in the mental lexicon. Previous work by our group has shown that dynamic interactions involving brain structures implicated in lexical representation drive both grammatical influences on speech perception (Gow & Nied, 2014), and phonotactic frequency effects on the perception of grammatical words (Gow & Olson, 2015). In this study we examine the role of brain regions involved in lexical representation on the gradient acceptability of ungrammatical nonwords. Methods: Subjects performed non-speeded acceptability judgments for a set of monosyllabic auditory nonwords while we collected simultaneous MEG and EEG data. These items were generated based on linguistic principles to be grammatical (blik), and either moderately (bnik) or severely (bdik) ungrammatical. These descriptions were confirmed by a pilot phonological acceptability rating task. The MEG/EEG data were combined with anatomical MR data to produce high spatiotemporal resolution source space MNE reconstructions of cortical activity, that we subjected to Kalman-filter enabled Granger causation analysis. Granger analyses focused on the period between 100-500 ms post stimulus onset. Results: All conditions produced patterns of strong bilateral perisylvian and prefrontal activation. Granger analyses underscored the strategic and metalinguistic nature of processing, with prefrontal regions implicated in the executive control of strategic memory processes exerting strong influence over structures associated with working memory. All conditions also showed strong influences by bilateral superior temporal structures involved in auditory and acoustic-phonetic processing. Critically, the left middle temporal and supramarginal gyri, regions believed to serve as mental lexica and shown to play a central role in our previous studies, also showed markedly strong influences on activation in other brain regions. These influences were stronger for moderately ungrammatical items than they were for severely ungrammatical items. Conclusions: These results are consistent with the theory that gradient phonological acceptability effects reflect lexical similarity rather than the application of gradient abstract phonological rules or constraints. Significantly, they suggest that lexical representations mediate grammaticality effects involving phoneme sequences not found in the lexicon.

E62 Flexibility of the human phonological system: investigating the roles of segment, tone, and syllable in Mandarin Chinese using the priming paradigm

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Facilitatory priming effect of segment has been consistently found in Indo-European languages (Levelt, Roelofs, & Meyer, 1999). In contrast, in Mandarin Chinese, facilitatory priming effect was only found for the whole syllable or syllable plus tone (tonal syllable), but never for segment or tone, no matter using explicit (Lee, 2007; Sereno & Lee, 2014; Zhang & Yang, 2005), masked (J. Chen, Lin, & Ferrand, 2003; You, Zhang, & Verdonschot, 2012), or implicit priming paradigm (J. Chen, 2002; T. Chen & Chen, 2013; O'Seaghdha, Chen, & Chen, 2010). We suspect that the use of tonal syllable as prime is the reason why no facilitatory effect was found for tone and segment. Despite the overlapped segment or tone between the prime and the target, at the syllable level, the prime and the target always activated distinct representations, which might induce a strong inter-syllable inhibition effect and eliminated any possible facilitatory effect. To examine this hypothesis, we conducted three experiments in the aim of reducing inhibitory effects between stored syllable representations. We asked the participants to name pictures with monosyllable or disyllable names and presented an auditory prime at the start of the picture display. In Experiment 1, we primed the tone of the target by "hum" sounds with the pitch patterns of Mandarin lexical tones, but carried no segmental information. In Experiment 2, in addition to tone, we added an onset consonant priming condition, under which the primes were isolated consonants. Namely, they were not embedded in syllables. In Experiment 3, instead of "hum" sounds and isolated consonants, we included learned Mandarin syllables and novel syllables consisted of Mandarin segments, but never really occurred in Mandarin as primes. Our results showed that tone, if not carried by a syllable, produced facilitatory priming effect. Namely, "hum" sounds shared the same tone with the target decreased the reaction time of picture

naming, compared to those unrelated to the target. Isolated consonant prime revealed similar tendency, although not statistically significant. Syllable prime only partially overlapped with the target increased the reaction time no matter the prime was learned or novel syllable. Our results showed that tone could produce facilitatory priming effect and provided evidence for inter-syllable inhibition in Mandarin Chinese. Such inhibition could be triggered even by novel syllables, for which temporary representations might have been formed on-line. It has been proposed that syllable, instead of segment, is the basic phonological unit of Mandarin Chinese (Dell, Chen, & Chen, 2007; O'Seaghdha et al., 2010). In this case, strong inter-syllable inhibition would be very useful in reducing selection error. By further clarifying phonological processing in Mandarin Chinese, this study demonstrated how diversity across languages helps to elucidate the flexibility and constraints of human phonological system.

Syntax, Morphology

E63 Familiarity effects on Language/Music P600 interactions

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[BACKGROUND] Whether language/music involve shared neurocognitive mechanisms remains a topic of debate (Patel 2003, Peretz & Coltheart 2003). Consistent with overlap in underlying mechanisms, ERP interference studies have demonstrated interaction patterns involving anterior negativities (LAN/RAN effects) when linguistic/musical syntax are simultaneously disrupted (using out-of-key notes or chords; see e.g., Koelsch et al 2005). However, whether the mechanisms underlying other ERP components (e.g., N400/P600) may be shared across domains remains undetermined. Our previous work tested familiar and unfamiliar melodies (from Miranda & Ullman 2007) containing musical syntactic violations (out-of-key notes) with simultaneous presentation of sentences containing lexical/conceptual semantic violations ("…the ball John will KICK/#BAKE…"). Such violations can elicit N400 effects followed by posterior P600-like positivities. In that study, P600 effects elicited by simultaneous music-syntactic and linguistic-semantic violations were subadditive when the melody was familiar/known (consistent with shared/overlapping generators). In contrast, unfamiliar/novel melodies containing simultaneous music-syntactic and linguistic-semantic violations yielded additive P600 effects (consistent with distinct underlying generators). [PRESENT STUDY] Using the same set of familiar/unfamiliar melodies and correct target sentences, the present study used musical syntactic violations (out-of-key notes) with simultaneous presentation of sentences containing linguistic-syntactic violations (e.g., "…the ball John will KICK/*KICKED…"). Sentences were presented word-by-word visually, while melodies were heard over headphones. Our aim was to determine whether the same influence of melody familiarity on language/music P600 interactions would arise with linguistic-syntactic violations. [RESULTS] Strikingly, the opposite pattern emerged, showing language/music P600 interactions for unfamiliar melodies only. Specifically, simultaneous violations of music-/linguistic-syntax with familiar melodies produced additive P600s (consistent with distinct underlying generators), while simultaneous violations of syntax across domains with unfamiliar melodies produced subadditive ERP profiles (consistent with shared/overlapping generators). [DISCUSSION] At a minimum, these results demonstrate that (1) music-related P600s for familiar and unfamiliar melodies are distinct, (2) linguistic P600 effects for conceptual-semantic violations and morphosyntactic violations are distinct. We suggest the P600 interaction effects for familiar melodies and lexical/conceptual linguistic violations arise when both streams are simultaneously reliant on mechanisms subserving access/retrieval of information from long term memory. The corresponding P600 interactions for unfamiliar melodies and linguistic morphosyntactic violations index simultaneous demands on the processing of abstract structure only. Independent of our interpretation of these data, however, the present findings demonstrate an important role for melody familiarity in understanding the relationships between the neurocognitive systems underlying language and music, and also demonstrate the utility of interference paradigms to distinguish superficially similar ERP response profiles ("semantic" and "syntactic" linguistic P600s) within domains.

E64 Comprehension of native- and foreign-accented speech: evidence from event-related potentials and neural oscillations

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Research shows that speaker identity cues (e.g., sex, foreign accent) affect the neural correlates of spoken language processing. For example, Dutch multilingual listeners did not show a P600 effect when listening to syntactic errors produced by foreign-accented speakers but did show P600s to native-accented speech (Hanulikova et al., 2012); similar ERP findings have been shown with Spanish multilingual listeners (Romero-Rivas et al., 2015). These studies suggest that listeners use foreign accent as a relevant speaker identity cue, and this affects ERP signatures of language. However, multilinguals may use the accent cue differently than monolingual listeners, who often have limited experience with foreign-accented speech (both as listeners and speakers). We tested 29 native English monolinguals who were recruited to have limited exposure to foreign accents and who listened to sentences spoken by a native English-accented speaker or a Chinese-English accented speaker while EEG was recorded. Sentences were either correct, or contained a semantic or syntactic error. We

measured comprehension accuracy and examined ERPs as well as neural oscillatory activity. Behavioral results show that comprehension accuracy was high for both accent conditions. ERP results showed an N400 in response to semantic errors for the native and foreign accented conditions, but it was weaker and delayed in the foreign accent condition. Analysis of the neural oscillations showed a decrease in upper beta power (20-30 Hz) for semantic errors in the native accent and no effects for the foreign accent condition. ERP results further showed an anterior negativity for syntactic errors in the native accent condition, and no effects in the foreign accented condition. The neural oscillations analysis yielded an increase in theta (4-7 Hz) power and decrease in upper beta (20-30 Hz) and gamma (30-50 Hz) power for syntactic errors in the native accent condition; there were no effects for the foreign accent condition. The behavioral measures indicate that monolingual listeners can accurately comprehend both foreign-accented and native-accented speech, but our ERP and neural oscillation analyses show differences in the neural processes associated with foreign- and native-accented speech comprehension. For semantic processing, although N400s were elicited in both accent conditions, it was weaker and delayed for the foreign accent. The neural oscillations analysis showed power changes in the native but not foreign accent. For syntactic processing, our monolingual listeners performed similarly to what has been found in multilingual listeners (e.g., Hanulikova et al., 2012). To conclude, although comprehension as indexed by behavioral measures was high for both accent conditions, the ERP and neural oscillations analyses provide converging evidence that semantic processing of foreign-accented speech is intact but more difficult than semantic processing of native-accented speech (in contrast to previous findings with multilingual listeners; e.g., Hanulikova et al., 2012). Furthermore, our ERP and neural oscillations results showed effects for syntactic processing of native-accented speech but no effects for foreign-accented speech, which suggests that grammatical processing does not proceed in the same way for foreign as for native-accented speech comprehension. We will discuss the theoretical implications of these results for speech comprehension

E65 Neural activity in the fronto-temporal language system predicts online language comprehension difficulty

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Introduction: Linguistic processing recruits two distinct large-scale neural systems: the specialized fronto-temporal language system (Fedorenko et al., 2011), and the domain-general fronto-parietal executive "multiple demand (MD)" system (Duncan, 2010, 2012). However, the precise contributions of each system to language comprehension and production remain unknown. One important question is which of these two systems "tracks" language comprehension difficulty. We here used a novel combination of approaches to address this question. Methods: Five participants listened to a set of naturalistic stories (~ 5 minutes / 1,000 words each) in fMRI. An independent set of 85 participants read the same stories in a self-paced word-by-word reading paradigm (Carpenter & Just, 1992). We then related the average per-word comprehension difficulty to neural activity in the language vs. MD systems. Language and MD regions were defined in each participant individually using previously validated functional "localizers": a contrast between the processing of sentences and nonword sequences (Fedorenko et al., 2010), and a contrast between a harder and an easier version of a spatial working memory task (Fedorenko et al., 2013; Blank et al., 2014), respectively. In addition, primary auditory regions were defined anatomically (Morosan et al., 2001). BOLD time-courses for the story listening task were then extracted from each region of interest (ROI; a primary auditory region, 8 language regions, and 9 MD regions in each hemisphere). For every 2-second epoch, we computed aggregate statistics about the stimulus words that were spoken during that epoch: we computed the average reading time (RT), the number of spoken phonemes and the number of words. Auditory processing effects were controlled by regressing RTs on the number of phonemes and words, obtaining residual RTs (rRTs). A four-dimensional vector X was then constructed for each epoch t that included the rRTs at time [t-4, t-3, t-2, t-1]. We then used the following procedure: iteratively, one story's data was held out. Using the remainder of the data, we learned a linear function that predicts neural activity in terms of X. We predicted the activity for the held out epochs, and computed the proportion of variance explained (PVE) from the observed activity in those epochs. The PVE was averaged for each ROI across voxels, testing folds, and subjects. To determine for which ROI the activity was predicted significantly above chance, we estimated the distribution of the chance level PVE empirically by circularly shifting the data time series by 200,201,202...599 epochs and computing the average PVE. We used this set to empirically determine a p-value for the PVE for each ROI. Results: Controlling the false discovery rate at 0.05, we observed a significant relationship between reading times and neural activity in the left-hemisphere language ROIs (and some right-hemisphere language ROIs), but not in any of the domain-general MD ROIs. Thus, neural activity in the specialized fronto-temporal language system reflects online language comprehension difficulty. This relationship between neural activation and behavior places important constraints on the possible accounts of the computations performed by the regions of the language system.

E66 Look before your leap: Careful incremental processing of idiosyncratic partial-agreement: ERP and self-paced reading evidence from Arabic

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Modern Standard Arabic verbs generally agree with their subject in person, number and gender in the subject-verb order. By contrast, in the verb-subject order, the verb agrees in person and gender, but its number-marking should be singular for the structure to be grammatical, regardless of whether the overt subject is singular or plural. However, a sentence-initial plural verb per se does not constitute a violation, because full agreement is necessary if the subject is covert or dropped. In short, what would be correct agreement in some cases would be ungrammatical in others. Exp.1. In an initial ERP study, we investigated whether the processing system is sensitive to this idiosyncratic behaviour of plural subjects in verb-initial intransitive structures with an overt subject. Our hypotheses were: there should be no ERP differences for singular versus plural sentence-initial verbs; ERPs for plural versus singular subjects must be qualitatively different; if the processing system initially adopts a non-anomalous reading for plural subjects, effects pertaining to the perception of anomaly must be observed only at the position of the following material that conclusively signifies the anomaly. Pseudo-randomised RSVP stimuli were of the form Verb-Subject-Adverb–PP, interspersed with fillers. Subjects were human common nouns (masculine & feminine), singular/plural; the verb was either singular/plural marked. Thus four conditions: 2 subject-types x 2 condition-types, with identical adverb ('yesterday'). Thirty-six sentences per condition were presented per participant; conditions were equiprobable. Participants (34 right-handed Arabic native-speakers) performed an acceptability judgement and a probe task. There were no effects at the verb. At the subject, singular subjects elicited a negativity effect as opposed to plural subjects; all conditions except the sg.V-sg.S condition elicited a late-positivity effect. Whilst both conditions with a sentence-initial plural verb were rendered anomalous when the subject was encountered, it appears that the processing system did not conclude as such until the adverb (which indicates the end of the clause), at which point both anomalous conditions elicited a negativity effect as opposed to acceptable conditions. This suggests the processing system is sensitive to the idiosyncracy of plural subjects in Arabic, and prefers to analyse them in the first instance as syntactically difficult but nevertheless not conclusively anomalous. Exp.2. To examine in detail how the acceptability changes word-by-word, 50 participants read a subset of the 4-word stimuli in a separate self-paced study (adverb in different positions) and provided word-by-word judgements. The judgements at each position analysed using a random-slopes linear mixed effects model revealed that, indeed, the singular verb conditions were consistently rated as significantly acceptable; the pl.V-sg.S condition remained quite acceptable before becoming significantly unacceptable at position 3. Showing a similar pattern, the pl.V-pl.S condition was nevertheless quite acceptable at the end (similar to the ERP study), in line with the relative acceptability of this condition in spoken Arabic despite its ungrammaticality. Taken together, these results suggest that, on encountering a plural subject in verb-initial sentences, the processing system proceeds carefully, awaiting converging evidence before deciding conclusively about potential violations of idiosyncratic partial-agreement in Arabic.

E67 Semantic Blocking revisited: Investigating individual variability in the elicitation of N400 and P600 components using Generalized Additive Mixed Models (GAMMs)

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In recent years, there has been confusion and frustration around the functional significance of the N400 and the P600. The starting point for our current investigation was Friederici's (2002) extraordinarily influential model of sentence processing, which links its three hypothesized processing phases to three ERP components: semantic N400s and syntactic ELANs and P600s. Based on the finding that in double semantic-syntactic violations, no N400 but only a P600 was found (Friederici, Steinhauer, & Frisch, 1999), Friederici formulated one core claim of her "syntax first" model, namely that semantic processing is blocked ("semantic blocking") when a syntactic word category violation is present, meaning that syntax takes precedence over semantics. When we tested an alternative explanation (see Steinhauer & Drury, 2012) as to why the N400 was absent in these double violations, we were unable to replicate this semantic blocking effect. In fact, we found a clear N400 not only in the double violation, but in the pure semantic and the pure syntactic violation as well. Since our task was different (acceptability judgment vs. probe verification in 1999) we followed up by varying task instructions in three additional groups. We found that when using the original probe verification task or a grammaticality judgment task there was no N400 in the double violation, but using an acceptability or sensicality judgment, an N400 was elicited. However, this summary only tells part of the story as it pertains to the group level. When investigating the subject level, we observed an astonishing amount of variation: in our total subject pool of n = 150 subjects, some subjects showed negativities, while some showed positivities on the target word. The relative frequency of the components within a group was influenced by the task instructions, in that for example the grammaticality judgement led to more positivities, while negativities were more common during the sensicality judgement. However, crucially, the subject's responses were never entirely in the negative or the positive voltage range, regardless of task instruction. How is it possible that

some subjects perform a grammaticality judgment by only employing a semantic process, if that is what we take the N400 to reflect? Therefore, we tested a subgroup of subjects (n=75) using an extensive battery of background measures (general language proficiency, semantic proficiency, syntactic proficiency, working memory, and motivation). Importantly, we made use of a novel and extremely powerful approach to data analysis, using Generalized Additive Mixed Models (GAMMs, see Wood, 2006). This method is capable of using each sampling point as a predictor (i.e. to model the complete ERP waveform), and test the influence of continuous subject-level variables such as, for example, language proficiency on the shape of the ERP. This is a major improvement over linear ANOVAs or regressions, as averaging across time windows is not necessary, and random subject and item effects can be taken into account. We will discuss the influence of these background variables on the N400 and P600, and relate the findings back to the functional significance of these components.

E68 Access to lexical category and verb argument structure in the early stages of processing morphologically complex words: MEG investigations of prefixation

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Recent MEG experiments find evidence for at least two spatiotemporally distinct neural responses sensitive to morphological complexity: the M350/N400m response (200-450ms) originating in left STG/MTG, first sensitive to factors plausibly associated with complex word-stem lexical access (stem lemma frequency and morphological family size, frequency and entropy) [1,2] then sensitive to the semantic well-formedness and/or the frequency of the stem plus affix combination [1], and an orbitofrontal response (290-500ms) sensitive to the semantic well-formedness of complex words [1,3]. [4] find that in English and Greek, pseudowords which violate the event semantics requirements of a derivational affix are rejected more slowly, and less frequently, than pseudowords which violate lexical category restrictions of those same affixes. We build on these two lines of research to investigate the parsing of the stem syntactic category and event semantics of prefixed words. We compare re-, out- and un-, which all require verbal stems, but differ in what event semantics those verbs should have, by contrasting well formed, familiar words (refill, outlast, untie) with strings that violate category restrictions/cat.viol (recold, outglad, ungirl) or semantic restrictions/sem.viol (redance, outshape, ungrow). MEG activity and lexical decision responses were collected from 25 participants (10 male, mean age 21.8) judging 520 trials each. MEG activity was analysed using MNE-Python . Behavioural Results: Category violating prefixation was rejected more often (t = 11.3066), and more quickly (t = 11.3296), than semantic-structure violating prefixation, replicating [4]. However, planned pairwise comparisons within each prefix reveal that for re- these effects are either not significant (rejection-rate, t=0.4132), or are in the opposite direction (RT, t=-6.1571). OF/BA11 Results: Spatio-temporal cluster analysis correcting for multiple comparisons across time and space finds that well-formed words evoked significantly less activation than illegal strings (collapsed across prefix type) in this ROI between 200-415ms (p=0.0117), a, similar, but earlier and more sustained effect than found by [1] for suffixed single words, or by [2] for prefixed words in sentences. aSTG Results: We identified a ROI in anterior STG based on the peak amplitude response between 300-400ms in the grandaveraged data. We found significant differences in the average amplitude of this aSTG activation between 250-450ms for all 3 prefix types, but the effect direction and timing varied. For un- and out-, cat. viol items evoked stronger negative activity than sem.viol items between 335-375ms (out-, p=0.033) and 365-440ms (un-, p=0.009), while for re-, the reverse pattern was found, between 270-320ms (p=0.011). The cat.viol vs. sem.viol contrast did not evoke significantly different activation in any other tested region (BA44,45,21,11) or time period. The out- and un- aSTG cat.viol costs were late compared to the (reversed direction) re- effects, and occurred in the time window associated with re-combination and well-formedness verification by [1]. The earlier sem.viol cost for re- items occurred in the time window associated with lexical access in [1], and may point to a lexical-level restriction (against unergatives). Refs: [1] Fruchter & Marantz. 2015. B&L.143. [2] Whiting et al, 2015. JCN.27:2. [3] Pylkkänen et al. 2009. LCP.24:9. [4] Manouilidou & Stockall. 2014. 26:2.

E69 Hemispheric differences in processing word class information—ERP evidence from Chinese

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Recent evidence suggests that, the right hemisphere (RH) is not as insensitive to syntactic information as previously thought. However, the extent to which the RH can engage combinatorial syntactic processes like the left-hemisphere (LH) does is still poorly understood. Recent data from right-handed young adults without familial sinistrality background (FS-) showed that, while disagreement on lexically coded grammatical number ("The grateful niece asked herself/*themselves…"), disagreement on morphologically coded grammatical number ("Industrial scientists develop/*develops…") and mismatch on word class expectancy (e.g., 'to solve/*solution') all elicited a P600 response relative to their corresponding grammatical construction in the LH, only the former but not the latter two elicited a similar P600 effect in the RH (Kemmer, Coulson, & Kutas, 2014; Lee & Federmeier, 2015). It is therefore possible that the RH can be boosted by the supplemental lexical information to appreciate the syntactic structure and combinatorial relation in the input. One way to test this hypothesis is to compare responses to similar

syntactic constructions that are lexically coded to different degrees across different languages. As a language with flexible word order and sparse morphological inflections, Chinese allows most words to be used as different word classes depending on the context they occur in without any additional morphological markings. As parts-of-speech information and syntactic dependency in Chinese is largely defined by lexical knowledge (of the word in question as well as its surrounding words) rather than through overt morphological markings, word class violations presented to the RH may be expected to elicit a P600 effect than a N400 effect that was previously seen in English (Lee & Federmeier, 2015). To test this hypothesis, we assessed ERP responses from twenty-two Taiwanese young FS-participants as they read nouns and verbs matching or mismatching the word class expectancy established by a preceding function word (classifiers/measure words for nouns; adverbs for verbs). Function words were presented centrally, followed by nouns and verbs presented laterally to either visual field. Participants were told to make a grammaticality judgment on each trial. Consistent with past findings, accuracy was higher for words with right-visual-field (RVF) presentation than with left-visual-field (LVF) presentation, although better than chance accuracy was seen in both VFs (RVF: 89%; LVF: 87%). ERP results from correct trials showed that, relative to the grammatical condition, the ungrammatical condition elicited a P600 effect as well as a more negative N400 response with both visual field presentations. The responses to the RVF stimuli were dominated by the P600 effect and the responses to the LVF stimuli were dominated by the N400 effect, however, there were no statistical differences between VFs. Our results thus extend the current understanding about the RH's capability of syntactic processing by showing that lexical information about a word's word class status can boost RH's sensitivity to syntactic structure such that word class violations elicit responses qualitatively similar to those observed in the LH.

E70 Head commitment and plausibility in English noun-noun compounds

Alicia Parrish[1], Joseph Jalbert[1], Alan Beretta[1]; [1]Michigan State University

Sentence environment can make it semantically plausible for the first noun (N1) of a compound to be interpreted as the head before the second noun (N2) appears (Staub et al., 2007). However, syntactic cues can forestall head commitment at N1 (Whelpton et al., 2014). The present study probes the effects of both syntactic head commitment and semantic plausibility at N1 and also at N2. Experiment 1: Self-Paced Reading - Fifty participants in an SPR paradigm saw 15 sentences per condition (novel/familiar x plausible/implausible) and completed a yes/no sentence comprehension task. N1 and verb frequencies matched across conditions. The average corpus frequency was 882 for familiar compounds and 1 for novel. N1 was designed to be either semantically plausible as the head or not: for example, the novel compound in "Claire folded her puppy[N1] blanket[N2]..." was implausible because a blanket can be folded, but not a puppy. The plausible counterpart used the verb "washed" because one can wash both a puppy and a blanket. We found that, for novel compounds, RTs were significantly slower in the implausible condition at both N1 and N2. The slowdown at N1 in the implausible condition replicated Staub et al. Continued slowdown at N2 could be due to (i) spillover from the mismatch at N1, or (ii) separate processing events at N2. SPR cannot distinguish between these, but ERP can. Spillover predicts an early effect at N2; a later effect would be consistent with a separate processing event. Experiment 2: ERP - Twenty participants, assigned one of two lists, completed a Y/N response task in RSVP (SOA 700ms) of novel compounds in implausible/plausible environments. Stimuli were the same as Experiment 1. At N1, we observed an N400 for the implausible condition at Pz, with the Centroparietal region approaching significance. At N2, a P600 for implausible compounds in Centroparietal and Frontocentral-Right regions was observed. Since there were no significant effects before 500ms, the observed effects are the result of processing at N2, not of spillover from semantic mismatch at N1. General Discussion - In the implausible condition, the parser commits to N1 as the syntactic head and to an anomalous interpretation of "a puppy" as foldable. Thus, the increased RT and the N400 compared to the plausible condition in which N1 is also assumed to be the syntactic head but the semantic interpretation is not anomalous. When the parser encounters N2, in both the implausible and plausible conditions, it has to restructure N2 as the syntactic head and N1 as the modifier. But the implausible condition also involves undoing the anomalous semantic interpretation at N1, which is not the case for the plausible condition. Therefore, the implausible condition incurs greater reanalysis costs than the plausible condition at N2. Hence, the increased RT and the P600. We conclude that an initial semantic mismatch must be repaired by the parser once the compound's meaning becomes apparent. Furthermore, unlike syntactic cues (Whelpton et al.), semantic implausibility does not forestall head commitment at N1.

E71 Imagining Accomplishments from Different Visual and Temporal Perspectives

Deanna Hall[1], Todd Ferretti[1], Jeffrey Hong[1]; [1]Wilfrid Laurier University

The current research examined the relationship between grammatical aspect (GA) (imperfective versus perfect; ongoing versus completed events) and accomplishment verbs in event imagining, and investigated the influence of visual perspective taking on this imagining process. The main prediction was that it would be easier to imagine perfect than imperfective accomplishment events because the lexical aspect (LA) of accomplishment includes a natural end point, which is temporally consistent with the completed reference of perfect aspect. Participants in Experiment 1 imagined accomplishment events presented to them in the imperfective or the perfect

aspect (e.g., I was building the fence. / I had built the fence.). Electroencephalography (EEG) was used to record scalp potentials during the imagination period. Slow cortical potentials were used as an index of the cognitive effort associated with imagining. Participants provided ratings on the vividness of imagined people, objects, and locations. Information was also gathered regarding the temporal component of the event that participants imagined (beginning, middle, end), the duration of the event, the importance of the event to the participant, and which visual perspective the participant used to imagine the event. The procedure was similar for Experiment 2, with the exception that participants were told the visual perspective they were to employ during each trial (first- or third-person). The results of Experiment 1 showed that participants had more difficulty imagining imperfective accomplishments than perfect accomplishments. Behavioural results demonstrated that people more often imagined the end stage of the events when the perfect form was used. In contrast, imperfective events more often featured the middle temporal component. The results of Experiment 2 indicated that it was easier to imagine accomplishments from the third-person perspective than from the first-person perspective. Interestingly, GA had no influence on the ability to imagine accomplishments from a first- or third-person perspective. The behavioural results demonstrated that ratings of the vividness of objects were higher for first- versus third-person perspective. Alternatively, ratings for vividness of people were higher for third-person perspective. Experiment 2 also showed that the middle temporal component of events was imagined most often for imperfective events and the end of events was imagined more frequently for perfect events. This research presents novel data on how GA, LA and visual perspective interact to influence the content of imagined events and the cognitive effort associated with event imagination. This research represents a notable extension on previous research investigating GA/LA in combination with visual perspective.

E72 Imagining events: The influence of grammatical aspect, lexical aspect, and visual perspective

Jeffrey Hong[1], Todd Ferretti[1], James Siklos-Whillans[1], Deanna Hall[1]; [1]Wilfrid Laurier University

The current research explored how language comprehension is affected by variations in grammatical aspect (GA; imperfective, perfective) and lexical aspect (LA; activities, accomplishments). Imperfective phrases (I was walking) represent events as naturally ongoing while perfective phrases (I walked) represent the completion state of events. Similarly, activities (act) do not possess natural endpoints while accomplishments (build) do. These factors have previously been found to influence ease of language comprehension (Yap et al., 2009; Becker et al., 2013). This research aimed to establish the roles of these morphosyntactic and semantic features in the process of imagining events during sentence comprehension. Additionally it explored how this temporal information interacts with the visual information from the perspective one is using to imagine an event. In Experiment 1, EEG was recorded while participants read and imagined the events of sentences composed of activities (act) or accomplishments (build) given in the imperfective (I was walking) or the perfective (I walked). Slow cortical potentials were analyzed as an index of cognitive effort of event imagination (Conway et al., 2003) and situation model formation (King & Kutas, 1995). Participants had less difficulty imagining events when the temporal properties of the two forms of verb aspect matched (imperfective activities, perfective accomplishments) versus mismatched (perfective activities, imperfective accomplishments). Behavioural data showed that events were imagined more often from the first-person perspective for activity than for accomplishment stimuli, and first-person perspective was used more frequently for perfective than for imperfective stimuli. In Experiments 2 and 3, participants imagined activity stimuli but were instructed to do so from various visual perspectives (first-person self, third-person self, third-person other). Imagining from the third-person self perspective was found to be more difficult than imagining from the first-person perspective, and this was true regardless of grammatical aspect. Interestingly, the third person other perspective was the easiest perspective for imagining completed activities. This research provides novel neurocognitive and behavioural insight into how event representation is influenced by temporal information associated with verbs and the perspective from which an event is represented.

E73 Representing the stems you can't see: A MEG study of morphological decomposition.

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The recognition of visually presented words crucially involves parsing morphological structure. At the M170 MEG response, from around 150 ms after reading a complex word (e.g., "leakage"), activity in the fusiform gyrus is modulated by variables directly related to the word's morphological constituents, independent of orthographic properties. Particularly relevant to lexical decomposition is the frequency of a derived word relative to its lemma, termed "Transition Probability" (TP). Previous studies (Solomyak and Marantz, 2010; Lewis et al., 2011) have found TP to modulate responses to both real morphologically complex items and pseudo-complex items (e.g., "brother"), supporting obligatory decompositional parsing based on stem and affix word forms. What remains unclear, however, is whether all items appearing to have a stem + affix structure are blindly decomposed by the system, or if parsing holds back erroneous decompositional processing of simplex items. If the latter, what information is used to alert the system that "leakage" == "leak" + "age", but "sausage" != "saus" + "age"? Given the morphological sensitivity of early processing, we chose to manipulate the presence/absence of morphological constituents in a 2x2

design: 1) Truly Complex, "leakage": +stem, +congruent suffix; 2) Pseudo-Complex, "brother": +stem, -congruent suffix; 3) Unique stems, "excursion": -[productive] stem, +congruent suffix); 4) Pseudo-Unique stems, "sausage": -[productive] stem, -congruent suffix). Unique items were defined as "congruent" because their form and meaning matches that of productively formed words with the same suffix - critically not the case for "incongruent" Pseudo-Unique items. Neural responses were recorded with a 208 channel MEG system, as 25 native English speakers made lexical-decisions on the visually presented words. Using a functional localiser for the M170, TP of both congruent and incongruent +stem items positively correlated with neural activity, corroborating the authors cited above. To assess whether the presence of a productive stem is mandatory for decomposition, we compared +stem items (collectively having relatively low TP values) to –productive stem items (which, if composed of stem + affix, have the highest possible TP: 1). If the latter are decomposed, they should evoke stronger activity than the +stem words. For the congruent pair, this is exactly our finding: Unique items elicited greater activity than their Truly Complex counterparts, but no difference was observed between incongruent Pseudo-Unique and Pseudo-Complex items. The divergence between Unique and Pseudo-Unique items was reinforced when plotting their by-item activity alongside the +stem's TP~activity correlation: Responses to Unique words fell towards "high TP", whereas Pseudo-Unique items did not systematically pattern. Finding TP to be relevant for the Unique items supports that they are processed through stem and affix units, and further, that the unique stem is represented in memory. Pseudo-Unique items however, which have the surface appearance of stem + affix but are not morphological derivatives, appeared to be parsed as monomorphemic words. Our results support the existence of decompositional gatekeeping, driven by the recognition of a stem morpheme contained in the lexicon (regardless of its morphological relationship with the attached suffix or whole-word), and not by the simple surface properties of a complex form.

E74 Neural Dynamics of Morphological and Phrasal Composition *Yohei Oseki[1], Laura Gwilliams[2], Esti Blanco-Elorrieta[2], Phoebe Gaston[1], Alec Marantz[1,2], Liina Pylkkänen[1,2]; [1]New York University, [2]NYUAD Institute, New York University, Abu Dhabi*

Does composition of morphemes within words (e.g. teacher) involve the same neural mechanism as composition of words within phrases (e.g. red boat)? Recent magnetoencephalography (MEG) work by Al Kaabi & Pylkkänen (2014) has shown that the left anterior temporal lobe (LATL) is recruited while building complex words and complex phrases (the latter replicating Bemis & Pylkkänen, 2011), but there was also an interaction in which effects of phrasal composition were not observed when target nouns were morphologically complex (e.g. tall teacher). Why? As a first step to understanding this, the current study tested whether the reason for the interaction was the visual or the semantic complexity of morphologically complex words such as teacher, which both visually decompose (i.e. teach + er) and semantically compose (i.e. someone who teaches). To tease apart these two factors, we used pseudo morphologically complex words (e.g. corner), which are complex visually (Rastle et al., 2004) but not semantically. Therefore, the prediction is that pseudo bimorphemic words in a modified context (e.g. dark corner) should pattern with real bimorphemic words under the "visual complexity" hypothesis, but with monomorphemic words under the "semantic complexity" hypothesis. Fourteen participants read stimuli comprising a 3 (morphological complexity: monomorphemic, pseudo bimorphemic, real bimorphemic) × 2 (phrasal composition: modified or unmodified) factorial design (50 trials in each condition), in which length, surface frequency, and base frequency were matched for across the target nouns. Transition probability (TP) from stems to affixes was used as a predictor in linear regression diagnosing morphological decomposition of real (Solomyak & Marantz, 2010) and pseudo (Lewis et al., 2011) bimorphemic words at the M170. In the MNE-Python suite, cortically constrained minimum-norm source estimates were calculated with the fixed/signed orientation parameters. Two regions of interest (ROI) were selected following prior literature: (i) the left inferior temporal cortex (BA37 and fusiform gyrus) for morphological decomposition and (ii) the left anterior temporal cortex (BA38) for morphological and phrasal composition. Correspondingly, two ROI analyses were performed: linear regression on BA37 at 120-220 ms and a full 3 × 2 ANOVA on BA38 at 150-250 ms. First, an effect of morphological decomposition was found in BA37 ($p = 0.0029$) and the fusiform gyrus ($p = 0.0045$) for all visually complex target nouns collapsed across modified and unmodified contexts, showing a positive correlation with TP and no interaction between TP and real/pseudo. Second, as predicted, an interaction between morphological complexity and phrasal composition was found in BA38 ($p = 0.0284$). Importantly, in answer to our research question, this interaction was driven by the pseudo bimorphemic words patterning with the monomorphemic words in an unmodified context (both showing smaller amplitudes than real bimorphemic words), but with the real bimorphemic words in a modified context (both showing no increase as a result of modification, unlike monomorphemic words). In conclusion, our results show that it is the visual as opposed to the semantic complexity of morphologically complex words that determines whether or not effects of phrasal composition are observed in the LATL at 200-250 ms.

E75 Phonological size matters in the detection of morphosyntactic errors: ERP evidence *Brigitta Fodor[1], John E. Drury[1]; [1]Stony Brook University*

[INTRODUCTION] Language ERP studies examining morpho-syntactic violations (e.g., "He *walk/They *walks") reliably find P600 effects which are often, but not always, preceded by left anterior negativities (LANs) (Molinaro et al., 2011; Steinhauer & Drury, 2012). However, the reasons why LAN effects are less consistently found are still not understood. Marcinek et al. (2014) showed that the presence of an illicit suffix (e.g., "They *walks") elicits a later onset P600 than an expected but absent affix (e.g., "He *walk"). [STUDY] The present study asked whether the phonological saliency (i.e syllabicity) of the affix affects P600 onset latency and/or amplitude, both for present illicit affixes and predicted but absent ones. We visually presented grammatical/ungrammatical sentences containing verbs with present/absent third person agreement affixes (non-syllabic [-s/-z], e.g. STARTS vs. syllabic [-Iz], e.g. BROWSES), and with past tense/perfective affixes (non-syllabic [-t/-d], e.g. BROWSED vs. syllabic [-Id], e.g. STARTED). [METHODS] We used 64 regular verbs, each in 8 different sentence contexts (4 third person agreement, 4 perfective), yielding 512 sentences. Sentence presentation was standard RSVP (500 ms per word), with sentence-final acceptability judgments. For all 8 conditions, single subject waveforms were averaged over 1200 ms epochs following target words, with a 200 ms pre-stimulus baseline. Two time-windows, 345–395 ms & 600–800 ms, were examined via repeated measures ANOVAs. [RESULTS] In the 600–800 ms time window, ungrammatical cases elicited a bigger amplitude P600 than grammatical counterparts, but suffixed forms also generally elicited a larger positivity than their non-suffixed counterparts. The latency of the P600 was also determined by the phonological content of the structure: sentences with illicit syllabic suffixes were resolved faster than those with illicit non-syllabic ones. Still, structure also contributed: non-suffixed cases started to show positivity earlier than their suffixed counterparts. However, the phonological quality of unexpectedly absent suffixes was not important. In the 345–395 ms time window, only the illicit non-syllabic suffixes evoked some anterior negativity (unlike illicit syllabic suffixes), which coincided with a later onset P600, and may be an indication LAN-type response. [CONCLUSION] These data provide important new information about the factors which determine P600 onset and amplitude in morpho-syntactic violation paradigms, and thus contribute directly to our understanding of the circumstances under which we may expect these (large amplitude) ERP effects to either co-occur (or not) with prior LANs. P600 amplitude proved to be sensitive to salience & complexity (syllabicity and suffixation) in addition to anomaly/deviance.

Poster Session F

Saturday, October 17, 10:00 am – 12:00 pm, French and Walton Rooms

Auditory Perception, Speech Perception, Audiovisual Integration

F1 Audiovisual speech perception and presence of the McGurk effect in left-hemisphere stroke patients and matched control participants

Laura Erickson[1], Mackenzie E. Fama[1], Katherine A. Spiegel[1], Elizabeth H. Lacey[1], Laura M. Skipper-Kallal[1], Shihui Xing[1], Josef P. Rauschecker[1], Peter E. Turkeltaub[1,2]; [1]Georgetown University Medical Center, [2]MedStar National Rehabilitation Hospital

Introduction: The McGurk effect is a behavioral measure of audiovisual (AV) speech integration, where the observation of incongruent auditory and visual speech can lead to a percept that is different from either input signal (McGurk and MacDonald, 1976). It is unclear how left-hemisphere (LH) damage impacts AV speech processes. In this study, we examined whether AV speech perception was altered in 34 people with LH strokes compared to 27 matched controls, as tested by the McGurk paradigm. Methods: An adapted McGurk paradigm was created to accommodate language impairments in stroke patients. Stimuli consisted of whole words ("key", "tea", "pea"), and three response options were presented as pictures and written words ("key", "tea", "pea"). For congruent trials, the sound and video matched. For incongruent trials, the "key" video was presented with the auditory "pea" and had 7 timing offsets binned into three types: auditory lead (AL), middle range (MID), and visual lead (VL). For these trials, responses corresponded to the "key" visual input (keyVIS), the "pea" auditory input (peaAUD), and the McGurk "tea" percept (teaMcG). Stroke participants were included if they had a LH stroke at least 6 months prior to the study, no significant brain damage outside the LH, and >80% accuracy on congruent trials. The behavioral analysis included 34 LH stroke patients (age: 59.6 ± 10.6; 10 females; 30 right-handed) and 27 control participants (age: 59.4 ± 13.8; 18 females; 24 right-handed). Results: There were no significant between-group differences or interactions for AL trials (keyVIS: 23.6% stroke vs. 26.4% control; teaMcG: 34.7% stroke vs. 36.2% control; peaAUD: 41.8% stroke vs. 37.4% control) or MID trials (keyVIS: 29.8% stroke vs. 31.7% control; teaMcG: 53.0% stroke vs. 63.0% control; peaAUD: 17.2% stroke vs. 5.3% control). For VL trials, stroke participants reported peaAUD more than controls (p=0.001; 21.8% stroke vs. 5.3% control); however, there were no differences for keyVIS (27.4% stroke vs. 34.6% control) or teaMcG (50.8% stroke vs. 60.1% control). Conclusions: In this preliminary between-group comparison, stroke patients and control participants demonstrated similar patterns of responses to McGurk stimuli. However, when the visual signal was presented

first, stroke patients reported the auditory percept more than controls. We suggest that since the current stroke group has heterogeneous LH damage, it is possible some regions necessary for AV speech integration may be intact in some subjects. Thus, the next stage of analyses will examine individual differences that may relate to AV integration in this task, such as lesion size and location.

F2 Predictive visual motion facilitates speech perception *David Brang[1,2], Satoru Suzuki[1], Vernon L. Towle[2], James Tao[2], Shasha Wu[2], Marcia Grabowecky[1]; [1]Northwestern University, [2]University of Chicago*

Auditory speech is typically accompanied by multisensory cues that enhance the speed and accuracy of auditory perception, compensating for degraded auditory processing in the presence of environmental noise or auditory deficits. Natural speech typically contains auditory phonemes as well as lip articulations that crossmodally provide probabilistic information about phoneme identity to facilitate speech perception. For some classes of phonemes, preparatory lip articulations additionally provide reliable timing information about when a sound will onset. Here we demonstrate that timing information provided by preparatory lip motion enhances phoneme identification and facilitates processing at the level of auditory cortex. Participants identified spoken phonemes (/ba/,/ga/,/ka/,/pa/) embedded in auditory noise either in isolation or in combination with visual movies. Viewing preparatory lip motion predictive of sound onset times improved phoneme identification despite the fact that the motion itself provided minimal phonemic information. In order to examine the role of predictive visual information on auditory neural processes, we acquired intracranial electrocorticographic (ECoG) recordings from the left superior temporal gyrus of four patients undergoing evaluation for intractable epilepsy who performed the same task. Indices of local spiking activity were computed from subdural electrodes on the lateral temporal surface neighboring auditory cortex or from depth electrodes placed within auditory cortex. Electrodes showed significantly reduced activity on predictive-motion trials relative to non-predictive-motion or auditory-alone trials, suggesting that predictive visual motion enhances perceptual fluency by reducing auditory processing requirements via reducing temporal uncertainty. These results support a model of auditory-visual speech perception in which preparatory lip motion facilitates phoneme identification by priming the auditory system for the identity of the upcoming phoneme as well as providing a dynamic cue to maximize the crossmodal priming effect at phoneme onset.

F3 Theta phase sensitization as a flexible neural mechanism for optimized syllable identification *Sanne ten Oever[1], Alexander Sack[1]; [1]Maastricht University*

In spoken language, visual mouth movements naturally precede the production of any speech sound and therefore serve as a temporal prediction and detection cue for identifying spoken language. It has been proposed that at the onset of visual mouth movements ongoing theta oscillations in auditory cortex align, providing the temporal reference frame for the auditory processing of subsequent speech sounds. As different syllables (e.g. /da/ and /ga/) are characterized by different visual-to-auditory temporal asynchronies, auditory signals should consequently be assigned to different phases of the aligned theta oscillation. This results in a consistent relation between syllable identity and theta phase. In the current study we tested whether this "phase-syllable identity" relation causes theta phase to systematically bias syllable perception when being confronted with ambiguous auditory stimuli in the absence of visual cues. To this end, we recorded EEG while presenting ambiguous auditory /daga/ syllables to investigate whether ongoing theta oscillation phase prior to stimulus onset biases syllable identification. In a second experiment, we externally entrained theta oscillations via rhythmic auditory stimulation - thereby controlling at which exact theta phase the ambiguous /daga/ stimulus was presented. In both experiments we revealed that participants perceive /da/ or /ga/ dependent on the underlying theta oscillation phase, establishing the functional relationship between pre-stimulus theta phase and syllable identification.

F4 Increased lip corticobulbar excitability during the perception of non-native phonemes *Judith Schmitz[1], Eleonora Bartoli[2], Laura Maffongelli[2], Luciano Fadiga[2,3], Nuria Sebastian-Galles[1], Alessandro D'Ausilio[2]; [1]Universitat Pompeu Fabra, [2]Istituto Italiano di Tecnologia, [3]Universita di Ferrara*

Listening to native speech has been shown to activate not only auditory regions, but also motor regions, as measured by corticobulbar excitability. However, it is not known if the motor activity is driven by experience with the speech sounds. In that case, motor activity should diminish when listening to non-native speech, for which we lack both sensory and motor experience. In the present experiment we test if listening to non-native speech engages the motor system by recording corticobulbar activity of the lip and tongue muscle from 17 participants when listening to German vowels. Some vowels were native-like in the language of the participants, Italian (/a/, /i/, /u/), and others were non-native (/y/). Additionally, we related the corticobulbar excitability to perception tasks (nativeness ratings of the vowels and similarity ratings between the vowels) and production measures (tongue height (F1), tongue backness (F2) and lip electromyography (EMG)) related to accuracy (mean) and uncertainty (standard deviation) when participants produced the German vowels. Results showed an increase in lip corticobulbar excitability for a combination of both lip use during articulation and non-nativeness: from the lowest activation

for /a/ (native-like, no lip use) to /i/ and /u/ (native-like, lip use during articulation) to the highest activation for /y/ (non-native and lip use during articulation), with significant differences between the extremes (/a/-/y/). Furthermore, lip corticobulbar excitability was negatively correlated with the nativeness ratings and positively with the uncertainty of lip movement during production of the same vowels (measured by the standard deviation of the lip EMG). These results suggest that participants engage the motor system more strongly when listening to perceptually and articulatory unfamiliar vowels. We suggest that the motor system may play an active role during the perception of non-native speech sounds and might compensate for not having an existent acoustic-motor representation.

F5 Is impaired repetition ability following left hemisphere stroke speech specific? *Sarah-Beth Bradford[1], Gregory Hickok[2], Alexandra Basilakos[1], Lorelei Phillip[1], Julius Fridriksson[1]; [1]Univeristy of South Carolina, Columbia, SC, [2]University of California - Irvine*

The ability to repeat speech is impaired in most aphasic patients. Recent evidence suggests damage to area Spt (the boundary of the parietal and temporal lobes at the Sylvian fissure) may be the cause of the speech repetition difficulties typically associated with conduction aphasia (Buchsbaum et al., 2011). It is suggested that area Spt serves as an auditory-motor interface between the dorsal and ventral streams (Hickok & Poeppel, 2000, 2004, 2007), and that even though it is active during the presentation of nonspeech, melodic stimuli, its activation is preferential to speech (Pa & Hickok, 2008; Buchsbaum et al., 2011). Therefore, if area Spt is implicated in the repetition of speech and nonspeech stimuli, the extent that repetition impairments in aphasia are specific to linguistic stimuli is uncertain. The purpose of this study was 1) to examine if repetition impairments are specific to language, or reflect a more general deficit, and 2) to determine if brain damage that predicts impaired speech repletion overlaps with brain damage that impairs the repletion of non-speech stimuli. Here, preliminary data are presented from participants in the chronic phase of left hemisphere stroke (N=16, 4 females, mean age=61.2±7.6). This study is ongoing and we anticipate at least a 50% increase in the sample size before the SNL meeting in October. Participants were included regardless of aphasia diagnosis or type, as follows: anomic n=3; Broca's n=3; conduction n=5; global n=1; Wernicke's n=1; no aphasia n=3. To assess the ability to repeat non-speech stimuli, participants listened to a series of 10 melodies consisting of 6 tones (Pa & Hickok, 2007), and hummed each melody immediately following presentation. Participants were given three trials per melody. Responses were recorded and rated based on similarity to the target melody, using a 1-5 rating scale (5 being the best). The highest rating from each of the three trials was selected, with ratings averaged across all 10 melodies (mean =2.7±1.1). A voxel-based lesion symptom mapping (VLSM) analysis (2000 permutations) revealed mostly distinct patterns of brain damage for melodic and word repetition (speech repetition sub-test of the WAB-R), with a small region of overlap for each measure. For word repetition, 10782 voxels were significant as follows (percentage of statistical map within each region in parentheses): posterior middle temporal gyrus (pMTG; 54%), posterior superior temporal gyrus (pSTG; 26%), and the angular gyrus (AG; 17.7%). For melodic repetition, 2433 voxels survived thresholding as follows: AG (43.1%), supramarginal gyrus (SMG; 18.3%), superior longitudinal fasciculus (SLF; 14%), superior parietal lobe (9.7%), and pSTG (8%). The greatest area of overlap for both measures was a cluster of 169 voxels, with almost half (49.7%) of this cluster localized in the pSTG, and the remaining in the pMTG (36%) and the SLF (14.2%). Preliminary results indicate both word and melodic repetition deficits in individuals with left hemisphere damage. Although there was some overlap in brain damage that gives rise to these repetition deficits, results suggest that regions involved in word and melodic repetition are not completely redundant.

F6 Motor suppression of the auditory system extends to the brainstem frequency following response and is mediated by attentional demands *Serena Klos[1], Howard C Nusbaum[1]; [1]The University of Chicago*

Neural theories of auditory perception are often limited to cortical networks. Subcortical structures are generally viewed as simple relay stations by which acoustic input is passively encoded into a neural representation that can be recognized and further processed by cortical networks. However prominent efferent projections throughout the peripheral auditory pathway (Huffman & Henson, 1990) suggests that a corticofugal network consisting of ascending and descending pathways may play an important role in the perception of acoustic signals. Investigations of the effects of long-term training and experience on the auditory brainstem response demonstrate that cortical systems responsible for attention and executive function can affect the way the inferior colliculus encodes pitch information through top-down efferent projections (Krishnan et al., 2005). The immediate or real time influence that these top-down projections have on the auditory brainstem response, however, is less clear (Galbraith et al., 1998; Galbraith & Arroyo, 1993). One approach to investigating possible corticofugal interactions is to manipulate top-down effects from the motor system on the auditory brainstem, as the inferior colliculus is also included in the motor execution pathway (Hashikawa, 1983). Research has demonstrated that movement leads to suppression of simultaneous activity in the primary auditory cortex (Houde, 2002; Schneider et al., 2014). Based on this finding of cortical suppression we investigated whether similar suppressive effects can be seen at the level of the auditory brainstem. The Frequency Following Response (FFR) to a 440Hz sine tone was measured while participants engaged in two finger tapping tasks varying

in attentional demand. In one condition (40bpm condition) participants were instructed to tap a photocell in response to every flash of a blinking light presented at 40 beats per minute. In the second condition (80bpm condition) participants tapped in response to every other flash of a light presented at 80 beats per minute, thereby equating motor behavior but varying attentional demand. Spectral peak analysis of the FFRs revealed decreased amplitude at 440Hz for the 80bpm condition compared to the 40bpm condition. Interestingly, when compared to a resting condition in which participants sat quietly while the sine tone was presented repeatedly, the amount of spectral energy at 440Hz increased for the 40bpm condition, suggesting an arousal effect of the additional task. These results indicate that, rather than a general suppression of the peripheral auditory pathway during motor behavior, the interaction between the motor system and the auditory brainstem is mediated by attentional networks that are involved in allocating resources to various sensory networks.

F7 Sensorimotor representations in the language network during sentence repetition *Kathrin Müsch[1], Taufik A. Valiante[1,2], Kevin Himberger[1], Christopher J. Honey[1]; [1]University of Toronto, Toronto, ON, Canada, [2]Toronto Western Research Institute, Toronto, ON, Canada*

Sensorimotor response patterns are observed in both left and right hemispheres during basic linguistic processes, such as phoneme perception and production (Cogan et al. 2014). Why are joint sensory and motor responses observed during perceptual and productive aspects of language? One fundamental aspect of real-life language is its temporally extended structure, and higher-order sensory and motor systems may support language comprehension by organizing and integrating sequential patterns of information over many seconds of time. To investigate the role of these higher-order systems in the process of temporal integration, it is important to map the spatial distribution and functional signatures of sensory and motor response patterns during temporally extended, meaningful language perception and production. We recorded electrocorticographic (ECoG) signals from the lateral surface of the human cerebral cortex, in seven patients with pharmacoresistant epilepsy. Participants performed a sentence repetition task: on each trial (i) two sentences were presented sequentially, (ii) participants silently rehearsed the second sentence, and (iii) finally they repeated the second sentence aloud. To estimate activity of neuronal populations beneath each electrode during task performance, we measured fluctuations of broadband power (70-200 Hz) in the voltage trace. During the initial perception of the sentence, we observed bilateral responses both in sensory regions (the superior temporal gyrus) as well as the motor system (dorsal motor and premotor cortices). During the silent rehearsal phase, we observed that (i) the dorsal motor and premotor activations were augmented by recruitment of ventral motor sites; and (ii) the activity in the superior temporal gyrus was shifted posteriorly towards lexico-semantic regions. Finally, during repetition, activity was focused in bilateral dorsal motor and premotor cortex and sites in posterior superior temporal gyrus. These results suggest that the representation of temporally extended information in natural linguistic contexts is supported by higher-order sensorimotor circuits within dorsal and ventral precentral sites as well as by circuits in the posterior temporal cortex. Our findings complement prior observations of sensorimotor transformations supporting phoneme production and perception, and extend them to the context of temporally extended linguistic perception and production. References: Cogan et al. (2014). Sensory-motor transformations for speech occur bilaterally. Nature 507, 94-98.

F8 Somatotopic EEG beta-band modulations during speech discrimination *Alessandro D'Ausilio[1], Eleonora Bartoli[1], Laura Maffongelli[1]; [1]Fondazione Istituto Italiano di Tecnologia -IIT*

When learning speech sounds, the listener maps accurately auditory information with the available visual information (lips movements) to increase the ability to classify accurately the speech, creating audio-visual maps. The pairing between articulator movements and sounds occurring during speech production allows the formation of audio-motor maps. These maps, matching motor gestures with somatosensory consequences, are also exploited to enrich the representation of speech sounds, allowing to predict auditory consequences of given articulatory movement, as well as reconstructing the motor gestures required to produce a given speech sound. The role played by sensory-motor maps during speech listening is a very debated topic. Here, we aim to address if sensorimotor recruitment, related to gesture reconstruction, can be detected analyzing brain rhythms recorded through EEG. To this end we test for the interaction of speech listening on well defined sensorimotor rhythms, as the event related desynchronazation (ERD) and synchronization (ERS) pattern, typically observed during the engagement of motor regions. The ERD/ERS pattern, elicited using an electrical stimulation of peripheral nerves, induces a somatotopic recruitment of motor and somatosensory areas. If the listening of speech sounds induces the reconstruction of the subtending articulatory gesture, then this should interact with a concurrent recruitment of the same motor region in a very specific way. We carried out an EEG study on 15 participants. Subjects received lower lip stimulation during listening of speech sounds produced with the lips (bilabials syllables) and a different critical articulator such as the tongue (dental syllables). The trial consisted in the presentation of a speech sound and after a delay, the participant was required to discriminate the sound using eye movements. On half of the trials, a stimulation was delivered to the lower lip synchronized with the onset of the plosive

sound. We report a specific and somatotopic modulation of sensorimotor rhythms in the left hemisphere. Listening to labial sounds decreased the beta rebound induced by lip stimulation, an effect that can be interpreted as the engagement of the sensorimotor cortex. These results suggest that beside motor areas, also somatosensory activities are somatotopically associated to the specific speech stimuli to be discriminated. The presence of a cross-talk between peripheral lips stimulation and speech discrimination adds support to the idea that during speech listening, highly detailed audio-motor maps can be accessed to support discrimination tasks.

F9 Feel the noise: Individual differences in perceived vividness of auditory imagery are reflected in human brain structure

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Imagine the voice of a friend when you laugh together, or a piano playing a familiar song. We can generate mental auditory images of songs or voices, sometimes perceiving them almost as vividly as actual perceptual experiences. Although the functional networks supporting auditory imagery have been described in previous studies, less is known about the systems that predict inter-individual differences in auditory imagery. Combining voxel-based morphometry (VBM) and fMRI approaches, in this study we examined the structural basis of inter-individual differences in how auditory images are subjectively perceived, and explored links between auditory imagery, sensory-based auditory processing, and imagery in the visual domain. We found that higher vividness of auditory imagery correlated with increased grey matter volume in the supplementary motor area (SMA), parietal cortex, medial superior frontal gyrus, and middle frontal gyrus (VBM study, N = 74). An analysis of functional responses during the processing of different types of human vocalizations (fMRI study, N = 56) revealed that the SMA and parietal sites that predict imagery are also modulated by sound type. Using a multivariate representational similarity analysis, we found that higher representational specificity of heard sounds in SMA predicts higher perceived vividness of auditory imagery, indicating a mechanistic link between sensory- and imagery-based processing in sensorimotor cortex. In a follow-up VBM study (N = 46), vividness of imagery in the visual domain also correlated with SMA structure, and with auditory imagery scores. Altogether, these findings provide evidence for a signature of imagery in brain structure. They additionally highlight a common role of perceptual-motor interactions for processing heard and internally generated auditory information.

F10 SPEECH IN THE MIRROR? NEUROBIOLOGICAL CORRELATES OF SELF-SPEECH PERCEPTION

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Self-awareness and self-recognition during action observation may partly result from a functional matching between action and perception systems. This perception-action interaction enhances the integration between sensory inputs and our own sensory-motor knowledge. We present combined EEG and fMRI studies examining the impact of self-knowledge on multisensory integration mechanisms. More precisely, we investigated this impact during auditory, visual and audio-visual speech perception. Our hypothesis was that hearing and/or viewing oneself talk would facilitate the bimodal integration process and activate sensory-motor maps to a greater extent than observing others. In both studies, half of the stimuli presented the participants' own productions (self condition) and the other half presented an unknown speaker (other condition). For the "self" condition, we recorded videos of each participant producing/pa/, /ta/ and /ka/ syllables. In the "other" condition, we recorded videos of a speaker the participants had never met producing the same syllables. These recordings were then presented in different modalities: auditory only (A), visual only (V), audio-visual (AV) and incongruent audiovisual (AVi – incongruency referred to different speakers for the audio and video components). In the EEG experiment, 18 participants had to categorize the syllables. In the fMRI experiment, 12 participants had listen to and/or view passively the syllables. In the EEG session, audiovisual interactions were estimated by comparing auditory N1/P2 ERPs during bimodal responses (AV) with the sum of the responses in A and V only conditions (A+V). The amplitude of P2 ERPs was lower for AV than A+V. Importantly, latencies for N1 ERPs were shorter for the "Visual-self" condition than the "Visual-other", regardless of signal type. In the fMRI session, the presentation modality had an impact on brain activation: activation was stronger for audio or audiovisual stimuli in the superior temporal auditory regions (A= AV=AVi> V), and for video or audiovisual stimuli in MT/V5 and in the premotor cortices (V=AV=AVi> A). In addition, brain activity was stronger in the "self" than the "other" condition both at the left posterior inferior frontal gyrus and cerebellum (lobules I-IV). In line with previous studies on multimodal speech perception, our results point to the existence of integration mechanisms of auditory and visual speech signals. Critically, they further demonstrate a processing advantage when the perceptual situation involves our own

speech production. In addition, hearing and/or viewing oneself talk increased activation in the left posterior IFG and cerebellum. These regions are generally responsible for predicting sensory outcomes of action generation. Altogether, these results suggest that viewing our own utterances leads to a temporal facilitation of auditory and visual speech integration. Moreover, processing afferent and efferent signals in sensory-motor areas leads to self -awareness during speech perception. Part of this research was supported by a grant from the European Research Council (FP7/2007-2013 Grant Agreement no. 339152, "Speech Unit(e)s")

F11 Motor Representations of Speech Articulators Are Modulated by Both Motor and Non-Motor Speech Distortions

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It has become increasingly evident that human motor circuits activate during speech perception. Furthermore, the extent of this activation increases when listening to speech that is difficult to perceive. It has been suggested that this increased motor activation may be useful for constraining perception (Wilson and Knoblich 2005). What is unknown, however, is whether different types of distortion in the speech signal differentially engage the speech motor system. Some assume that motor activation is modulated specifically when processing variation from a biological or motor source (Knoblich and Sebanz, 2006; Pickering and Garrod, 2007). More generally, others assume motor activation helps to disambiguate information whenever the incoming action is noisy or ambiguous (Wilson and Knoblich 2005). The present study aimed to disambiguate between these two accounts and assess if speech motor activity during perception is independent of, or dependent on, the source of speech distortion. If it is independent, then motor activation will be equivalent between sources of motor and non-motor distortion. Conversely, activity will be modulated by motor variation specifically if motor-dependent. These predictions were investigated using transcranial magnetic stimulation (TMS). Stimulation of the lip representation in the left primary motor cortex elicited motor evoked potentials (MEPs) that indexed excitability of the underlying motor representation whilst perceiving tongue- (ata/ada) and lip-articulated (apa/aba) speech syllables presented in three conditions: 1) motor-distorted (imprecisely articulated), 2) noise-distorted (presented in speech-shaped noise), or 3) non-distorted (normally articulated clear speech). Eighteen normally-hearing adult subjects (aged 18-30; 5 males) participated in the study. To equate for intelligibility differences between distortion types, difficulty levels were individually matched across conditions according to performance on pre-test. Results indicated that lip MEPs were significantly modulated by speech listening condition ($F(2,34) = 9.78$; $p < .001$). Bonferroni-corrected comparisons confirmed a significant difference in MEP size between non-distorted and motor-distorted responses ($p = .006$), and between non-distorted and noise-distorted conditions ($p = .005$). MEPs elicited during perception of different types of speech distortion were not significantly different. There was also no main effect or interaction for place of articulation. Data presented from this study were found to be consistent with predictions made by Wilson & Knoblich (2005); that increases in speech motor activation during challenging listening conditions is a distortion-general phenomenon. Our results provide direct evidence of increased neurophysiological signaling when speech perception is difficult, and confirm that the speech motor system supports speech perception under challenging listening conditions. References Knoblich, G., & Sebanz, N. (2006). The Social Nature of Percepton and Action. Current Directions in Psychological Science, 15(3):99-104. Pickering, M. J., & Garrod, S. (2007). Do people use language production to make predictions during comprehension? Trends in Cognitive Sciences, 11(3):105-110. Wilson, M., & Knoblich, G. (2005). The case for motor involvement in perceiving conspecifics. Psychological Bulletin, 131:460-473.

F12 No Evidence of Place of Articulation Feature Mapping in Motor Cortex during Speech Perception

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There has been a recent resurgence of the motor theory of speech perception, the idea stemming from the work of Liberman and colleagues (1967) suggesting that the way in which we understand speech is by mapping the sounds of speech to the movements associated with producing those sounds (i.e., Galantucci, Fowler, & Turvey, 2006; Meister, Wilson, Deblieck, Wu, & Iacoboni, 2007; D'Ausilio, et al., 2009). An fMRI study by Pulvermüller and colleagues (2006) was of substantial importance to the recent revival of this idea, and demonstrated that the lip and tongue areas of the motor cortex respond differently to the perception of lip (labial) and tongue (alveolar) sounds. The objective of the current study was to replicate and extend the findings of Pulvermüller and colleagues using a wider stimulus set. Thirteen healthy young adults (mean age = 27.5yrs, SD = 4yrs; six females) participated in two MRI scanning sessions within one month. The first session consisted of a speech perception task during which participants passively listened to female speakers presenting consonant-vowel stimuli (four labial and four alveolar syllables; e.g., "ba"). During the second session, participants performed an articulatory localizer by silently mouthing the same eight syllables that were presented during the first session. Initial univariate analyses were conducted in order to test for a difference in perception using the subset of our stimuli that were used in the Pulvermüller study (/p/ and /t/) in the coordinates specified by Pulvermüller and colleagues. In this analysis, we failed to replicate the original results; the lip and tongue areas of the motor cortex as specified in the original study were not associated with differential

activation patterns during perception in our participants (p = 0.46). Next, we used our own functional coordinates derived from the articulatory localizer as well as the full set of 8 syllables to test for motor cortex sensitivity to place of articulation during speech perception. Once again, we found no significant difference between labial and alveolar sounds (ps > 0.5). In a final attempt, we used anatomically-based regions of interest (ROIs) and multivoxel pattern analysis (MVPA) to test for place of articulation differences in the left and right precentral gyrus, central sulcus, and postcentral gyrus. While a pattern classifier produced significant classification accuracy for our localizer task (average across the ROIs = 86.2%; chance performance = 50%), it failed to reliably classify place of articulation for the speech perception task (average classification accuracy = 49.7%). We also used Bayesian hypothesis testing to determine the likelihood of the null hypothesis compared to the alternative and found that the null was determined to be 2-3 times more likely than the alternative across our ROIs. These results suggest that the motor cortex does not map place of articulation during passive speech perception. Using both univariate and multivariate statistical methods, we determined that the areas of the motor cortex that are active during production do not display similar patterns of activation during perception.

F13 Reading Comprehension Ability and Semantic Activation to Single Words and Discourse: An fMRI Partial Least Squares Analysis *Kayleigh Ryherd[1], Emily Baron[2], Kaja Jasinska[2], W. Einar Mencl[2], Nicole Landi[1,2,3]; [1]University of Connecticut, [2]Haskins Laboratories, [3]Yale Child Studies Center*

Approximately 10% of school-aged children with normal cognitive ability have difficulties with reading comprehension despite intact decoding and phonological processing abilities (Nation & Snowling, 1998). Recent studies indicate that this deficiency is not simply the result of domain-general mechanisms, such as reduced working memory, but instead is related to underlying language-specific processing deficits (c.f. Van Dyke & Landi, in press). These poor comprehenders display poor performance on reading comprehension tasks while performing at or above average on tests of phonological processing and word reading. Studies of comprehension deficits have revealed lexical-semantic weaknesses in poor comprehenders, such as reduced lexical-semantic priming and poor word knowledge (Nation, 2005). We suggest that this comprehension deficit is related to low-quality semantic representations that arise from a lack of high-quality experiences with language (both spoken and printed). Thus, we predicted that poor comprehenders should show different patterns of activation in semantic processing areas from those of better comprehenders in response to both printed and spoken language stimuli. We also hypothesized that differences in activation related to reading comprehension skill will occur at both the word and passage level (consistent with previous behavioral work). In order to investigate these hypotheses we used passive word- and passage-level fMRI tasks to examine print and speech processing in skilled and less-skilled comprehenders (ages 14-18). We used behavioral Partial Least Squares (PLS) to explore how experimental conditions (modality: aural vs. visual; level of processing: word vs. passage) interact with behavioral measures of comprehension skill. PLS is a multivariate data-driven method particularly useful for exploring relationships between brain activity and behavioral measures or experimental conditions without top-down constraints on the outcome. When we compared spoken and printed language processing, we found greater activation in semantic processing areas for better comprehenders regardless of modality or task, confirming our hypotheses. We also found that better comprehenders showed more semantic, as well as visual, activation for visual conditions, while poorer comprehenders had more activation in phonological processing areas. The fact that poor comprehenders (who behaviorally demonstrate intact phonological decoding skills) show phonological processing even in response to single printed words suggests a lower-level difference that merits further investigation. In conclusion, our evidence suggests that reading comprehension skill is related to brain activation differences in response to word- and passage-level tasks in both the auditory and visual modalities.

F14 Modality-independent activity during sentence comprehension *Larissa Cuenoud[1], Sonia Brownsett[2], Fatemeh Geranmayeh[1], Richard Wise[1]; [1]Imperial College London, UK, [2]University College London, UK*

Learning to read, such as by phonics, depends on forging close links between the auditory and visual forms of phonemes/graphemes. This progresses to the rapid recognition of bi-/trigrams and then whole word forms. Based on the Hebbian principle, it would seem likely that, although auditory and visual form of words most strongly activate their modality-specific pathways, activity will also propagate between these pathways. This would predict that the ventral occipito-temporal junction (vOT), a region that responds strongly to written words (1), also responds to spoken words. The study by Spitsyna and colleagues (2) on PET data did not demonstrate this prediction, but a univariate analysis of functional imaging data, PET or fMRI, is likely to be too insensitive to reveal subtle cross-modal activity. This study is a copy of the original PET design, but using fMRI and a multivariate analysis of the resulting data. Seventeen right-handed participants (10 males, mean age 38 years) were scanned on a Philips 3.0 Tesla MRI scanner, using T2*-weighted gradient-echo echoplanar imaging. Data were acquired using 'sparse' sampling to avoid interference from scanner noise during the listening trials. There were five experimental conditions: listening to sentences (SpS); reading sentences (RdS); listening to unintelligible spectrally-rotated speech (RotSp); scanning false font

(RdFF); and a simple decision-response task on single numbers (Num). The listening/reading trials were carried out without an explicit task demand. After image pre-processing, Probabilistic Independent Component Analysis was performed, implemented in FSL. The data was decomposed into 50 spatio-temporal components using Principal Component Analysis. Most components were of obvious artifact, or were related to modality-dependent auditory [(SpS + RotSp) > (RdS + RdFF)] or visual [(RdS + RdFF) > (SpS + RotSp)] processing. Only one component contained signal that was related to modality-independent intelligibility [(SpS + RdS) > (RotSp + RdFF + Num)]. This was symmetrically distributed between the cerebral hemispheres: inferior parietal, temporal and frontal cortex, with midline posterior and anterior signal. One clearly lateralized signal was in the left vOT. The other three networks were: a largely right-lateralized fronto-temporo-parietal and left cerebellar) system that was specifically deactivated by the two intelligible conditions [(RotSp + RdFF + Num) > (SpS + RdS)]; and two associated with the Num task. Therefore, the data analysis demonstrated a bilateral fronto-temporo-parietal (FTP) network that was active during modality-independent language comprehension; but, as predicted, this activity extended into the left vOT. Therefore, activity from auditory pathways processing spoken language interacts with a left ventral pathway (3), which through education adapts to the recognition of visual word forms. 1 Dehaene S, Cohen L (2011) The unique role of the visual word form area in reading. Trends Cogn Sci 15:254-62. 2 Spitsyna G, Warren JE, Scott SK, Turkheimer FE, Wise RJ (2006) Converging language streams in the human temporal lobe. J Neurosci 26:7328-36. 3 Price CJ, Devlin JT (2011) The interactive account of ventral occipitotemporal contributions to reading. Trends Cogn Sci 15:246-53.

F15 Left posterior segment of the arcuate fasciculus mediates vocabulary comprehension and reading

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The inferior parietal lobule (IPL) has been characterised as a multimodal integration hub, also involved in language processing. The IPL is connected to Wernicke's (posterior segment - PS) and Broca's territories (anterior segment); together, these regions also form the long segment of the arcuate fasciculus (AF)1,2. Although imaging studies have elucidated important information about the role of AF in general language processing, the possible functional correlates of its separate segments are still under debate. We used diffusion imaging tractography based on spherical deconvolution to study whether the PS of the AF is associated with oral reading and vocabulary comprehension. Results showed that clearer and faster pronunciations in reading as well as improved vocabulary comprehension were correlated with increased volume of the posterior segment of the left AF. METHODS Human Connectome Project3 datasets were used. 21 healthy participants(11 females, aged 23-35 years, right-handed) were scanned on a 3T GE MRI scanner (voxel size 1.25mm3, 210x210 matrix, 111 slices, b-value 2000s/mm2, 90 diffusion-weighted directions and 18 non-diffusion weighted volumes4). Diffusion tensor imaging data were preprocessed using ExploreDTI and corrected for eddy-current and motion artefacts. White matter pathways were obtained using a two regions of interest approach2. Behavioural tasks were acquired from the NIH Tollbox4. Oral Reading task: participants were asked to read and pronounce words as accurately as possible. Higher scores indicate better pronunciation of increasingly difficult words. Picture vocabulary comprehension: Participants are presented with an audio recording of a word and four photographic images on the computer screen and are asked to select the picture that most closely matches its meaning. Higher scores reflect better and faster reading and quicker/wider vocabulary comprehension. Correlation analyses were perfomed to investigate the relationship between pathway properties of the posterior segment and behavioural variables. The long segment (between Broca's and Wernicke's) was chosen as a control tract. RESULTS Better Reading performance correlated with increased volume of the left hemisphere posterior segment (Pearson r=0.510; p=0.04). Similarly, higher vocabulary comprehension scores correlated with increased volume of the left posterior segment (Pearson r=0.473, p=0.04). No significant association for oral reading and the long segment of AF was observed(Pearson r=0.234, p=0.238). Conversely, no relation was found between reading (Pearson r=0.132, p=0.210) or vocabulary comprehension and the long segment (Pearson r=0.198, p=0.175). CONCLUSION:Our study showed, for the first time in a high resolution dataset, that better reading and vocabulary comprehension were associated with increased volume of the left PS of the AF. This relationship might be explained by different mechanisms. The PS connects the visual word form area (temporal-occipital region)5 and inferior parietal areas and might be involved in mapping orthographic to phonological as well as visual representations of words6, 7. Moreover, the posterior segment might also be involved in enforcing a semantic route that is dependent on auditory and temporal connections related to word comprehension. As the inferior parietal is amongst the latest to evolve and develop, this might explain why general semantic knowledge progressively increases throughout life and why learning to read begins around the age of 5-6.

F16 Computational and Neural Mechanisms of Top-Down Effects on Speech Perception

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During speech perception, listeners integrate information from many sources. For instance, both contextual and acoustic cues influence the identification of phonetically ambiguous stimuli (between bay and pay) following biasing sentence contexts (He liked [the/to]...) (Fox & Blumstein, 2012). How listeners weight these disparate information sources remains unclear. Moreover, although both frontal (Snijders et al, 2009) and posterior (Guediche et al, 2013) brain regions have been implicated in such tasks, little is known about top-down speech processing in aphasia. The present study investigates the computational and neural mechanisms underlying contextual and acoustic cue integration. Building on previous cue integration models of phoneme perception (Clayards et al, 2008; Feldman et al, 2009; Kleinschmidt & Jaeger, 2015), we formalize contextual influences on word recognition within a Bayesian speech perception model (BSPM). BSPM integrates contextual and acoustic cues with stored statistical knowledge (estimated from corpus statistics; Michel et al, 2010). We then conduct 3 experiments to examine the extent to which behavioral responses of young adults fit BSPM's predictions and to identify which computational mechanisms in BSPM characterize behavioral differences in older adults and persons with aphasia who have either frontal or posterior lesions. In Experiments 1-2, young, healthy adults (n=36) heard tokens from a bay-pay continuum following auditorily presented noun- and verb-biasing contexts and indicated (via button press) whether the sentence-final target was bay or pay. In E1, all acoustic tokens occurred in every context. Results showed subjects were sensitive to both contextual ($p<.001$) and acoustic ($p<.001$) cues. Furthermore, greater acoustic ambiguity predicted larger observed bias effects ($p<0.01$), fulfilling BSPM's optimal cue-weighting predictions. In E2, subjects heard the same contexts and tokens, but the bay- and pay-endpoint tokens only occurred in congruent contexts (...the bay, ...to pay), exposing subjects to fewer ungrammatical trials. E2 replicated E1's basic findings, but elicited more contextually-biased responses to boundary tokens ($p<0.01$). Thus, consistent with BSPM, subjects adapted their expectations when contextual cues proved unreliable. E3 examined the ability of two of BSPM's parameters (ω,ε) to capture group differences among patients with aphasia and age-matched controls in top-down processing. Higher values of ω reflect overweighting of context (versus acoustic cues); higher values of ε reflect less reliable mapping between lexical representations and associated phonological forms. BSPM was refit to data from a new sample of young controls (n=34), and, other than ω and ε, its parameters were fixed. BSPM was then fit to behavioral responses of elderly controls (n=8), frontal patients (n=3), and posterior patients (n=3) separately. Optimal parameter settings showed elderly controls overweight context compared to young controls, and both frontal and posterior patients overweight context even more. Additionally, posterior patients' behavior indicated less reliable phonological representations of words. These results suggest that a Bayesian framework can account for integration of top-down and bottom-up information in both healthy and brain-injured adults. Aging and aphasia increase reliance on top-down information (Abada et al, 2008; Baum, 2001; Blumstein et al, 1994; Boyczuk & Baum, 1999), and posterior lesions disrupt lexical-phonological mapping more than frontal lesions (Milberg et al, 1988).

F18 Real-time dynamics of lexical processing in auditory areas revealed with intercranial recordings

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A fundamental problem in speech perception is time. At any moment there is not sufficient information to identify a word. For example at the onset of a word like dynamite (dy…), the input is consistent with many words (dinosaur, diary, dice, etc.), creating a problem of temporary ambiguity that cannot be resolved until more information arrives (…amite). Cognitive/behavioral research suggests listeners solve this problem by making early partial commitments to many lexical candidates, and these compete as the input unfolds (Marslen-Wilson, 1987; McClelland & Elman, 1986). While we know a great deal about the network of brain regions that support lexical access (e.g., Hickock & Poeppel, 2007; Yee, Blumstein & Sedivy, 2008; Zhuang, Randall, Stamatakis, Marslen-Wilson, & Tyler, 2011), we know little about how and where these competition dynamics unfold. We investigated this with electro-cortigraphy on adults undergoing monitoring for seizure localization. By using classifier analyses (rather than raw activation) targeted to multiple time points and brain areas, we asked whether the distributed pattern of activity in a brain area supports the kind of dynamic competition process posited by models of word recognition. Eight adults were implanted with grid and depth electrodes covering Heschyl's gyrus (HG), Superior Temporal Gyrus (STG), Supramarginal gyrus (SMG), and parts of Inferior Frontal Gyrus (IFG). Five were implanted on the left hemisphere. Stimuli were three sets of three words. Words within a set overlapped heavily at onset (dinosaur/diary/dynamite, calculate/caliber/calorie, manatee/mandarin/manicure). Ten unique exemplars of each word were presented in a passive listening task (5 times each). Results were analyzed using support vector machine (SVM) classifiers. Local field potentials and gamma band activity from a single brain area over a 75 msec time window was used to train an SVM to predict which word was heard (9AFC). Confusion matrices were computed to determine if the distributed pattern of activity in that brain area (at that time) had sufficient information to discriminate the target (e.g., manicure) from competitors (manatee, mandarin) and unrelated items (dynamite, etc). This was repeated from 0 to 2000 msec (in 25 msec increments) at each brain area. The analysis showed evidence for parallel activation/competition as early as Heschl's gyrus and throughout superior temporal gyrus:

early in the word, the distributed pattern of activity could discriminate targets and competitors from unrelated words but not from each other. After the point of disambiguation, targets and competitors were discriminated, and remained so remained until well after word offset. In contrast, neither IFG, SMG nor other areas showed this pattern. Here, the classifier discriminated the set (e.g., dinosaur/dynamite/diary vs. manatee/mandarin/manicure) but could not distinguish individual words at any timepoint. Hemispheric differences were also observed: the right hemisphere showed much stronger classification performance in HG than the left, but markedly weaker accuracy in STG. These results suggests that the dynamics of lexical competition play out in the same brain areas currently thought to perform phonological and even acoustic analysis, ruling out strongly stage like accounts of lexical access. Dynamic competition among candidates is embedded throughout the processing chain.

F19 The neural correlates of linguistic rhythm during natural story listening

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Rhythm in language involves an alternation of strong and weak beats (Rhythm Rule, Liberman&Prince, 1977). Previous neuroimaging studies on linguistic stress used phonological tasks and found effects in the supplementary motor area (SMA), insula, precuneus, superior temporal gyrus (STG), parahippocampal gyrus (PHG), lingual gyrus (LG) and inferior frontal gyrus (IFG). Here, we investigated the neural correlates of linguistic rhythm during natural story listening, with no further control for a metrically isochronous speech rhythm and no phonological task. We examined if a) well-formed structures are processed differently than rhythmic deviations in compound words for German, b) this happens in speech processing in the absence of phonological task. We created 20 compounds [A[BC]] as follows: [Holz-]A[spiel-zeug]BC (wooden toy) – [Pla-stik-]A[spiel-zeug]BC (plastic toy). Following the rhythm rule, when "Holz" combines with "Spiel-zeug", the initial lexical stress on "Spiel" needs to be shifted to "zeug" (SHIFT), creating the stress pattern "HOLZ-spiel-'zeug". In contrast, when "SPIEL-zeug" is combined with "PLAS-tik-", "PLAS-tik-'spiel-zeug" needs no stress shift (NOSHIFT). Additionally to these two well-formed conditions, we created two ill-formed conditions: a) CLASH: the stress from "Spiel" is not shifted to "zeug" in "Holz-spiel-zeug", thereby creating a clash of two adjacent stressed syllables "HOLZ-'spiel-zeug" and b) LAPSE: two adjacent unstressed syllables (a rhythmical lapse), by shifting the initial stress of "Spiel-zeug" against the rhythm rule: "PLAS-tik-spiel-'zeug". These manipulations created a 2×2 design of well-formedness (rhythmically well-formed vs. ill-formed) x stress shift (yes, no). The compound pairs were embedded in 20 two-minute long stories. We obtained images (3T) of 20 healthy right-handed German monolinguals (9 male). Subjects were instructed to listen to the stories and answer two comprehension questions after each story. The compounds were modelled as critical events; in the group level analyses we employed the previously mentioned 2×2 design. Clusters of $p<.005$ and of at least 72 voxels (Monte Carlo corrected) are reported. For the main effect of well-formedness, we found effects in the left cuneus, precuneus and LG. Our main finding is the interaction of well-formedness and stress shift in the pre-central gyrus (preCG) and SMA bilaterally. We resolved this interaction by well-formedness thereby examining how the shift manifests itself depending on whether it leads to a well-formed or an ill-formed structure. For SHIFT vs. NOSHIFT we found activation in the left middle temporal gyrus (extending to the STG). For LAPSE vs. CLASH, which is especially interesting because LAPSE involves two violations (rhythm rule, initial lexical stress) whereas CLASH only one (rhythm rule) activation was found in the right IFG, bilateral SMA and left premotor cortex. The differences in activations found for well-formedness show that the brain is sensitive to subtle deviations in the alternation of strong and weak beats during natural story listening. This is particularly evident in the activation of the MTG/STG, which has been associated with the processing of linguistic prosody, of the SMA, which has been suggested to support temporal aspects of processing sequences of strong and weak syllables, and IFG activation associated with tasks requiring more demanding processing of suprasegmental cues.

F20 Timing predictions in speech are affected by attention and speaking rate: evidence from electrophysiological omission responses

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Human speech processing relies on predictive processes that operate on meaning-, sound-, and timing-based information. Omissions of sounds at anticipated time points result in an automatic change detection response, the "omission mismatch negativity" (OMMN). Previous research has provided evidence that the OMMN is positively correlated with the predictability of the omitted speech sound. Simultaneously, experiments on non-speech sounds have provided evidence for temporal constraints for the elicitation of the OMMN, implying a maximum stimulus-onset-asynchrony (SOA) of 150 ms between actual (preceding) and anticipated (omitted) sound ('temporal window of integration', TWI) beyond which no OMMN is generated. Given the rather flexible temporal structure of speech afforded to differences in speaking rate, this TWI may actual differ between non-speech and speech stimuli, albeit longer SOAs might be dispreferred because slow speaking rates are less expected. Furthermore, slower speaking rates might necessitate increased attention to the

acoustic input. In this EEG-study (N=21, 64 electrodes), we compared the OMMN in response to word-final consonant omissions (La– from German Lachs 'salmon') across two levels of SOAs, 150 and 300 ms (corresponding to a normal and slow speaking rate). Additionally, we contrasted a passive condition (listening-only) with an active condition (probe-word detection) and thereby achieved a 2-by-2 design with the effects of speaking rate (normal, slow) and attention (passive, active). Results showed discernible OMMNs peaking between 120 and 170 post deviance onset that differed between conditions. Mixed-effect models on mean amplitudes in this window from central midline electrodes revealed an effect of speaking rate, with greater OMMN amplitudes for the normal speaking rate (short SOA) than for the slow speaking rate (long SOA). This effect crucially depended on attention, as suggested by a significant speaking rate x attention interaction. Importantly, speaking rate influenced the OMMN more in the active than in the passive condition. In the passive condition, OMMN sources revealed by VARETA analyses were found in left superior temporal gyrus (STG) and left angular gyrus for the normal speaking rate; for the slower speaking rate, sources predominantly occurred in left STG. In the active condition, sources were seen in left STG for the normal speaking rate, while the slow speaking rate revealed an additional source in left angular gyrus. Altogether, both speaking rate and attention affected the OMMN and its neural generators. Pre-attentively, an extension of the TWI seemed to indeed cause a reduction in the OMMN response, as expected from non-speech findings. Furthermore, the lack of the angular gyrus sources for the passive slow speaking rate and the active normal speaking rate conditions suggests that the omission resulted in a less severe lexico-semantic violation. When attention was directed towards the speech signal, the effect of speaking rate on the OMMN was even more pronounced, implying that the TWI crucially depends on attention.

F21 Interaction of top-down and bottom-up predictions in degraded speech perception *Alessandro Tavano[1,2], Mathias Scharinger[1,2]; [1]BioCog - Cognitive incl. Biological Psychology, Department of Psychology, University of Leipzig, Germany, [2]Max Planck Institute for Empirical Aesthetics, Frankfurt, Germany*

Speech perception is a fast and automatic process, that shows its robustness particularly in adverse listening conditions, for example when speech is spectrally degraded. Spectrally degraded speech taxes on the efficient extraction of syllabic structure, and but it can still be understood in some cases. It has been suggested that the restoration of missing information in sequential speech may rely on fast predictive processes, but the evidence remains sparse. Can predictive dynamics help filling in for the missing information? To test this hypothesis, we combined a repetition suppression paradigm with a multi-feature oddball paradigm and contrasted the neuroelectric responses of standard pairs of spectrally intact consonant-vowel syllables (category standard) with those of three types of syllabic pairs: spectrally intact category deviants, using a different vowel with intact spectral information; spectrally degraded category deviants, presenting an unintelligible (4-band noise vocoded) version of category deviants; spectrally degraded category standard, displaying an equally unintelligible (4-band noise vocoded) version of category standards. The three deviant types alternated with the standard type in continuous stimulus sequences while participants' attention was directed away from the stimuli. We postulated the interaction of two distinct predictive mechanisms: 1) top-down expectations, that is pre-activated "templates" of upcoming stimulus, based on the statistical predictability of syllable repetition within a pair (predictable deviant repetition = 100%, unpredictable deviant repetition = 50%); 2) bottom-up predictions, based on point-wise matching of the detailed sensory memory traces of incoming deviant pairs to the alternating standard pairs. In agreement with the literature on contextual effects of repetition suppression, we found an attenuation of the neural response for predictable as compared to unpredictable deviant syllable repetitions. These effects were localized to the left frontotemporal areas in both sensor and source spaces (left STG, Variable Resolution Tomography, VARETA), suggesting the speech specificity of top-down predictions. Importantly, repetition suppression effects were significant not only for spectrally intact category deviants, but also for spectrally degraded category standards. A similar pattern of results emerged for the responses to rare omissions of repeated deviant stimuli. In this case, the assumption is that larger omission responses are to be found if a top-down expectation is violated. We found significantly larger omission responses for predictable than unpredictable deviant repetitions only for spectrally intact category deviants and spectrally degraded category standards. No effect of top-down expectations emerged for degraded category deviants, either delivered or omitted. From the interaction of bottom-up predictions with top-down expectations we conclude that matching to a sensory memory trace (the standard) does not simply serve deviance-detection functions, but also helps enriching the sensory representations of spectrally congruent albeit degraded incoming stimuli. Such enriched representations are sufficient to output a neural response to higher-order, top-down expectations, comparable to that of spectrally intact stimuli.

F22 Incremental processing of Chinese spoken words and the influence of fluent speech on lexical competition effects: Evidence from eye movements *Jie-Li Tsai[1], Chung-I Erica Su[2], James Magnuson[3]; [1]National Chengchi Univsersity, Taiwan, [2]National Chiao Tung University, Taiwan, [3]University of Connecticut & Haskins Laboratories, USA*

Many studies have demonstrated an incremental time course to spoken word recognition in non-tonal languages. For example, Allopenna, Magnuson, & Tanenhaus (1998) used eye tracking in the "visual world" paradigm (VWP) to estimate lexical competition that tracked phonetic similarity over time (with early effects for onset overlap and late effects for rhymes), suggesting a segmental grain (and Dahan, Magnuson, Tanenhaus & Hogan, 2001, found evidence for a sub-segmental grain). On the basis of ERP evidence with Mandarin materials, Zhao, Guo, Zhou, & Shu (2011) proposed that the grain of spoken word recognition may be syllabic for tonal languages due to pressures for the system to integrate syllabic tone (based on similar timing for interference from items overlapping phonologically in onset or rime). We reassessed onset and rime effects with native speakers of Mandarin using a standard VWP, which provides a more direct comparison with earlier reports supporting (sub-) segmental incrementality. The picture/name matching paradigm used by Zhao et al. differed from that original method in many ways, including the absence of a carrier phrase (e.g., target words in Allopenna et al. occurred in the sentence context, "pick up the…"). It is possible that the carrier phrase is critical, as isolated words in clear speech may present very little uncertainty about the initial segment (Mirman, Kornilov, & Magnuson, 2011). In two experiments, we used standard VWP trials with a target (e.g., 鈔 /chao1/), two unrelated distractors (e.g., 搜 / sow1/, 哼 /xəŋ1/), and either an onset competitor (e.g., 娼 /chang1/) or a rhyme competitor (e.g., 稍 /shao1/). To isolate effects of onset uncertainty, we used carrier phrases in two experiments, but manipulated onset salience. Targets were either isolated words excised from a fluent carrier phrase (reducing onset uncertainty, e.g., "please move the mouse to [pause] chao1", Experiment 1), or were produced fluently in a carrier phrase without a pause inserted (Experiment 2, making the onset less salient / more uncertain). In Experiment 1, we observed a robust onset competition effect (large and early), but not a rhyme effect. In Experiment 2, we observed both robust onset (large, early) and robust rhyme (later, weaker) effects. Our results have two important implications. First, the robust onset effect in Experiment 1 and robust onset and rhyme effects in Experiment 2 demonstrate that the grain of processing of spoken words in tonal languages is at least segmental, since eye tracking revealed that listeners track sub-syllabic phonetic similarity on-line as a word is heard. Second, the fact that the rhyme effect emerged only when targets were produced under conditions of lower certainty (fluently following a carrier phrase) suggests (a) that carrier phrase conditions are more representative of speech processing outside the lab (that is, processing of words in fluent sentences rather than in isolation), and (b) that task details must be considered carefully when subtle details of spoken word recognition fail to replicate.

F23 Speech perception – effects of attentional modulation on syllable processing

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Speech processing involves distributed brain areas that operate in synchrony, each contributing with a certain expertise in processing a certain cognitive task or information within the stimuli. It has been proposed that acoustic information is mainly processed in the primary auditory cortex (PAC). From there it is directed to higher-order cortical areas through a dorsal and a ventral pathway linking acoustic speech input to articulatory (e.g. area sylvio-parieto-temporal –Spt–) and semantic codes (e.g. in the medial temporal gyrus –MTG–), respectively. Paying attention to what we hear plays a relevant role in comprehension. But how attention modulates information processing within the language network is still unknown. In this 7-Tesla fMRI study (N=5), we investigated whether attention to different phonological components of a syllable (consonants or vowels) modulates blood oxygenation level-dependent (BOLD) responses to these stimuli in dedicated regions of interest (Spt and MTG). Stimuli were recordings of 18 consonant-vowel syllables pronounced by three female Dutch speakers. Syllables were combinations of six consonants (/p/, /t/, /f/, /s/, /m/, /n/) and three vowels (/a/, /i/, /u/). The syllables vary in place of articulation (labiodental and alveolar) and manner of articulation (stop, fricative and nasal), resulting in a stimuli matrix that allows analysis across these dimensions (e.g. labiodental vs alveolar or stop vs fricative). Sounds were delivered during a silence gap within the acquisition sequence. The experiment had a slow event-related design with 4 runs and 2 tasks. Subjects were asked to perform two different tasks with identical auditory stimuli. Subjects were presented with a syllable sound followed by a written letter (consonant or vowel), 12-16 s inter-stimulus interval. Attention was modulated via a delay-match-to-sample task. Subjects were asked to match any auditory presented syllable with a written vowel or a consonant. They had to report whether the written vowel or consonant was included in the preceding sound by pressing button '1'or not by pressing button '2'on a MRI-compatible box. From a total of 54 trials, 50% where matched, balanced across conditions. Functional responses were measured with gradient echo-planar imaging at 1.5mm iso-voxel resolution. FFX-GLM showed clusters for the main effect (syllables>silence) along the temporal lobe and bilateral ventro-lateral frontal areas, reflecting the language network consistent with the literature. Preliminary univariate analyses suggested that differentiation between sounds with different articulatory properties -labiodental (/p/, /f/, /m/) vs alveolar (/t/, /s/, /n/) consonants - could take place in the right temporal lobe. The results suggest

that sounds composing syllables may be differentially processed according to their articulatory dimensions. More conclusive evidence will be obtained by including additional subjects and using multi-voxel pattern analysis, which could find subtle distributed differences in neural representation of these dimensions and task effects.

F24 Neural correlates of individual differences in processing of rising tones in Cantonese: Implications for speech perception and production *Jinghua Ou[1], Sam-Po Law[1]; [1]University of Hong Kong*

Introduction The present study examined the neural processes underlying the discrimination of the high rising and low rising tones T2/T5 in Hong Kong Cantonese (HKC) from two groups of typically-developed native speakers of HKC. The participant groups represented, respectively, the pattern of good perception and good production of all Cantonese tones [+Per+Pro] (N = 20, female = 8), and that of good perception of all tones but poor production of specifically the T2/T5 distinction [+Per-Pro] (N = 21, female = 13). Electrophysiological responses to the contrasts of pitch and amplitude envelope between T2 and T5 were measured to allow us to assess the timing and strength of neural activities associated with the auditory stimuli unfolding over time. Any difference in neural response between the two groups would shed light on how the acoustic cues of pitch and amplitude envelope are differentially represented in their auditory memory, and enable us to consider the relationship between perception and production. Method The EEG experiment consisted of four oddball conditions of different Standard/Deviant pairs, including T2/T5 and T5/T2 as two experimental conditions. The pre-processed EEG data were analyzed in two ways – a non-parametric cluster-based random permutation approach implemented in Fieldtrip and the conventional analysis to assess whether the two groups differed in the ERPs to rise time, the magnitude and latency of the MMN to pitch level/contour. The relationship between perception and production was also explored. Results and Discussion Results of the tone discrimination task showed that the [+Per-Pro] group had significantly longer RT in discriminating T2 and T5 than the [+Per+Pro] group, [$t(39)= -3.57$, $p = .001$, Cohen's $d = 1.14$], although both groups achieved high accuracies (above 98%). The cluster-level permutation test revealed that both participant groups exhibited the MMN to pitch contrast and an early positive-going cluster in the T2/T5 condition to rise time ($p < .05$), but an absence of MMN in both groups and a negative cluster to rise time for the [+Per+Pro] group in the T5/T2 condition. Neural responses at Fz and FCz did not show any group difference in MMN amplitude or latency in the T2/T5 condition. For rise time, there were main effects of tone condition [$F(2, 39) = 47.18$, $p < .001$] and group [$F(2, 39) = 75.89$, $p = .017$], with T5 eliciting more positive responses than T2, and stronger responses from the [+Per+Pro] than [+Per-Pro] group ($p < .01$). Correlations between production and perceptual measures found that T2-T5 pitch offset and rise time differences were negatively correlated with discrimination RT ($p < .001$) but positively associated with the magnitude of brain responses to rise time of T5 ($p < .01$). In short, the present study have revealed differential perceptual sensitivities between individuals with and without distinctive production of the two rising tones. The individual differences found in production are proposed to have a perceptual origin.

F25 The ERP Evidence for the Integration of Lexical Tone and Segmental Information in Chinese Syllable Perception *Rong Zhao[1], Rong Fan[1], Rui Zhang[1], Min Dang[1], Xiaojuan Wang[1], Jianfeng Yang[1]; [1]School of Psychology, Shaanxi Normal University, Xi'an, China*

An increasing interest in spoken word recognition focuses on studies of tone language recently, since previous cognitive and neuroanatomical models of speech perception are based on studies of non-tone language. Whether these models are language general is investigated by comparing the processing between segmental and supra-segmental information in tonal language. Thus the underlying processing of Chinese tone has been widely tested. Previous studies have focused its role of semantic access in spoken words recognition, in speech development, and its cognitive neuroscience basis. However, the role of tone in Chinese syllable perception and their combined impact with segmental information (initial consonant and vowel) are not well understood yet. The current study adapted the oddball paradigm in an event-related potential (ERP) experiment to test the integration of tone and segmental information in Chinese syllable perception. Motivated by comparing the role of tone and segmental information, the experiment presented a stream of standard syllable (da1) interrupted by deviant syllables, which created three types changes: Initial Consonant (C, "ga1"), Vowel (V, "du1") and Tone (T, "da4"). In order to test the combined effect of tone and segmental information, two types of deviant syllables were created from the standard syllable ("da1") by changing tone plus consonant (T+C, "ga4"), tone plus vowel (T+V, "du4"). The rate of standard and deviant syllables was 8:1 and the interval of each pair of deviant syllables included at least 5 standard syllables. The stimulus duration was normalized to 250 ms with a stimulus onset interval of 650 ms. Participants listened to the auditory stimulus passively and watch a silent documentary film during the course of experiment. The EEG data was analyzed with EEGLAB. The results showed the function role in speech perception among consonant, vowel and tone is different. Both vowel and tone change evoked a stronger typical Mismatch Negative (MMN) at F3 than consonant changes. But the latency of the peak value of the MMN for tone change is relative later than vowel changes. When tone change was combined with segmental information change together, the C+T change only elicited stronger MMN than C change at early stage (150-200ms). In contrast, the V+T

change elicited stronger negative response than V change after 300ms, although the MMN for V+T and V change are almost the same at the early stage (150-200ms). Our results suggested the impact of tone change in syllable perception is weaker than vowel change, but stronger than consonant change. The integration of lexical tone and segmental information facilitates Chinese syllable perception. The impact of combined vowel and tone change is dramatic that the integration processing is evoked for further semantic processing in syllable perception. It is the first neural evidence to show how the lexical tone facilitates the Chinese speech perception.

F26 The time-course of cohort restriction in syntactic context: MEG evidence for a single auditory word-form

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The size and distribution of a word-form's cohort of lexical competitors influence auditory processing (Gagnepain, Henson & Davis, 2012; Ettinger, Linzen & Marantz, 2014) and can be constrained by syntactic category information (Strand et al. 2014). Debate over category representations continues in the literature but increasingly converges on a Combinatorial rather than a Lexicalist view of syntactic class (Vigliocco et al. 2011), such that neural differences between nouns and verbs emerge only in syntactic context. This experiment uses noun/verb homonyms to explore the influence of syntactic category on cohort restriction in auditory processing, aiming to clarify the nature of this process and its implications for theories positing single versus multiple word-forms in cases of category ambiguity. Unconstrained phoneme surprisal (the inverse of the log of a phoneme's conditional probability given the phonemes preceding it) was calculated for each phoneme in a set of 97 monomorphemic, monosyllabic noun/verb homonyms (e.g. ache, vow) which were presented auditorily within noun phrase, verb phrase, and ambiguous contexts in an acceptability judgment task, along with filler items to minimize morphological and phrasal predictability. Two additional context-constrained phoneme surprisal measures were calculated for each phoneme in reflection of two possible mechanisms for cohort restriction: form-conditional and usage-conditional. The form-conditional measure was calculated by restricting the cohort from which surprisal is derived to members consistent with the syntactic category, while the usage-conditional measure also restricted the frequencies of those cohort members to their specific frequency of usage within the category. Participants (n = 24) provided acceptability judgments for three-word phrases (e.g. the vow expired, *to vow taker, juh vow writing) during MEG recordings, and the open-source MNE-Python and Eelbrain packages were used to process the data, obtain distributed source solutions, and perform statistical analyses. Correlations between neural activity and the relevant unconstrained and conditional measures were calculated at each source and time point for use in cluster-based nonparametric tests (to solve the multiple comparisons problem; Maris & Oostenveld, 2007). While significant correlation between either conditional measure and neural activity in auditory cortex would support previous behavioral evidence for cohort restriction based on syntactic category, a finding of significant correlation with the form-conditional measure could support only a hypothesis of single word-forms in cases of category ambiguity, because under a multiple word-forms hypothesis the form-conditional and usage-conditional measures are not distinct. Threshold-based spatiotemporal cluster tests were performed on beta values in windows time-locked 150-450 ms from the onset of each phoneme, in STG and TTG. Clusters of significant ($p < .05$) correlation with neural activity were found for unconstrained phoneme surprisal at phoneme 2 in anterior STG, for an interaction between form-conditional phoneme surprisal and phrasal context at phoneme 3 in STG and TTG, and for usage-conditional phoneme surprisal at the final phoneme, in STG. This pattern of correlations supports a model of auditory processing in which noun/verb homonyms are derived from single word-forms, contextual information is integrated midway through the word, and the cohort is restricted incrementally, by form and then by usage.

F27 On the Mental Representation of German Strong Verbs: an ERP Study

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The representation and processing of irregular stem allomorphs of German strong verbs were investigated in a series of auditory ERP experiments. The objective of the study was to determine whether present and past tense forms of strong verbs are stored in a morphologically underspecified manner. According to the morphological underspecification account, the features that are highly predictable should be underspecified. We assumed that a lexical entry of a strong verb should be organized hierarchically with the underspecified stem at the first level and the specified/marked stems at the second level. Thus, a basic/ present tense stem should only carry the verbal feature [VERB]. Irregular stem allomorphs of a strong verb, such as a past tense form and a past participle, should add their specific features, such as a tense feature [PRET] and an aspect feature [PERF] respectively. We hypothesized that (i) if irregular stem allomorphs were fully specified the cases of allomorph misapplication should trigger parsing, whereas (ii) if basic stems were underspecified for tense, their misapplication should induce a semantic conflict. Additionally, we expected the processing of basic stems of strong verbs to be distinct from that of weak verbs. To test our hypotheses, we compared the processing of correctly inflected strong verbs with the processing of incorrectly inflected strong verbs: geh-t/ ging (Control – C) vs. *ging-t/*ging-te (Excessive Inflection – EI) and *geh (Bare Stem – BaS irregular), in the Present (Experiment 1) and Past (Experiment 2) tense context experiments. We also compared the strong verb conditions

with the processing of correctly and incorrectly inflected weak verbs in both experiments: schenk-t/schenk-te (C regular) vs. *schenk (BaS regular). We argued that (i) in case of full specification, the allomorph misapplication, i.e. BaS irregular in the Past context and EI in the Present context, should evoke a P600. The rest of the violation conditions were expected to trigger a LAN. In case of underspecification of basic morphemes (ii), we expected the items underspecified for tense (BaS irregular condition) to induce an N400. The results of the experiments revealed the following pattern. The EI items (*ging-te) evoked a prominent LAN effect only in the Past context experiment. The BaS regular items (*schenk) elicited a delayed LAN effect in both experiments. The BaS irregular (*geh) condition triggered an N400 in both experiments. The LAN effects elicited by the EI (*ging-te) and BaS regular (*schenk) conditions were only observed if suffixation rules were violated. The EI condition (*ging-t) met the paradigmatic requirements in the Present context, viz. the suffix {-t}, hence the lack of violation effects. We attributed the N400 effect evoked by BaS irregular items (*geh) to the underspecification of the basic allomorph for the tense feature. The data demonstrated that strong and weak verbs are represented in a different manner. Moreover, the differential violation effects triggered by past and basic stem allomorphs of strong verbs provided support for a lexical representation with partly underspecified morphological features.

Discourse, Combinatorial Semantics

F28 Adjective conjunction as a window into the LATL's contribution to conceptual combination: Sensitivity to intersective but not collective readings

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Though a large literature implicates the left anterior temporal lobe (LATL) for combinatory operations, recent MEG studies have suggested that it is specifically involved in the composition of complex concepts, rather than syntactic or semantic composition in a more general sense (Westerlund & Pylkkänen, 2014; Zhang & Pylkkänen, 2015; Del Prato & Pylkkänen, 2014). To further specify the computational contribution of the LATL, we tested whether LATL effects as observed in MEG require a situation in which features combine to form a single coherent entity representation or whether the relevant computation simply requires the attribution of features to a set but not necessarily to the same members of the set. Under the former hypothesis, the LATL is sensitive to the number of features added to the representation of a single entity whereas under the latter account, LATL activity reflects the total number of features integrated across different members of a set. To test this, we employed conjunctions of two adjectives whose lexical semantics were varied such that they either allowed or disallowed the attribution of their denoted properties to the same members of a set, i.e., the properties were either compatible or incompatible. The compatible properties resulted in so-called intersective and the incompatible in so-called collective readings (Krifka, 1990). Visual displays of objects were followed by sentences which were judged for veridicality as descriptors of the display. Adjective conjunctions either allowed for an intersective interpretation (e.g. visual display of [four big green hearts] followed by the sentence 'The hearts were green and big'), or forced a collective one (e.g. visual display of [two big green hearts and two small green hearts] followed by 'The hearts were small and big'). The baseline condition contained only one adjective, e.g. visual display of [four big green hearts] followed by 'The hearts were big'. The target of MEG analysis was always the sentence-final adjective. Cluster-based permutation tests on ROI activity showed a sensitivity to intersective conjunctions in the left ATL, with intersectives showing higher amplitudes than collectives or the baseline at ~200-250ms. Interestingly, the reverse pattern was found in the right ATL, where collectives elicited more activity than intersectives or the baseline. Our results show that the addition of a feature is not enough to increase LATL amplitudes: this feature needs to enrich the representation of an individual (as compared to a control condition) in order for the LATL to be affected. Since the collective and baseline conditions both attribute two features per individual (heartness and smallness/bigness in collectives and heartness and bigness in baseline), there is no LATL relevant contrast. Only the intersectives increase LATL amplitudes in comparison, as they attribute three features to each individual in the set (heartness, greenness and bigness). The reverse pattern in the right ATL shows that although this region often shows parallel effects to the LATL, its functional contribution is clearly distinct. The reverse effect could for example reflect more global right lateral interpretation allowing for reinterpretation of sentences with antonymic adjectives (cf., Caramazza et al. 1976).

F29 Neurodynamics of minimal visual and written narrative comprehension

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Introduction: Narrative comprehension requires the integration of successive elements into a consistent narrative structure. Successive elements that follow a predictive narrative structure should require less processing to integrate than those that are incoherent with respect to the evolving narrative structure. We recently demonstrated (Jouen et al. 2015 Neuroimage) the existence of a common extended semantic network recruited in the comprehension of visual scenes, and sentences. fMRI and DTI revealed the spatial organization of this network and aspects of its connectivity. The current research addresses temporal neurodynamics involved in the same kind of

sentence and scene comprehension. Methods: We recorded 64 channel scalp surface EEG from 18 naïve subjects in a protocol where they saw a visual scene (or read a sentence) depicting a human event, and after a 1-1.5 second pause saw a second scene (or sentence – always in the same modality) that was either a coherent discourse follow-up, or not, of the first scene (or sentence). Our objective was to test the predictions (P1) that comprehension of the second stimulus would require additional processing for incoherent vs. coherent stimuli, and that this would be the same for sentence and scene processing, reflecting the operation of the common meaning system, and (P2) that this processing would be manifest by a late positivity as has been recently attributed to the integration of mental representation of what is being communicated (Brouwer et al. 2012 Brain Research). Results: To characterize the neural activity, we performed PCA on the signals from the 64 electrodes over all conditions (coherent vs. incoherent), modalities (sentence vs. image) and stimuli (first and second) confounded, starting from 500ms prior to stimulus onset, to 1000 ms post offset. We then examined the data for specific conditions, modalities and stimuli in the resulting PCA space. The first principal component reliably captured the coherent-incoherent contrast, in late windows (750-100 and 1600-1800 ms post stimulus onset) only for the second stimulus. The trajectory of the coherent and incoherent trials significantly deviate in these two time windows. In order to determine if the same mechanisms are involved in the sentence and image comprehension, we then performed PCA only on the sentence data, and observed coherent vs incoherent trails in this PCA space for sentences and images. Again, the first PC reliably distinguishes coherent vs. incoherent. The same effects were observed for the reverse operation, that is, extracting PCAs using image data, and testing on sentences and images. We verified the individual component electrodes that contributed to the first component and found classic late positivity responses. Conclusions: (1) Unsupervised PCA processing discovered the neural correlates of precisely the experimental parameter that we manipulated – the discourse coherence of the second stimulus, in sentence and image discourse conditions. (2) Cross validation revealed that the PCs identified in one modality allow a reliable "decoding" of the coherent/incoherent status in the other modality. We interpret the late positivity as an index of the processing required to generate a narrative representation consistent with the two successive stimuli.

F30 Scaling up to a sentence: The temporal unfolding of conceptual specificity and sentential polarity effects in left anterior temporal and medial prefrontal cortex

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Research on both single-word concepts as well as minimal two-word phrases has implicated the left anterior temporal lobe (LATL) as a site of conceptual integration with robust sensitivity to conceptual specificity (e.g., Hodges et al., 1992; Mummery et al., 2000; Binney et al., 2010; Westerlund & Pylkkänen, 2014; Zhang & Pylkkänen, 2015). However, this research has not yet been scaled up to a sentence and thus the impact of conceptual specificity on natural sentence comprehension is not known. Here we built on the finding that concept specificity modulates combinatory LATL activity in two-word phrases (Westerlund & Pylkkänen, 2014; Zhang & Pylkkänen, 2015) and embedded such phrases into the subject position of full sentences. Additionally, half of the determiners of the subjects evoked sentential negation while the other half did not, with the aim of eliciting semantic specificity effects at a level higher than concept composition (given that negated sentences are semantically very uninformative). In all, the design contained three factors, determiner polarity (a vs. no), adjectival modification (adj vs. no-adj) and noun specificity (specific vs. general), with MEG analyses focusing on activity at the noun and the words presented after the noun (pattern of each trial: Determiner-(Modifier)-Noun-Copula-Verb; stimulus example: a/no (green) reptile/lizard is resting). To ensure attention, participants performed a matching task on the sentences and subsequent pictures that either matched or mismatched the sentence. MEG analyses targeted the LATL as well as the ventromedial prefrontal cortex (vmPFC) as a possible site of later higher-level semantic effects (e.g., Bemis & Pylkkänen, 2011; Pylkkänen & McElree, 2007). Both the LATL and the vmPFC were sensitive to determiner polarity, showing larger amplitudes for positive than negative determiners. The LATL effect occurred early at ~250-300 ms after the onset of the noun, while the vmPFC trended towards larger amplitudes for the positive sentences throughout the sentence, with the most significant increase occurring at the end, at 450-550 ms after the onset of the sentence-final verb. In the LATL, noun specificity did not reliably affect amplitudes on the noun itself, but rather on the next word, the copula, on which significantly larger amplitudes were observed when the preceding noun was specific. This conforms to prior findings from a two-word study where the specificity of the first word was shown to modulate LATL amplitudes of the second word, with no immediate effects on the first word (Zhang & Pylkkänen, 2015). In the current data the same trend was also still observed on the verb. In the vmPFC, a subtle specificity effect with the same trend (specific > general) was observed only during the copula presentation, but not later. Our results suggest a division of labor between the LATL and vmPFC in semantic processing: The determiner polarity was first processed by the LATL locally and eventually by the vmPFC at the sentential level, while it is more likely that concept specificity is mainly processed by the LATL locally.

F31 Inferential processing in natural reading vs. RSVP: a FRP vs. ERP study *Jonas Diekmann[1], Dietmar Roehm[1]; [1]University of Salzburg*

While being confronted with the task of comprehending a narrative, inferential linking processes are conducted to connect given information to either the subject's world knowledge or a preceding context. Previous ERP-studies have shown that the processing of varyingly strong inferential relations results in effects within the N400's as well as the P600's time window [1,2,3]. We carried out two experiments to extend previous research [2] by investigating the influence of discourse prominence on inferential processing. We used a 3x2 design with three context types that introduced either a necessary (HIGH), plausible (MED) or inducible (LOW) inferential relation between an implicit actor/instrument and a described event. Afterwards that actor/instrument became explicit in the target sentence. Context sentence: HIGH: Am Freitag wurde am Zentrum ein Student erschossen. On Friday was at the center a student shot. MED: Am Freitag wurde am Zentrum ein Student ermordet. On Friday was at the center a student killed. LOW: Am Freitag wurde am Zentrum ein Student tot aufgefunden. On Friday was at the center a student dead found. Target sentence: ACTOR: Die Presse berichtete, dass der Schütze bereits gefasst wurde. The press reported, that the shooter already arrested was. INSTRUMENT: Die Presse berichtete, dass die Pistole aus Armeebeständen stammte. The press reported, that the pistol from army stocks was. In Experiment 1 (N=34) we used a natural reading paradigm and analyzed participant's eye-movements and FRPs. With respect to the participant's eye-movements we found increased total reading times for discourses including difficult inferences. Difficult inferences also resulted in significantly increased regression-path durations and amount of fixations. Thus, as readers engaged in the processing of entities that were less plausible related to a preceding context, they spent more time with regressive eye-movements while trying to maintain discourse coherence. In addition to this the context manipulation led to reduced total reading times and amount of fixations for discourses including inferable actors as compared to instruments. With respect to the electrophysiological measurements FRPs related to the first fixation on a critical noun revealed a N400 effect for more difficult inferences versus less difficult inferences. The inferential processing of entities associated with the thematic role of an instrument elicited a P600 effect in comparison to the inferential processing of an actor. In Experiment 2 (N=24) the same critical material was presented word-by-word to allow for a comparison between natural reading and RSVP. We found that the manipulation of inferential relation and thematic role elicited a N400 as well as a P600 effect. Taken together, in a natural reading paradigm the absence of a P600 effect for more difficult inferences might indicate that inferential processing in natural reading is executed in a more divergent manner, as compared to a RSVP paradigm. Due to the increased amount of time available within a RSVP paradigm, sufficient cognitive resources might be obtainable to immediately integrate new information into a previously established situation model. References: [1] Burkhardt, 2006. Brain and Language. [2] Burkhardt, 2007. Neuroreport. [3] Kuperberg, Paczynski, Ditman, 2011. Journal of Cognitive Neuroscience

F32 Motion-based cues for animacy do not trump actor prototypicality in language comprehension *Svenja Luell[1], Franziska Kretzschmar[1], Phillip M. Alday[2], Friederike Seyfried[3], Ina Bornkessel-Schlesewsky[2], Matthias Schlesewsky[1,3]; [1]Johannes Gutenberg-UniversityMainz, [2]Justus-Liebig-University Giessen, [3]University of South Australia*

Motion cues provide the human brain with a salient means of categorising entities as animate or inanimate. Biological motion in particular stands out for its high effectiveness in signalling the animate nature of an observed entity. Previous neuroimaging studies suggest that the brain circuits underlying the processing of biological motion in action perception -- and particularly the posterior superior temporal sulcus (pSTS; e.g. Pelphrey et al., 2005) -- also contribute to the processing of animacy in language comprehension (Grewe et al., 2007). One possible interpretation of this functional-anatomical convergence between action and language is that common underlying mechanisms support the understanding of actions performed by animate and inanimate event participants in both domains. The present study set out to examine these mechanisms in more detail by means of an event-related potential (ERP) study on language comprehension. Specifically, the study sought to dissociate the contributions of motion-based and entity-based cues to the neural processing of animacy when these are separated in time in the signal. Thirty-six healthy, young, right-handed native speakers of German read sentences of the form "Es schwimmt/driftet ein Tourist/Frachter über den See..." ("There swims/drifts a tourist/trawler over the lake,..."). The sentence structure ensured that motion information as conveyed by the verb was always available prior to the subject (or actor participant) of the sentence, thus setting up an expectation about the animacy of that participant. Verbs were biased towards animate ("swim") or inanimate motion ("drift") and the subject argument was also animate or inanimate. An additional set of conditions employed the same manipulation but placed the directional PP in the sentence-initial position prior to the verb (e.g. "Across the lake swims/drifts ..."). Critical nouns and verbs were matched for frequency and length and sentences were pretested for plausibility and degree of semantic fit between subject and verb. Participants performed a probe recognition task following each sentence. At the position of the actor ("a tourist/ a trawler"), repeated measures ANOVAs on mean ERP amplitudes revealed an interaction between verb type (animate vs. inanimate

motion biased) and actor animacy (inanimate vs. animate) between 450 and 550 ms post noun phrase onset, which resulted from an increased, broadly distributed negativity for inanimate versus animate-biased verb conditions in sentences with animate actors. These results are indicative of an inherent asymmetry in the use of motion-based and entity-based animacy information in language processing: in the context of explicit, predictive motion cues, there was no comparable (cross-over) mismatch effect for animate entities in the context of inanimate-biased verbs and inanimate entities with animate-biased verbs. Rather, the mismatch effect was restricted to animate -- and thereby potentially prototypical -- actors, thus supporting the notion of actor-centred language comprehension (e.g. Bornkessel-Schlesewsky & Schlesewsky, 2009, 2013). This actor-centredness may provide an explanation for the special status of biological motion in action recognition and social cognition, since it allows us to efficiently identify potential actors (and causers) in the world around us.

F33 Investigating the Neurocognitive Mechanisms Underlying Truth-Conditional and Logical Semantic Aspects of Sentence Processing: An ERP Study

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OVERVIEW: The present event-related brain potentials (ERP) study investigated questions concerning the neurocognitive mechanisms and temporal dynamics underlying the processing of two manifestations of truth-conditional/logical semantic anomalies: namely, (1) logical contradictions/hyponymy violations (e.g., Because Sarah loves all vegetables, she decided to buy #apples/broccoli at the store); and (2) unlicensed negative polarity items (NPIs) (e.g., Surprisingly, Frank did finish #any of his work yesterday) – alongside (3) 'classical' conceptual semantic violations, during written sentence comprehension. BACKGROUND: Previous ERP studies have reported a mix of ERP effects elicited by logical contradictions, the most consistent being the absence of N400 modulation as a function of truth-value. We argue, however, that the validity of previous research findings may have been compromised due to methodological weaknesses related to experimental design, data analysis, and failure to control for priming effects. METHODS: To address these concerns, we tested 26 native English speakers using a balanced and rigorously controlled semantic violation paradigm in which the factors PRIMING and TRUTH-VALUE were orthogonally crossed. The subject task required participants to judge the acceptability of the sentences on a five-point scale (1: 'perfectly acceptable,' 5: 'completely unacceptable'). Participants were instructed to attend to all aspects of language (i.e., 'grammar, meaning, and logic') while processing the sentences and as a basis for their acceptability judgments. RESULTS: (1) Our study demonstrated that although significant inter-individual variability in ERP responses to logical contradictions was observed, truth-value was indeed reflected online in the local N400 time window in a subset of participants – an effect that was moreover strikingly similar (in terms of scalp distribution and size) to the large, predicted N400 effects elicited by conceptual semantic phenomena observed in our data. Logical contradictions additionally elicited a late left anterior negativity (L-LAN) across all participants – an effect that was not modulated by working memory factors. (2) By contrast, unlicensed NPIs elicited a P600 component that was present only in high working memory span participants. Taken together, these findings suggest that not all anomalies classified as logical semantic in nature are reflected by the same ERP profile. (3) Finally, all three classes of violations elicited a robust, N400-like negative component time-locked to the sentence-final word. The amplitude of this late N400 component was moreover found to pattern closely with acceptability ratings between conditions: A bivariate correlation revealed a highly significant negative correlation between mean absolute N400 amplitude and mean acceptability ratings across sub-experiments, $r(6) = -.92$, $p = .001$, indicating that as the N400 became larger, acceptability ratings approached the 'completely unacceptable' end of the rating scale. These negativities therefore appeared to reflect the degree of perceived acceptability of the sentences, independent of the type of semantic anomaly evaluated. FUTURE DIRECTIONS: Future research should be directed toward determining the factors that distinguish participants who show an N400 effect as a function of truth-value from those who do not, and understanding the functional significance of late N400-like effects observed at sentence offset.

F34 Using neurobiologically-motivated features to investigate the semantic composition of adjectives with nouns

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Language is not just isolated words; their meanings are influenced by their surroundings. This process of semantic composition is explored in several fields. However, within psychology and neuroscience most research focuses on individual words instead. Both how our brains compute semantic composition and how that meshes with behavior are open questions. Since many word meanings are learned through sensory-motor information, grounding semantic composition in the brain's perceptual systems would allow us to address these questions. A large literature (e.g. Binder's work (e.g. Fernandino et al., 2015)) suggests that perceptual systems contain semantic information that can be extracted using neural decoding (e.g. Anderson, Murphy & Poesio, 2014). Within semantic composition research, adjective-noun composition has been relatively well-studied due to their concrete nature, making this ideal for exploration of composition of these neurobiologically-based features. Fyshe, Talukdar, Murphy, and Mitchell (2015) have used large corpora to construct co-occurrence vectors to represent the adjectives, nouns, and adjective-noun phrases, matching the meanings of the composed

phrases using a combination of corpus information. They utilized the phrase output vectors and MEG data to predict unseen phrases given novel MEG data. Chang, Cherkassky, Mitchell, and Just (2009) conducted similar research using co-occurrence vectors and fMRI, finding that multiplication of the vectors representing the adjectives and nouns best reconciled with the brain activity findings. These studies utilized large corpora to create vectors for the meanings of the adjectives and nouns, which does not reflect how humans learn language and likely not how we store the meanings of words (Aitchison, 2012). This current work uses neurobiologically-based features of meaning (from Fernandino et al., 2015: sound, color, manipulation, motion and shape) to form vectors for the adjectives, nouns, and adjective-noun phrases. The phrases were formed using all combinations of our selected adjectives and nouns. Using Amazon's Mechanical Turk, participants rated how much each of the words and phrases evoked the features. Each item is a vector of the averaged values of each feature. Although there are several potential composition functions suggested in the literature, the two most successful, easily interpretable functions have been multiplication (e.g. Chang et al., 2009) and addition (e.g. Mitchell & Lapata, 2010). Following this, we calculated what the feature vector should be for each adjective-noun pair using element-wise multiplication and element-wise addition. All actual phrase vectors (from the human judgments) were ranked using Euclidean distance from the calculated vector and the rank of the correct pairing was recorded. Both multiplication and addition surpass chance at matching the correct phrase, but addition outperformed multiplication (addition = 7.6/60, multiplication = 13.4/60). Addition allows the adjective to weight the important sensory-motor attributes for the noun. Addition is a better semantic composition function than multiplication when using neurobiologically-based features to represent adjectives and nouns. Since it has been shown that these sensory-motor attributes have known brain regions associated with them (Fernandino et al., 2015), we can predict that addition will also be successful when using brain activity (from fMRI) as the representations of the adjectives, nouns, and phrases.

F35 fMRI activity during a spontaneous dialogue task *Emilio R. Tamez[1], John C. Trueswell[1], Marc N. Coutanche[2], Sharon L. Thompson-Schill[1]; [1]University of Pennsylvania, [2]Yale University*

Most neuroscientific studies of language production and comprehension to date have relied on careful experimental control to isolate specific stimulus- or process- related neural activity. While these paradigms are thought to mimic natural language processing, it remains an open question whether the results of those studies can be generalized to everyday language use. In order assess the extent to which those results apply in a real-world context, much of the control exerted in those paradigms must be stripped away. In addition, there remain some aspects of natural language use, such as turn taking or interrupting, that are most suitably studied in a naturalistic, spontaneous manner. Here, we present a novel paradigm that facilitates the production of spontaneous, dialogical speech in an fMRI scanner. Right handed, native English speakers were placed in a 3T fMRI scanner with a 32- channel head coil. Noise cancelling microphone and headphones were used. All dialogue was recorded from outside of the scanner. Subjects were presented with arrangements of numbered shapes made out of tangrams. The shapes were designed to vary in how easily they could be identified and described as familiar objects. The spatial positions of the shapes were pseudo-randomized. Subjects were paired with an experienced confederate. Both the confederate and the subject were naive to each other's screen. Subjects were instructed to guide the confederate through the process of identifying each shape, in order, by its physical characteristics, ascribing a name to the shape by likening it to a real object, and conveying the location of the shape so that the confederate could place the shape in the correct location on their screen. While some instruction was given to the subjects to improve early performance, little control was exerted over the precise strategies used to complete the tasks, or the form of language used. The interactions between the subject and confederate took the form of dialogue comprised of spontaneous utterances. Each subject completed a practice screen to develop a strategy and become comfortable working with the confederate. They then completed 5 screens in the scanner. Speech was annotated for variables of interest, including properties of the shapes on the screens (e.g. if they are animate or not), which speaker produced each utterance, and the purpose of each utterance. fMRI data was analyzed using a GLM with annotations as explanatory variables. We have validated our results against those of previous fMRI studies that used traditional experimental techniques. Therefore, our novel paradigm provides a means to investigate the neural substrates of language use in a naturalistic dialogical scenario. For example, we have found differences in the neural substrates of dialogical speech when the goal of speech changes: the neural activity during dialogue aimed at establishing a name for a shape is distinct from when the goal is to describe the location of the shape. This paradigm therefore allows us to observe concomitant neural processes at work during spontaneous dialogue, including some aspects of language that cannot be studied using traditional experimental designs.

F36 Context matters: ERP evidence provides new insights into the mechanisms of generating and updating predictions in real-time. *Sarah Tune[1], Steven L Small[1]; [1]Department of Neurology, University of California Irvine*

Introduction Language comprehension is guided by number of default processing strategies that generate predictions about the unfolding of linguistic input in time and sequence-independent conceptual combinations of elements, respectively [1]. One particularly robust structural prediction assumes correspondence between the

first nominal argument in a sentence and its interpretation as both grammatical subject and instigator of the described action. In addition, we generally expect the assignment of thematic roles to participants involved in a given event to conform to our knowledge about the state of affairs in the real world. In English sentences, these assumptions are validated most of the time, but when they are not, e.g., in object-first sentences, the application of default strategies can lead to prediction errors and incomplete or inaccurate interpretations [2]. The present study investigated the role of different linguistic contexts on the processing of sentences that confirmed or disconfirmed default predictions about their sequential structure and/or the described thematic role assignment. Methods We conducted an auditory ERP experiment (n=24) for which we paired subject- and object-initial it-cleft sentences (factor WORD ORDER) that expressed expected or unexpected thematic relationships between two animate nouns and a verb (factor PLAUSIBILITY) with three different context sentences (factor CONTEXT TYPE): A neutral context that did not change default predictions, a "syntactic" context that confirmed or updated word order predictions, and a "semantic" context that strengthened or reduced expectations about the plausibility of the following sentence. To ensure ecological validity, context sentences only provided information that would facilitate the correct interpretation of the subsequent target sentence but never contradict it. Participants listened to these sentence pairs and indicated via button press which of the involved nominal arguments corresponded to the actor. The ERP analysis focused on the electrophysiological responses to the first noun (N1), the verb (V), or the second noun (N2) of the target sentences. We examined the impact of the different context types by investigating whether they modulated the neural responses to each of the four target sentences. Results Overall, the results showed a reduction in N400 amplitude at the position of V and N2 (in some cases also N1) for target sentences following syntactic and semantic contexts compared to those following neutral context. Moreover, the attenuation was strongest for target sentences that contradicted default expectations. We also observed a graded N400 effect for the position of the verb that appears to reflect the relative strength of predictions: the amplitude was largest for neutral contexts and smallest for syntactic contexts that elicit precise predictions about the position and identity of the verb. Conclusion Our results attest to the application of predictive coding mechanisms [3] in language processing that inform and update the output of internal models based on prior input. We argue that the observed modulations of N400 amplitude reflect the relative levels of uncertainty associated with the current input [4]. References [1] Bornkessel-Schlesewsky et al. (2015). TiCS. [2] Ferreira (2003). Cognitive Psychology. [3] Friston (2005). Phil. Trans. R. Soc. B [3] Frank et al. (2015). Brain & Language.

F37 ERP effects of sentential context in semantic number interpretation

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We used event-related brain potentials (ERPs) in a dual task study to investigate how comprehenders interpret number in different semantic contexts. Borrowing from recent behavioural work (Berent et al., 2005; Patson & Warren, 2010), 24 participants made judgments on the number of words presented in single sentences appearing on a computer screen. Equal numbers of one- vs. two-word chunks were presented throughout the experiment. Participants indicated their decision as to whether one or two words appeared by pressing "1" or "2." We employed a 3 X 2 design. The subject noun was either universally quantified or not (referential), e.g., (i) Every kid climbed a tree vs. (ii) The kid climbed a tree. The direct object was either indefinite singular, see (i), (ii) above, or definite singular/plural, as in (iii)/(iv) Every/The kid climbed the tree and (v)/(vi) Every/The kid climbed the trees. Number judgments were required at tree(s), which was always presented alone (and was never sentence-final). We hypothesized that neurophysiological responses to a single noun on the screen, marked as morphologically plural, e.g., trees, (requiring a "1" response on the number judgment task) would empirically differ from responses to morphologically singular tree. Furthemore, this hypothesis was extended so that in quantifier scope ambiguous sentences, nouns such as tree, which though morphologically singular, would be interpreted as conceptually plural in (i) vs (ii) above. A P300 effect was found at the critical word tree(s) where amplitudes differed depending on the presence or absence of a quantifier, not on morphological marking of plural. In addition, sentence final words revealed a P200 effect which was left lateralized, for (ii) The kid climbed a tree in the autumn vs. (i) Every kid climbed a tree in the autumn. We interpret this finding as an effect of pragmatic congruency: the former sentence condition results in the semantic categoization of tree as unambigously singular , which would be congruent with an "action context" of pressing the button "1". In contrast, sentences beginning with Every result in number interpretation at tree as underspecified . As a consequence, that interpretation would be less congruent with the action of pressing the "1" button. This difference in congruency of interpretation and action accounts for the difference in left lateralized P2 amplitudes.

F38 "Before" and "after": investigating the relationship between temporal connectives and chronological ordering using event-related potentials

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A well-known psycholinguistic phenomenon is that sentences like "Before B, A" elicit greater processing cost (reflected by a sustained frontal negativity in event-related potentials) than sentences like "After A, B" (Münte et

al., 1998). This effect has traditionally been attributed to the fact that the "before" sentence presents two events in the opposite of the chronological order they actually occured in, whereas the "after" sentence mirrors the actual chronological order of the events. There are, however, several other semantic differences between "before" and "after" (e.g., Beaver & Condoravdi, 2003); among these, Xiang and colleagues (2014) have recently argued that presuppositions about veridicality can account for this processing cost. "After" presupposes that the event in the temporal clause must have happened, whereas "Before" does not (i.e., the fragment "Before the bomb exploded..." can be continued with "the police defused it"). Therefore, the processing cost observed could be because the "before" clause introduces ambiguity regarding whether or not the event described in the temporal clause actually happened, whereas the "after" clause is unambiguous. In the present study we test these accounts by recording event-related potentials elicited by temporal clauses in sentence-initial position ("Before the psychologist submitted her article, the journal changed its criteria" and "After the psychologist submitted her article, the journal changed its criteria ") as well as sentence-final position ("The journal changed its criteria before the psychologist submitted her article" and "The journal changed its criteria after the psychologist submitted her article"). The traditional account based on chronological ordering would predict a reversed effect for sentence-final temporal clauses: "B after A" should be more difficult since it presents the events out of chronological order. The account based on presuppositions of veridicality would either predict the same effect for both sentence-final and sentence-initial temporal clauses (sustained negativity for "before" clauses), or no effect in sentence-final temporal clauses (since by the time the temporal clause is encountered in this case, the participant has already read the matrix clause which typically disambiguates whether or not the event in the temporal clause happened). Participants (preliminary sample of 20) read 160 sentences (adapted from Ye et al. [2012] and Xiang et al. [2014], plus 160 unrelated fillers) word-by-word for comprehension. Within a given item, the temporal clause and matrix clause were not causally related to one another, and most did not include anaphoric relations between the clauses. Sentence-initial "before" clauses ("Before B, A") elicited a frontal sustained negativity, which lasted throughout the clause, compared to sentence-initial "after" clauses ("After A, B"). On the other hand, sentence-final "after" clauses ("B after A") did not elicit this sort of effect relative to sentence-final "before" clauses ("A before B"). We take this result to be more in line with the account based on presuppositions of veridicality than the account based on chronological ordering. This finding adds to existing evidence that the parser is strongly incremental and uses many sources of information—in this case, the veridicality presupposition associated with "after"—to constrain processing as discourse unfolds.

F39 The role of discourse context in pronoun resolution

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Native Spanish speakers and highly-proficient English-Spanish bilinguals are sensitive to local violations of grammatical gender and number between the antecedent and its pronoun when presented in the context of a single clause (e.g., "Antes de comer la manzana (fem.sing), Maria lo (masc.sing) peló con el cuchillo"; "Before eating the apple, Maria peeled it with the knife") as revealed by a P600 component (Rossi et al., 2014). Moreover, recent research has suggested that broader discourse incongruency makes lexical integration more difficult, while discourse congruency facilitates it (Nieuwland & Van Berkum, 2006). However, relatively few studies have investigated how information provided in a broader discourse context might guide morpho-syntactic processing in native and bilingual speakers (Brown et al., 2000; Van Berkum et al., 1999). The present study uses ERPs to test 1) whether a local pronominal violation between an antecedent and its pronoun can be modulated by linguistic information provided in a preceding discourse context and 2) whether performance differs between native Spanish speakers (n=23) and English-Spanish bilinguals (n=21). In this study, target sentences (containing a grammatical mismatch between an antecedent and the object pronoun) were preceded by context sentences in which two possible antecedents were introduced which could or could not match in grammatical gender the pronoun presented in the target sentence. In the baseline condition (Table 1: example 1), neither of the two antecedents matched the incorrect pronoun in the target sentence. However, in the critical condition, (Table 1: example 2) one of the two antecedents matched the incorrect pronoun in grammatical gender, possibly providing a potential alternative referent for the locally ungrammatical pronoun. We hypothesized that if speakers use discourse context information and integrate it on-line, we should expect a modulation (e.g., reduction) in the P600 amplitude. For bilinguals, results show a significant decrease of the P600 component measured at the target sentence pronoun only when preceded by a context that contained a possible antecedent. For monolinguals, no modulation of the P600 was observed. However, behavioral and ERPs results reveal that a subset of monolingual speakers (n=12) actively utilized the information provided in the context to re-analyze morpho-syntactic information in the target sentence, as revealed by a reduced P600. Overall, these results suggest that bilinguals actively utilize grammatical information provided in the sentential context predictively to help morpho-syntactic analysis, while only a subset of monolingual Spanish speakers does. It could be hypothesized that bilingual speakers rely more heavily than native speakers on the use of discourse context information to process grammatical dependencies, especially when those very dependencies in

the second language rely on grammatical structures that are not present in the native language. Table 1: Example of stimuli CONTEXT SENTENCE 1 Ayer Ana fue al mercado. Compró una manzana(fem) y una banana(fem). 2 Ayer Ana fue al mercado. Compró una manzana(fem) y un mango(masc). TARGET SENTENCE 1 Antes de comer la manzana(fem), Ana lo(masc) peló con un cuchillo. 2 Antes de comer la manzana(fem), Ana lo(masc) peló con un cuchillo. Legend: Fem: feminine; Masc: masculine

Language Development, Plasticity, Multilingualism

F40 How language shapes the brain: cross-linguistic differences in structural connectivity *Tomás Goucha[1,2], Alfred Anwander[1], Emmanuel A Stamatakis[3,4], Lorraine K Tyler[3], Angela D Friederici[1,2]; [1]Max Planck Institute for Human Cognitive and Brain Sciences, [2]Berlin School of Mind and Brain, Humboldt University of Berlin, [3]Centre for Speech, Language and the Brain, University of Cambridge, [4]Division of Anaesthesia, School of Clinical Medicine, University of Cambridge*

Language contributes to the architecture of the human brain. Whereas some of the perisylvian white matter pathways seem to be hard wired, other develop in parallel with language acquisition. However, studies on language-related neuroplasticity have focused on developmental aspects that are transversal to all languages, ignoring possible language differences. For example, languages like German require online processing of abstract structural information (morphosyntax), anatomically supported by the dorsal arcuate fascicle, whereas languages like English more strongly engage lexical-semantic processing, which involves predominantly ventral fibre tracts. We therefore investigated how languages with different processing demands shape the language network. We compared diffusion MRI scans for three age, sex and education-matched groups with three different native languages: German, English and Mandarin Chinese. Anatomical regions of interest (ROIs) were defined in a template generated for this subject group, both in the inferior frontal gyrus and in the anterior and posterior superior and middle temporal gyri. Using probabilistic fibre tracking, we computed anterior-posterior, fronto-temporal and whole-brain connectivity of these ROIs and compared the respective connectivity strengths and maps of connection probability. We found higher dorsal fronto-temporal connectivity in the German group than in both the English and Chinese groups. Conversely the English group showed higher ventral connectivity between the posterior temporal cortex and anterior frontal regions. In turn, the medium and short-range connectivity to the neighbouring temporal cortex and to the inferior parietal lobe was higher in Chinese speakers. These differences in connectivity indeed reflect the particular demands of the native language of the individuals as hypothesised. This study is a first indication that the wiring of language-relevant areas depends on the specific demands of each language. Further studies taking into account the genetic background and functional connectivity are needed to understand the implications of the study.

F41 Gamma band functional connectivity mirrors the dynamics of novel grammar learning *Olga Kepinska[1,2], Ernesto Pereda[3], Johanneke Caspers[1,2], Niels O. Schiller[1,2]; [1]Leiden University Centre for Linguistics, [2]Leiden Institute for Brain and Cognition, [3]University of La Laguna*

High-level cognitive functions, such as language, necessarily depend on synchronized activity of distributed brain areas (cf. e.g. Friederici & Singer, 2015) and investigations into the interactions of different areas and the networks arising from them are invaluable for understanding the neural underpinnings of human communication. The network approach seems particularly promising for investigating individual variability, one of the main interests of this study. Our goal was to investigate the initial phases of Second Language Acquisition (SLA), when completely new linguistic input is identified, analyzed, processed, and – with various levels of success and different degrees of efficiency – learned. We were interested in the way such a learning process proceeds on neural level and in the mechanisms responsible for inter-individual variability. We concentrated on language analytical ability (LAA) (one of the components of language aptitude, defined within the field of SLA as a specific ability for learning languages) due to its importance for learning outcome in a variety of settings, including immersion classroom and lab. We wanted to explore how LAA influences initial phases of L2 acquisition and synchronization properties of EEG signal measured during such a learning task. An Artificial Grammar Learning (AGL) paradigm, based on Opitz et al. (2011), was used. We investigated whether participants with different degrees of LAA (measured prior to the experiment) exhibit different connectivity patterns during acquisition of novel grammar and explored the dynamics of the learning process as reflected in brain oscillations in the gamma band frequency (>30 Hz). Two groups of participants, High LAA (N=22) and Average LAA (N=20), performed an AGL task consisting of learning and test phases, during recording of EEG signals from 32 cap-mounted electrodes. Epochs recorded during learning phases were analysed employing a bivariate, frequency-specific index of phase synchronization termed Phase Locking Value (PLV, Mormann et al., 2000). Behavioral data showed learning effects in both groups, with a steeper learning curve and higher ultimate attainment for highly skilled learners. Besides, we found group differences in the global PLV, in particular in the first learning block: High LAA participants exhibited higher gamma coherence. Furthermore, there was a linear increase of the global PLV during the task, which mirrored the behavioral learning curve, and no between-group differences in later stages of learning. Initial

value of gamma phase synchronization was thus predictive of learning success and language learning skills. The study provides evidence for a relation between successful SLA and gamma band functional connectivity and contributes to the understanding of the neurophysiology of individual differences in SLA. || Friederici, A.D., & Singer, W. (2015). Grounding language processing on basic neurophysiological principles. Trends in Cognitive Sciences, 19(6), 1–10. Mormann, F., Lehnertz, K., David, P., & Elger, C.E. (2000). Mean phase coherence as a measure for phase synchronization and its application to the EEG of epilepsy patients. Physica D, 144(3), 358–369. 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, 5(February), 8.

F42 Differential changes in the dorsal language pathway for general development and L2 learning

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The cortical regions supporting language functions are mainly connected by dorsal and ventral language pathways, and the anatomical properties of these pathways may reflect certain maturational factors. Previous studies have suggested that the ventral pathway matures more rapidly than the dorsal one in infants and children. However, it has not been clarified how far these pathways change for general development and second-language (L2) learning in juvenile ages. Here we focused on the arcuate fasciculus (Arcuate) of the dorsal pathway and the inferior fronto-occipital fasciculus (IFOF) of the ventral pathway. We recruited participants in three groups: 14 junior high-school students [Jr group, age: 13−14], 18 senior high-school students whose performances in L2 tasks matched those of the Jr group [Sr (Low) group, age: 16 −17], and age-matched 15 senior high-school students with higher performances [Sr (High) group, age: 16−17]. The tasks were error-detection regarding English syntax or spelling. In both tasks, the Sr (High) group showed higher accuracy and shorter RTs than the Sr (Low) group ($p < 0.05$, one-way t-tests), while no difference in performance was observed between the Sr (Low) and Jr groups. Diffusion MRI scans were conducted on a 3T scanner (GE Healthcare, b-value = 4,000 s/mm2), and diffusion-weighting was isotropically distributed along 60 diffusion-encoding gradient directions. The Arcuate and IFOF were successfully reconstructed in both hemispheres of every participant using FSL [Oxford Centre for Functional MRI of the Brain's (FMRIB) Software Library 4.1.9]. After normalizing each tract into the Montreal Neurological Institute (MNI) coordinates, we selected regions of interest (ROIs) that minimized variances among participants, thereby excluding the branching or curved parts of the tracts that showed great individual variances. In the ROI of each tract, we then measured the mean thickness and fractional anisotropy (FA). One-way repeated-measures analyses of variance with the group indicated significant effects of group for the thickness of the Arcuate in both hemispheres, as well as for FA in the left Arcuate ($p < 0.05$), but not for the thickness or FA in the IFOF ($p > 0.08$). As regards the left Arcuate, the thickness was significantly larger for the Sr (High) and Sr (Low) groups than the Jr group, whereas FA was significantly higher for the Sr (High) group than the Sr (Low) and Jr groups ($p < 0.05$, one-way t-tests), suggesting differential changes for general development and L2 learning. Regarding the right Arcuate, the thickness in the Sr (High) group was significantly larger than that of the Jr group, suggesting changes for general development or L2 learning. These results indicate that the white matter plasticity in juvenile ages was more prominent in the dorsal pathway than the ventral pathway.

F43 Language learning efficacy in adults is predicted by the electrophysiological markers of native language processing

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Studies of adult language learning suggest that an individual's cognitive abilities and native language characteristics may be linked to foreign language aptitude. However, little is known about how native language processing could affect one's potential to become proficient in a new language. Despite behavioral fluency, adults display large variability in electrophysiological responses to inputs in their native language. In this study, we use electrophysiology to connect adults' native language processing to their success in learning a novel language at the individual level. Thirty-eight adult native English speakers completed an auditory sentence acceptability judgment (SAJ) task in English while 32-channel EEG was recorded. Half of the critical sentences were either semantically incongruent or grammatically incorrect. On the same day after the English task, as well as on each of the following 3 days, participants watched an animated training video while listening to pre-recorded sentences describing the scenes. The sentences were spoken in a miniature artificial language (MAL) containing 4 novel verbs, 30 novel nouns, 2 noun-specific particles, and 2 verb-agreement suffixes. All of the sentences used subject-object-verb order. Daily language training sessions were followed by proficiency tests, including a four-alternative forced choice vocabulary test and a SAJ task in MAL that probed semantic congruency and morphosyntactic rules. As expected, participants performed highly accurately in the English SAJ task, with a significant semantic congruency effect on their N400 amplitude and a significant grammaticality effect on their P600 amplitude, time-locked to the onset of the error or its correct counterpart. After the 1st day of MAL exposure, participants were able to reliably judge semantic violations in the new language. After the

4th day, they performed reliably above chance in detecting both semantic and syntactic errors. Most interestingly, individuals' N400 and P600 effect sizes measured during English sentence processing predicted their MAL proficiency. N400 effect size was significantly correlated with initial MAL vocabulary learning and with accuracy in detecting MAL semantic violations on both the 1st and the 4th days. P600 effect size was significantly correlated with detection of MAL morphosyntactic errors on the 1st but not the 4th training day. Consistent with previous research (Tanner & Van Hell 2014), individuals varied in the polarity of their responses to English violations. Those with a negativity dominance to semantic anomalies and those with a positivity dominance to syntactic anomalies tended to perform better in detecting semantic and syntactic anomalies in MAL, respectively. Together, results show that individuals' N400 and P600 responses to English anomalies predict learning of the semantic and syntactic features, respectively, of a novel language. This suggests that the neural correlates of native language processing are related to how adults encode and/or retrieve newly learned linguistic knowledge.

F44 MEG correlates of short-term grammatical plasticity: Grammatical number processing in Spanish learners of Basque

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The present study used magnetoencephalography (MEG) to investigate whether adult learners of a second language would show sensitivity to L2 morphosyntactic violations after a short period of training. We trained Spanish native speakers on a small fragment of Basque grammar that encodes number. Participants (n=17) were exposed to violation and control phrases in Basque in three phases (pre-test before training, three training blocks, and a generalization-test), and in Spanish pre-training and post-training. In each Basque phase, participants listened to short Basque phrases and judged acceptability. During the three training blocks, subjects were given the rule for the plural, and feedback was provided after each response. During the pre-test and generalization-tests, participants did not receive any feedback. In the pretest behavioral discrimination was below chance and we found no electrophysiological (ERF) differences between violation and control stimuli. From the first training block participants were able to correctly classify control and violation stimuli and there was a greater evoked response to the violations. Although the timing of the electrophysiological responses was consistent with their L1, the magnitude was smaller for L2 and the topographical distribution differed from the L1. While L1 effect was bilaterally distributed on the auditory sensors, the L2 effect was localized at right frontal sensors. During training blocks two and three, the violation-control effect size increased and the topography evolved to a more L1-like pattern. Moreover, this pattern was maintained in the generalization test. We conclude, that rapid changes in neuronal responses can be observed in adult learners of a simple morphosyntactic rule, and that native-like responses can be achieved at least in small fragments of second language.

F45 First-language attrition in morphosyntactic processing: More than L1-proficiency effects

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"First-language (L1) attrition" offers new insight on neuroplasticity and the role of language experience in shaping the neurocognitive correlates of second-language (L2) processing. Contrary to the majority of L2-learners, "attriters" are individuals for whom advancing L2 proficiency/exposure comes at the cost of limited exposure and decreased automaticity in the L1, as they experience a shift in language-dominance due to particular socio-linguistic circumstances (e.g., immigration). To date, the neurocognitive mechanisms underlying L1 attrition are largely unexplored. Using event-related-potentials (ERPs), we examined L1-Italian morphosyntactic-processing in 24 first-generation immigrants who reported changes in L1-proficiency after a prolonged period in the L2-English environment, compared to 30 native-controls in Italy. Rather than testing salient violations involving only local mismatches, we manipulated number-agreement between three inflected constituents and examined ERP-responses on two of these (subject, verb, modifier). A previous study (Molinaro et al., 2011) showed that, when a verb mismatched in number with the subject, Italian monolinguals "repaired" the error and assigned the number value of the verb to the rest of the sentence. The subsequent modifier was perceived as a violation if it clashed with the verb (xyx), but not if it clashed only with the subject (xyy). We assessed whether (1) Attriters differed from Controls in their online detection and/or repair of number-agreement violations, and whether (2) differences in processing were modulated by L1-proficiency, L2-to-L1 transfer and/or characteristics specific to attriters' socio-linguistic circumstances. Our results revealed that L1-proficiency modulated ERP-effects on the modifier – lower L1-proficiency individuals elicited a smaller, less frontal and longer-lasting N400 and a smaller P600 than high-proficiency individuals. However, we also found differences between the two groups of native-Italian speakers. On the verb, Controls elicited a small left-temporal negativity, whereas Attriters elicited a more robust and broadly-distributed N400. Differences in amplitude and distribution were not due to component overlap, as the groups were indistinguishable in the frontal positivity that followed. Rather, Attriters seemed more likely than monolingual-controls to immediately process subject-verb disagreement as a morphosyntactic violation (as in English grammar, contrary to Italian which allows post-verbal subject-nouns). A second group difference

was that, on both target-words, Attriters elicited shorter P600-effects than Controls. This pattern, together with Attriters' longer response-times on end-of-sentence acceptability judgments, as well as their tendency to elicit larger P600-responses to the "repair" condition (xyy) than monolinguals, suggest that Attriters engage in shallower online repair/re-analysis processes than non-attriting Controls. The late P600 in Attriters was positively correlated with amount of L1-Italian exposure. An additional finding that has implications for ERP research on sentence-processing was that the P600-effect was differentially modulated by proficiency (650-900 ms) and group-membership (beyond 900 ms), emphasizing that the P600 should not be considered a monolithic component. Our results provide the first ERP evidence of attrition in L1-morphosyntax by revealing processing differences in demanding sentences that required online repair. Attrition is not merely L1-proficiency variation within the normal native-speaker range, as additional group differences may reflect factors particular to their socio-linguistic circumstances (e.g., L2-dominance, limited L1-exposure, increased self-consciousness, etc).

F47 Shared syntax for bilinguals extends to language-specific constructions *Eve Higby[1,2], Ibana Vargas[1], Stephanie Perez[1], Wendy Ramirez[1,2], Eva Fernandez[1,2], Valerie Shafer[1], Loraine K. Obler[1]; [1]The Graduate Center of the City University of New York, [2]Queens College, City University of New York*

Introduction: A growing body of research on bilingual language processing suggests that languages in the bilingual mind interact in dynamic ways and that fluent language processing is different for monolinguals and bilinguals. The current study investigates how language processing in the native language is modified by syntactic structures acquired in the second language. We tested native Spanish speakers and native English speakers on induced motion causatives, a construction that consists of a manner-of-motion verb (e.g., run and jump) and two animate arguments: the Subject, which is the Causer of the action, and the Direct Object, which undergoes the action denoted by the verb (e.g., John ran the mouse around the maze). This construction is either ungrammatical in Spanish (*Juan corrió al ratón por el laberinto) or interpreted as both arguments doing the action together (as opposed to the Subject being the Causer). The current study is designed to determine whether native Spanish speakers with a high proficiency in English are able to interpret these ungrammatical sentences in Spanish on the basis of their typical interpretations in English. While previous research (e.g., Hartsuiker, Pickering, & Veltkamp, 2004) has demonstrated that similar constructions in two languages appear to have overlapping representations for bilinguals, it is still unknown whether language-specific constructions are also shared (wholly or partially), allowing these constructions to be available during the processing of either language. Methods: The first stage of the study involved obtaining acceptability judgments: 26 participants were native English speakers who completed the judgment task in English, 18 were native Spanish speakers living in the United States who completed the task in Spanish, and 20 were native Spanish speakers living in Spanish-speaking countries who completed the task in Spanish (65 participants total). Participants rated the sentences using a 7-point scale (1 = "not at all natural" and 7 = "completely natural"). Stimuli included 33 induced motion causative sentences and 131 filler sentences. Results: English speakers had a mean rating of 5.40 (SD = 0.84) for the English causative sentences. Spanish speakers overall had a mean rating of 3.47 (SD = 1.18) for the Spanish versions of the causatives, with higher ratings for Spanish speakers in the U.S. (3.79, SD = 1.30) compared to those abroad (3.16, SD = .99). Furthermore, Spanish speakers in the U.S. showed much more variability across participants: only 46% of the sentences were consistently given low ratings by this group whereas 33% were not consistently rated high or low (compared to 67% and 12% for the Spanish abroad group, respectively). Conclusion: The behavioral results suggest that Spanish speakers living in an English-speaking environment use their knowledge of English-specific constructions when processing sentences in Spanish. A second stage of the study involves collecting ERP data to determine whether Spanish-English bilinguals can process these constructions in real time. We are comparing Spanish monolinguals with Spanish-English bilinguals in the U.S. who learned English either in early childhood or in adolescence/adulthood. We will describe the ERP results and how they relate to the behavioral results (acceptability judgments).

F48 Associative networks learn abstract grammatical categories *Geoffrey Brookshire[1], Daniel Casasanto[1]; [1]University of Chicago*

How do people learn syntactic categories? Learning categories like "noun" and "verb" could depend on innate, language-specific mechanisms. Here we tested an alternative: Could a domain-general learning mechanism allow people to learn categories based solely on the sequential order of events? To address this question, Elman (1990) trained a Simple Recurrent Network (SRN) with a stream of simple sentences. The SRN developed implicit structure that resembled lexical categories: hidden-layer representations were more similar for words of the same lexical category than for words of different categories. The network learned how each word transitioned into other words, and formed similar representations for words with overlapping transition signatures. However, this result is not informative about whether the network can make novel inferences by generalizing an instance to a category: the hallmark of human categorization. In the present experiment, we show that an associative network can discover abstract grammatical categories based only on the sequence of symbols in the input, and that it can generalize beyond the bigram transitions present in the

input stream. We trained a feedforward neural network model, with one hidden layer, to predict the next symbol in a continual sequence. Symbols were grouped into three categories (A, B, C), with the sequence following the pattern ABCABC, etc. Category membership was therefore only present implicitly in the model's training input; the training set contained no explicit cues about a symbol's category membership. Crucially, each symbol in a category transitioned to most – but not all – of the symbols in the next category. We tested whether the model generalized category membership to predict novel item transitions. After training the network, we froze the connection weights and measured the response at the output layer to each item. In the training set, each item transitioned to all but one member of the next category. Each A-item, for example, transitioned to all but one B-item. In the generalization test for a given A-item, we compared the activation of its left-out B-item to a C-item. The correct-incorrect activation ratio was computed separately for each item. Of primary interest, the model showed higher activations on the correct-category items than on the incorrect-category items, despite the fact that neither transition was present in the training set. This correct-category preference is robust to changes in the duration of training, the number of nodes in the hidden layer, the number of exemplars per category, and the learning rate. These simulations demonstrate that an associative mechanism sensitive only to bigram transitions can productively generalize beyond the transitions present in the input, and can learn to treat symbols as members of abstract grammatical classes. Domain-general associative sequence-learning mechanisms may be sufficient to acquire syntactic categories in natural language.

F49 Developmental differences in neural oscillations supporting online sentence processing *Julie Schneider[1], Alyson D. Abel[2], Diane Ogiela[3], A. Middleton[1], M.J. Maguire[1]; [1]University of Texas at Dallas, [2]San Diego State University, [3]Idaho State University*

Introduction: Real-time language comprehension is a complex task that requires rapid integration of semantic and syntactic information, which continues to develop through age 12 or later (Atchley et al., 2006). Research using ERPs has identified developmental differences in the engagement of semantics and syntax, in which children generally display an N400 that is later, larger and more broadly distributed and a P600 that is larger and later compared to adults (Friedrich & Friderici, 2004). Time frequency analysis provides a different means of analyzing EEG data that is beneficial for studying language processing (Cohen, 2014). Specifically, in adults, previous research indicates that theta changes relate to semantic integration (Hald et al., 2006) and beta changes relate to syntactic unification (Bastiaansen et al., 2010). Therefore, the current study uses both ERP (e.g., P600, N400) and time frequency (e.g., theta, beta) analyses to investigate developmental differences in the underlying neural processes engaged during a grammaticality judgment task to better understand the development of auditory language processing. Methods: Eighteen adults and eighteen children ages 10-12 years (all right-handed, monolingual English-speakers) performed grammaticality judgments of 160 sentences as their EEG was recorded. Stimuli were naturally paced auditory recordings of simple active sentences. Errors were verb agreement errors; however, only correct responses were included in the current analysis. Analysis: EEG data were epoched from -500 to 1500 msec in relation to the critical verb's onset. Single trials were averaged together to obtain a stable waveform ERP for every subject. Time–frequency analysis was used to quantify event-related spectral perturbations. Throughout the epoch, data was Fourier transformed, magnitude squared, and normalized to obtain the power spectral density. Data were averaged across trials and subjects, and computed using the log power values minus the baseline (Delorme & Makeig, 2004). Within EEGLAB, an interactive Matlab toolbox, random permutation statistical analysis of the EEG data were performed and p-values for both the time and frequency points for each comparison of interest were computed. Results: Overall, children made significantly more errors compared to adults: 17.17% and 6.13%, respectively ($F(1,35)= 12.06$, $p<0.001$). The EEG findings revealed very few differences between children and adults in comprehending grammatically correct sentences; however, when identifying grammatical errors adults displayed widely distributed beta and theta desynchrony. Adults also demonstrated a significant P600, while, contrary to current findings, children exhibited an apparent N400, and less pronounced beta desynchrony in conjunction with theta synchrony. Conclusions: In line with previous research, adults displayed greater activation associated with syntactic processing when identifying subtle grammatical errors in real time. It is somewhat surprising that children exhibited neural markers more commonly associated with semantic processing; however, similar research by Hahne, Eckstein & Friederici (2004) found a sustained negativity and lack of P600 in response to errors in children less than 13 years of age. Therefore, these findings are an early step in supporting support previous claims that the neural underpinnings of syntactic processing continue developing in adolescence, and add to them by identifying the potential role semantic processing has in supporting this process.

Language Disorders

F50 Separate neural systems support representations for actions and objects during narrative speech *Ezequiel Gleichgerrcht[1], Julius Fridriksson[2], Chris Rorden[2], Alexandra Basilakos[2], Rutvik Desai[2], Leonardo Bonilha[1]; [1]Medical University of South Carolina, [2]University of South Carolina*

Representations of objects and actions in everyday speech are usually materialized as nouns and verbs, two grammatical classes that constitute the core elements of

language. Given their very distinct roles in singling out objects (nouns) or referring to transformative actions (verbs), they likely rely on distinct brain circuits. Here, we tested this hypothesis by conducting network-based lesion-symptom mapping in 38 patients with chronic stroke to the left hemisphere. We obtained measures of noun and verb production from narrative discourse elicited by picture naming tasks. We built the individual connectome for each patient in accordance to the following pre-processing steps: 1) segmentation of the probabilistic gray matter map from T1-weighted images; 2) division of the probabilistic gray matter map into regions of interest (ROIs) based on the John's Hopkins University (JHU) atlas; 3) segmentation of the probabilistic white matter map from T1-weighted images; 4) registration of the individual white matter map and cortical ROIs into the individual diffusor tensor imaging (DTI) space; 5) probabilistic DTI fiber tracking, 6) iterative evaluation of the number of tractography streamlines connecting each possible pair of grey matter ROIs generated in step 2 above; 7) correction of each pair-wise connection strength (i.e., number of streamlines between two ROIs) based on the volume of the connected ROIs and the distance travelled by the streamlines. Because of the major anatomical distortions occurring as a result of stroke-related necrotic changes, we employed methods designed and previously used by our group to preserve the anatomical authenticity of grey and white matter without computing fibers embedded in these necrotic areas. We computed the correlation between discourse measures of production of nouns and verbs with the corrected weight of the connections between all ROIs. Because of the continuous nature of both behavioral and neuroimaging variables, this was achieved by employing the general linear model. This approach yielded more positive z values when increased image brightness (i.e., stronger connection between two ROIs) correlated with increased behavioral scores (i.e., larger number of nouns and verbs per minute). The alpha value was set at 0.05, one-tailed, as we predicted injured tissue to cause poorer performance. We controlled for familywise error rates by means of permutation thresholding (5000 permutations). We found that verbs were associated with a frontal network involving the pars opercularis and triangularis of the inferior frontal gyrus as well as the precentral gyrus. Nouns, instead, were related to a posterior network spreading across the occipital, posterior inferior temporal, and parietal regions. We propose that these connectivity-based results add valuable information to findings from voxel-based lesion-symptom mapping and functional neuroimaging both in aphasia and healthy control. In conclusion, we found that the two major grammatical classes in human speech rely on two dissociable networks. Each of these networks engaged brain areas typically involved in cognitive and sensorimotor experiences equivalent to the function served by each grammatical class (e.g. motor areas for verbs, perception areas for nouns).

F51 Rehabilitating Speech Production and Fluency in Nonfluent Primary Progressive Aphasia: Treatment Outcomes and Patterns of Underlying Atrophy

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Introduction: Individuals with the nonfluent variant of primary progressive aphasia (nfvPPA) show a gradual decline in speech production and grammar in conjunction with atrophy in left posterior fronto-insular regions (Gorno-Tempini et al., 2011). Speech and language interventions have yet to target the core deficits observed in nfvPPA. However, nonfluent stroke patients have exhibited gains in fluency as a result of script training and more recently, script training via unison speech production with an audiovisual model (Fridriksson, Hubbard, Hudspeth, Holland, Bonilha, Fromm & Rorden, 2012). A study examining this "speech entrainment" approach as a means to facilitate fluency in individuals with stroke-induced aphasia identified damage to left inferior frontal gyrus (pars opercularis and pars triangularis; IFGpo and IFGpt) as the lesion site most associated with improvement (Fridriksson, Basilakos, Hickok, Bonilha & Rorden, 2015). Given that speech production and grammar have yet to be systematically treated in individuals with nfvPPA, the pattern of atrophy associated with responsiveness to this type of intervention is unknown in patients with neurodegenerative disease. We investigated the utility of a unison speech production script training protocol in a group of individuals with nfvPPA. We predicted that individuals with nfvPPA would demonstrate improved speech production and grammar as a result of this treatment. Further, we hypothesized that patterns of regional atrophy would confirm prominent damage to IFG in patients who are responsive to this type of intervention. Method: Seven individuals with nfvPPA underwent a novel, homework-based video script training protocol. Individualized scripts were developed and video stimuli created for each participant. Treatment sessions with the clinician targeted memorization and conversational usage of scripts and daily homework consisted of unison speech production with a video model. Voxel-based morphometry (VBM) was used to examine patterns of regional atrophy in participants with nfvPPA relative to healthy controls. Results: All individuals with nfvPPA displayed large and significant changes in intelligibility and accuracy of scripted material as well as improved grammaticality for scripted topics. VBM revealed significant atrophy in IFGpo and IFGpt, consistent with the lesion profile observed in stroke patients who were responsive to speech entrainment. Left middle frontal and precentral gyri were also damaged in both patient groups. In the nfvPPA group, left supplementary motor area, basal ganglia, and insula were additional areas of significant damage, with less prominent atrophy in bilateral temporal and parietal regions, as well as the right insula and basal ganglia.

Conclusion: This is the first group study to examine treatment for the core grammatical and motoric deficits in nfvPPA. Outcomes suggest that video script training is an efficacious treatment for speech production and fluency in this patient group. Our findings corroborate the lesion profile (IFGpo and IFGpt) associated with improved fluency in a previous study of speech entrainment in aphasia caused by stroke. Atrophy encompassed additional regions within networks supporting motor speech and syntax in nfvPPA patients who were responsive to this treatment. Future studies with more participants will allow voxel-wise analysis of the relation between treatment outcomes and regional atrophy within these networks.

F52 Procedural memory of children with specific language impairment

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Specific language impairment (SLI) is a developmental disorder characterized by deficits in language abilities which cannot be explained by frank neurological damage, social/emotional disorders, hearing loss, or frank oral motor dysfunction (Leonard, 1998, 2014). Due to limited understanding of SLI, services delivered to children with SLI may not fully address the challenges they face. Recently, studies have reported motor deficits in SLI (Sanjeevan et al., in press). The comorbidity of language and motor impairment in SLI has been attributed to deficits in the sequencing component of procedural memory (Ullman & Pierpont, 2005). However, the sequencing impairment has predominantly been captured using button-press tasks (for review, see Lum, Conti-Ramsden, Morgan & Ullman, 2014), which potentially raises questions about the generalizability of the results. Furthermore, it is unclear whether deficits in procedural memory are limited to learning sequence-specific information or extend to learning that is not sequence-specific, as in visuo-motor adaptation. To specify the nature of the procedural memory impairments in SLI, we asked (1) whether children with SLI would perform differently from typically-developing (TD) children on a skill-oriented measure of motor sequencing (knot tying), (2) whether children with SLI would perform differently from TD children on a skill-oriented measure of visuo-motor adaptation (mirror-drawing), and (3) whether children with SLI would retain what they learned as well as TD children. Data from 18 children (ages 9;5-12;7; 10 TD and 8 SLI) have been collected so far. In the knot-tying task, children were shown how to tie two knots using an instructional video. The time required to tie each knot and the number of errors made at test (immediately after training) and retest (2 hours post-test) were recorded. In the mirror-drawing task, children were asked to trace a diagram while looking only at their hand in a mirror. The time required to complete the trace and the number of errors made at baseline, test, and retest were recorded. Group comparisons revealed that children with SLI did not differ significantly from TD children on the test condition of the knot-tying task or on the baseline and test conditions of the mirror-drawing task. However, on the retest condition, children with SLI made significantly more errors on both the knot-tying and mirror-drawing tasks than did the TD children. These findings are consistent with the hypothesis that procedural memory is compromised in SLI. For the data collected, children with SLI showed difficulties with retention rather than acquisition of procedural knowledge, but it would be premature to conclude that acquisition of procedural knowledge is always unaffected in SLI.

F53 Does Semantic Mediation Contribute to Successful Word Reading in Phonological Aphasia?

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Despite the large number of functional neuroimaging investigations of chronic aphasia, it is still unknown whether recovery of language capacity results from reorganization of damaged processes, recruitment of compensatory processes, or some interplay of both. Recovery of the ability to access phonology from orthographic input, as in reading aloud, provides a potential model for studying this problem. Phonologic access processes are particularly sensitive to damage from left middle cerebral artery ischemic strokes due to their localization in perisylvian regions at the core of this arterial territory. The relatively undamaged semantic system might support word reading ability in this situation, via orthographic-semantic connections, by providing additional input to the damaged phonologic system. Alternatively, reorganization of phonologic processes may be the primary mechanism for recovery. We showed previously that aphasia patients with an isolated phonologic retrieval deficit activate the left angular gyrus, a region strongly linked with semantic processing, more when they make a correct response than when they make an error in reading aloud. Here we characterize the processing in this functionally-defined region of interest (ROI) in the same patients using a separate fMRI paradigm contrasting explicit semantic and phonologic tasks. Participants were 21 chronic left hemisphere ischemic stroke patients (10 women) with an isolated phonologic retrieval deficit. All patients were at least 180 days post-stroke, native English speakers, and pre-morbidly right-handed. The left angular gyrus functional ROI was defined using an event-related oral reading protocol, described elsewhere, in which brain activity occurring during correct responses was contrasted with activity during incorrect responses. In the same imaging session, the participants also performed two visual matching tasks designed to selectively elicit either Phonologic (matching pseudowords on rhyme content) or Semantic (matching words on meaning) processes. Anatomical and functional images were morphed to a stereotaxic template using a nonlinear

constrained cost-function incorporating the lesion as a mask. The average of voxel beta coefficients (representative of signal magnitude) from the Phonologic and the Semantic matching tasks (relative to a low-level sensorimotor control condition) was calculated in the functional ROI. The left angular gyrus region associated with successful word reading did not show a significant difference between the Semantic and Phonologic conditions: paired t(20) = 0.26, p = .799. Inspection of the data, however, showed that the anterior part of the ROI overlapped with areas activated by the Phonological task, while the posterior part of the ROI overlapped with areas activated by the Semantic task. Dividing the ROI into anterior, middle, and posterior subregions revealed a significant task x subregion interaction (p = .006), with anterior voxels showing stronger Phonologic activation and posterior voxels showing stronger Semantic activation. This ROI, which is adjacent to the damaged phonologic system, appears to participate in both phonologic and semantic processing in this patient cohort. Thus these results provide evidence for both compensatory semantic mediation and phonologic system reorganization mechanisms in recovery of oral word reading. Supported by NIH grants: R01 NS033576, R01 DC003681, R03 NS054958 and AHA grant 13PRE16510003

F54 Alterations of language related oscillatory activity and spontaneous neural dynamics after stroke

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Introduction: We used magnetoencephalography (MEG) to understand the roles of perilesional and contralesional activity in processing of semantic and syntactic information in patients with post-stroke aphasia, and to explore the potential of right hemisphere (RH) activity to support recovery. Methods: The brain regions involved in processing of semantic and syntactic anomalies during sentence comprehension task were mapped using MEG beamforming in a group of 19 patients with post-stroke aphasia, 19 healthy age matched controls, and 20 young adults. I addition, we analyzed resting MEG to quantify the complexity of spontaneous brain signals using multiscale entropy (MSE) and spectral measures. These measures were used to identify perilesional cortex that is structurally intact, but physiologically dysfunctional. We also assessed the relationship between altered neuronal dynamics, language related activation, and task performance. Results: We found that in healthy controls, activation of a left lateralized temporo-frontal "ventral network" was responsive (8-30 Hz ERD) to semantic anomalies, and a bilateral fronto-parietal "dorsal network" responded to syntactic anomalies. In the presence of lesions, language networks reorganized and recruited available regions in both hemispheres. However, the specific pattern of compensatory recruitment depended on the type of linguistic information that was processed. For semantic violations, patients with aphasia activated preserved LH regions adjacent to the lesion, as well as preserved parietal and temporal RH areas. In addition, patients recruited a right anterior portion of the frontal cortex that was not activated in the healthy participants. Correlation analyses indicated that this shift to preserved RH regions and compensatory recruitment of new RH areas were associated with better semantic performance, whereas higher accuracy on the syntactic task was related to right dorsal and frontal activity. Furthermore, abnormalities in spontaneous neural signals were associated with less task-related activation in the vicinity of the affected regions, and at the same time recruitment of alternative brain regions. Conclusions: These results suggest that reduced task-related responses in the LH and engagement of compensatory RH areas during language processing, are related to abnormal neuronal dynamics in perilesional tissue. Based on these findings, reversal of such abnormalities may be an important target for interventions such as noninvasive brain stimulation. The results suggest that recovery of semantic processing is associated with activation of preserved parts of the LH ventral pathways adjacent to the lesions, homologous RH areas, and recruitment of alternative brain networks. In contrast, syntactic processing seems to show less potential for compensation after a LH lesion.

F55 Effects of language and tDCS interventions in PPA and their neural correlates

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Language intervention has been shown to critically affect the course of post-stroke language rehabilitation. Interventions at early or chronic stages (either by reperfusion, speech-language therapy or tDCS) have dramatically improved outcomes in language post-stroke rehabilitation. Little is known, however, about interventions in neurodegerative diseases and the changes in neural substrates they may induce. It has been shown that language therapy is indeed beneficial and improves language outcomes, both with behavioral interventions and more recently with tDCS for longer lasting and more generalizable effects even in PPA(Cotelli et al., 2014; Tsapkini, Frangakis, Gomez, Davis, & Hillis, 2014). However, it has not been addressed how this is instantiated in the brain. In this poster we evaluate the effects of tDCS in 13 participants with PPA who received both sham and tDCS coupled with language therapy. Our aim was to evaluate the effects of intervention(s) and determine the neural correlates of tDCS vs. sham interventions that led to improved language outcomes using resting-state fMRI (rs-fMRI). Method: Thirteen patients diagnosed with PPA underwent written or oral language production intervention with and without tDCS (sham) in a within-subjects cross-over design. Participants received treatment

for 2 weeks, 10 sessions for each condition. Each condition was separated by 3 months. Resting-state fMRI data were obtained on the first treatment condition only from 13 participants who underwent language intervention at 3 time-points: before, after and 2-months post-intervention. Participants were pseudo-randomly assigned in either tDCS or sham condition first. In the imaging study we used a between-subjects design. Results: First, we replicated our previous results obtained with fewer participants: all improved in both tDCS and sham conditions on trained items. Generalization of treatment on untrained items was significant (in the group results) only in tDCS condition. Therapy gains lasted longer in tDCS condition as well. Second, analyses of rs-fMRI revealed that tDCS increased the correlation between left and the homologous right inferior frontal gyrus (IFG). This change was significant even 2 months post intervention and the effect was stronger for participants with larger baseline volumes in the right IFG. Conclusions: tDCS represents an increasingly valuable treatment option in language rehabilitation even in neurodegeneration. Larger baseline volumes in the right IFG are usually indicative of earlier stages of the disease, i.e., less overall atrophy. Therefore, tDCS seems to alter brain functional connectivity more dramatically in earlier than later stages of the disease despite the fact that behavioral (language) improvement may be similar. The correlation between functional connectivity and language production outcomes is expected to shed light on how tDCS works in the brains of people with a neurodegenerative disease. Implications of functional connectivity changes between language areas involved in the targeted language function will inform further interventions.

F56 Neurobiological predictions of reading intervention response: an fMRI study of children with reading difficulties

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Background: An estimated 6-17% of children struggle with reading difficulties (RD) based in word-level reading deficits. While reading interventions have been extensively studied and applied in research and educational settings, a non-trival number of readers show minimal behavioral response to reading intervention. The present study explored whether responsiveness to a short-term reading intervention could be predicted from pre-intervention functional magnetic resonance imaging (fMRI) scans of word reading. Subjects: We examined children ages 8-14 years (n = 38; 17 females; mean age = 9.8 +/- 2) with typical IQ (standard score of greater than or equal to 70 on subtests of the Wechsler Intelligence Scale for Children (WISC)–IV), and who either had typical reading development (TD) or RD. Participants were categorized in the RD group if they obtained a standard score less than 90 (below 25th percentile) on at least one of the following measures: the Woodcock Johnson III Letter Word ID and Word Attack subtests, or Wechsler Individual Achievement Test II Word Reading. Participants were categorize as TD if they obtained a standard score of greater than or equal to 96 (40th percentile) for the average of the above tests, and standard score greater than 90 for all individual tests. In addition to behavioral reading measurements, the Behavior Rating Inventory of Executive Function (BRIEF) was used to test subjects on metacognitive ability, and the WISC-III Processing Speed Index was used to capture processing speed. Intervention: RD participants were assigned to one of two 15 hour reading interventions. Both interventions incorporated systematically structured, research-based principles of reading instruction, largely derived from Orton-Gillingham (Orton, 1937) methods. For the current study, groups included RD (n = 23) and TD (n = 15). Following intervention, the RD group was divided into Responders (n = 12) and Nonresponders (n = 11) using a median split on the Woodcock-Johnson-III Basic Reading score. FMRI: Subjects underwent pre-intervention MRI scans, and completed a single word reading task. The stimuli consisted of real words (80%) and decodable pseudowords (20%); subjects provided in-scanner responses to whether the stimulus was a real word or pseudoword. Results: Despite no statistically significant behavioral differences in pre-intervention reading scores, Responders showed differential pre-intervention activation and functional connectivity patterns compared to Nonresponders. Specifically, while the total RD group showed decreased activation in areas previously associated with fast and efficient word reading (the left occipitotemporal area) as compared to the TD group, this decrease was significantly greater in Nonresponders. Interestingly, pre-intervention behavioral scores of metacognition and processing speed differentiated Responders from Nonresponders, and subsequent functional connectivity analysis showed that Responders have greater connectivity between executive function regions (left dorsolateral prefrontal cortex; BA 46) and orthographic processing regions. Additionally, during word reading, metacognition predicted greater correlation between executive function regions and language areas in RD groups. This is the first task-based fMRI study to show that pre-intervention activation and connectivity patterns can predict responsiveness to intervention in RD populations, and that these neurobiological predictions are related to executive function.

F57 Neural correlates of phonological and orthographic processing in children with developmental dyslexia

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Introduction: Converging behavioral and neurological evidence from alphabetic languages has demonstrated phonological deficits in children with developmental dyslexia (DD) (Bruck, 1992; Rack, Snowling, & Olson, 1992). However, whether phonological deficit is also the core problem in children with DD in logographic languages

is still a debate (Siok & Fletcher, 2001; Siok, et al., 2004). Our study provides neurological evidence for whether Chinese children with DD also experience phonological deficits in an auditory rhyming task using fMRI. Reading is a complex process and skilled orthographic processing also plays an important role in fluent reading (Siok et al., 2004; Cao et al., 2008), which is especially true in logographic languages such as Chinese. Our study also examined whether there are orthographic deficits in Chinese children with DD. Method: 5 dyslexic fifth-graders (DD), 13 typically developing fifth-graders (age control, AC) and 14 typically developing third-graders (reading-matched control, RC) participated in an auditory rhyming task and a visual spelling task during fMRI scanning. During the auditory rhyming task, participants judged whether two orally presented words rhymed or not; during the visual spelling task, participants judged if the second character of two visual presented words shared a radical or not. Result & Discussion: Behavior results showed no significant differences in reaction time (RT) or accuracy among the three groups in the visual spelling task. For the auditory rhyming task, the AC group was significantly faster and more accurate than the DD group and the RC group. fMRI results indicated that in both tasks AC showed greater activation than DD in two IFG regions: the left dorsal IFG (-48, 8, 34) and the left anterior IFG (-50, 34, 18). These two regions have been found to show developmental increase in our previous studies using the same tasks (Cao et al, 2011, 2012). It suggests that children with DD have a developmental delay in these two regions. We also found DD showed reduced activations in comparison to both AC and RC in left middle occipital gyrus (MOG) for the auditory rhyming task and in left cuneus for the visual spelling task. The reduced activation in MOG suggests a weaker integration of orthography and phonology during the rhyming judgment (Fiebach et al, 2002; Gold et al, 2007); the reduced activation in ceneus suggests less elaborated visual-spatial processing of Chinese words (Kim et al, 2015). Both of these mechanisms are related with the etiology of DD rather than the result of being DD.

F58 Reduced P300 and N300 Effects to Printed English Stimuli in Early Poor Readers

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Reading is a complex multi-step process which requires readers of English to assign sounds to letters to decode words, and then map onto meaning to achieve comprehension. Despite multiple points where a beginning reader may struggle, the current definition of reading disability is imprecise and does not extend beyond "difficulties in reading and spelling despite adequate general cognitive ability and instruction" (Stanovich & Siegel, 1998). The goal of this experiment was to find neurobiological indicators of reading disability in order to refine understanding of when problems in word reading may arise. Behavioral assessments were conducted to assess phonological awareness, spelling and decoding ability. A composite Reading Average score was calculated from standard scores from Woodcock Johnson III: Letter-Word Identification and Spelling, and Test of Word Reading Efficiency (TOWRE): Phonemic Decoding Efficiency. A simple word reading task was conducted on young readers of English (mean age=9) while event-related potentials (ERPs) were recorded. Pictures of familiar objects were displayed on-screen, followed by either: (1) a matching word, (2) an unrelated real word, (3) a pseudoword, or (4) a consonant string. The participant would judge whether the print stimuli matched the picture. ERPs were extracted from the onset of the print stimuli. Components of interest included the P300 and N300. The P300 consists of a positive peak at ~350ms after stimulus onset and lateralized to the left parietal-occipital lobe, and has been shown to index attention and categorization (Duncan, et al., 2009). The N300 consists of a negative peak in the frontal-temporal lobe at ~350ms after stimulus onset, and indicates mastery of orthographical to phonological mapping (Hasko, et al., 2012). ERP amplitudes were compared to behavioral measures. Initial analysis split participants into Typically Developing (TD, N=13, composite score >100) and Reading Disabled (RD, N=10, composite score <90) groups. Participants with mid-range scores (composite score = 90-100) were excluded. Repeated Measures ANOVA and follow-up Univariate ANOVA and post-hoc Tukey tests showed significantly higher P300 amplitude in the TD group for both consonant string and pseudoword conditions than the word condition. In addition, N300 amplitudes in the TD group were significantly more enhanced for the word condition than the consonant string condition. A continuous analysis utilizing the full dataset was conducted using a linear mixed-effects model (N=33). Participants displayed a significantly enhanced P300 for the Word condition relative to the other conditions. This effect varied as a function of reading skill such that better readers had larger P300 effects. We found larger N300 effects for the pseudoword condition relative to other conditions. We also found a significant interaction between condition and reading skill, such that larger N300 effects were observed for better readers. In conclusion, reduced P300 and N300 effects were observed for participants with poor reading ability. These results suggest that more skilled readers are better able to rapidly decode (translate orthography to phonology) and categorize words. These findings complement an emerging neurobiological model of typical and impaired reading by identifying temporal windows during which problems with word identification may arise.

F59 Failure to deactivate in precuneus: functional abnormalities of orthographic processing in dyslexia

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Due to the long-standing hypothesis that neural computations function mainly in the service of stimulus processing, neuroimaging studies have emphasized the functional relevance of task-positive deflections in blood-oxygenation-level-dependent (BOLD) signals (Anticevic et al., 2012). However, a set of regions including medial prefrontal cortex (mPFC), posterior cingulate cortex (PCC), inferior parietal lobule and precuneus (PRC), were found to consistently exhibit deactivation across tasks and their functional importance have been recently discussed (Binder, 2012). Resting-state functional connectivity (RSFC) studies revealed the existence of RSFC between reading-related areas and PCC/PRC (Koyama et al., 2010), and the strength of RSFC were further found to correlate with reading competence (Koyama et al., 2011; Zhang et al., 2014). A recent structural study found that the gray matter volume of PCC/PRC was uniquely associated with phonological decoding ability, also confirming the role of PCC/PRC in reading processing (He et al., 2013). All these evidences revealed that deactivated areas, particular the PCC/PRC, were highly involved in fluent reading. However, to date no study has directly investigated and deeply discussed the function of deactivation in reading and reading impairments. 22 Chinese dyslexia and 26 age-matched normal readers participated in the experiment. In the fMRI scanning, children were required to passively view a series of visual stimuli, including faces, tools, houses, Chinese characters etc. The experiment procedure was adapted from Dehaene et al (Dehaene et al., 2010). To specifically focus on deactivation, in each visual stimuli condition, we first did one-sample t test (visual stimuli vs fixation) in each group and formed a union of two deactivated maps which served as a mask for subsequent group contrast analysis. We first selected 3 ROIs showing under-activation in dyslexic readers in a recent meta-analysis and extracted the eigenvalue. Group contrast was computed and significant group difference was found in the L.FFG and L.MTG, repeating the results found in early research. As for deactivation which was ignored in previous studies, we found that in Chinese character condition, significant group difference was revealed in the precuneus. In more detail, dyslexic readers showed less deactivation in the precuneus compared to normal readers. What's more, deactivation in the precuneus was positively correlated with behavior scores in Chinese phonological awareness test in dyslexic group. However, group difference in deactivation was not found in other visual stimuli conditions, including face, house and tool conditions. This is the first study to delineate the functional abnormality of deactivation in dyslexia. Less deactivation in precuneus may reflect that dyslexic readers more frequently use this region in orthographical processing task which may serve as a compensation mechanism.

Lexical Semantics

F60 Neural overlap of L1 & L2 semantic representations in bilinguals

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The study of the neural basis of bilingual language processing has gained much interest in cognitive psychology. The main question has been whether the representations of both languages in bilinguals are integrated in one system or rather rely on separate cognitive/neural representations for each language. Behavioral research has shown that lexical representations from a native language (L1) become active during second-language (L2) processing and vice versa, both in language recognition and production (Van Assche et al., 2009). In the neuroimaging literature, the question about functional integration had been operationalized as the hypothesis that both languages are represented by overlapping, rather than distinct cortical language areas. To date, these neuroimaging studies have provided very divergent results as a result of their huge methodological heterogeneity and because they typically do not make a distinction between language modalities (comprehension vs. production) and representational levels (form, semantics, syntax), despite the obvious consequences of such factors for neural activation (Rapp, 2001). To compensate for this shortcoming in previous literature, we investigated the neural overlap in different language modalities (language production, auditory comprehension and visual comprehension) within the same individuals to make comparisons between the different language modalities possible. In the literature, the fMRI-adaptation paradigm has been proposed as a useful tool to study the neural overlap between L1 and L2 representations in bilinguals (Chee, 2009). Adaptation refers to the phenomenon where a pair of identical stimuli elicits a smaller neural response than a pair of dissimilar stimuli. However within this approach, neural overlap between languages within an area can be caused by different neural representations within the same area representing the different languages or by the same neural population representing both languages. Only the latter observation is supportive of a real integrative view of L1 and L2 in bilinguals. Both the classical (univariate) fMRI approach and the adaptation approach are unable to separate these two possibilities. That's why an important goal of this study was to make a shift towards multi-voxel pattern analysis (MVPA) to get a better idea about how specific the neural overlap is between L1 & L2 by looking at prediction accuracies instead of looking at the amount of activation. More specific, a pattern classifier was trained on the activation pattern associated with the naming, reading or listening to each of the 10 concepts in one language for 4 of the 5 blocks (training data). Subsequently, this pattern classifier was used to classify the activation pattern associated with the naming, reading or listening of the 10 concepts in the

corresponding fifth block of the other language (test data). The results showed that the classifier was able to accurately predict the concepts across languages in the different language modalities (production, auditory comprehension and visual comprehension). Although the brain regions in which significant decoding accuracies were observed did show overlap across the different modalities, we also found brain regions which were specific for the different language modalities. Overall these results provide evidence for overlapping conceptual representations across languages.

F61 Neural signatures of language co-activation and control in bilingual spoken language comprehension

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A bilingual's two languages are co-activated and compete for selection even in a monolingual context (e.g., Marian & Spivey, 2003). Previous studies suggest that bilinguals may recruit inhibitory control to resolve language competition in order to use one of their two languages selectively (e.g., Kroll et al., 2008). The current study examined neural signatures of language co-activation and inhibitory control during bilingual spoken language comprehension. Korean-English bilinguals and English monolinguals were asked to make semantic relatedness judgments on auditorily presented English word pairs (e.g., moon-lock) while their EEGs were recorded. Words were presented one after another. Half of the prime words were interlingual homophones (i.e., words that sound the same but have different meanings across two languages, e.g., "moon" and "mat" mean "door" and "taste" in Korean, respectively) and the other half were non-homophones (e.g., "jail" and "cake"). The interlingual homophones and non-homophone controls were paired with semantically related words (e.g., "moon-lock," "jail-lock") or unrelated words (e.g., "moon-sweet," "jail-sweet"). Thus, the present study included four critical conditions: Homophone Related across languages ("moon-lock," "mat-sweet"), Homophone Unrelated ("moon-sweet," "mat-lock"), non-homophone Control Related within language ("jail-lock," "cake-sweet"), and non-homophone Control Unrelated ("jail-sweet," "cake-lock"). EEGs were time-locked to the onset of the second target word. In order to obtain both behavioral measures and response-free EEG data, all word pairs were presented once as Go trials where overt responses were required, and once as NoGo trials where judgments were made silently. Critical comparisons were made between the Homophone Related across languages and Homophone Unrelated conditions as well as the non-homophone Control Related within language and non-homophone Control Unrelated conditions. Behavioral results did not reveal accuracy or reaction time differences between critical conditions. However, ERP results from the Go trials revealed that, in contrast to English monolinguals, bilinguals showed semantic priming effects not only for word pairs related in English, but also for word pairs related across languages as indexed by a reduced N400. These findings suggest that the homophone's Korean meaning was activated during an English comprehension task. Critically, in the NoGo trials, only bilinguals showed less positive-going waves around the 600-800 ms time window (Late Positive Component: LPC) for the Homophone Related across languages condition than the Homophone Unrelated condition. Since the LPC is thought to reflect elaborate and explicit stimulus evaluation, this attenuated LPC effect may indicate less elaborate semantic processing of cross-language word pairs due to allocation of cognitive resources to resolving cross-language competition. Altogether, these findings suggest that language co-activation occurs even when the experimental environment is English only and when a bilingual's two languages do not overlap in orthography. These results also provide further neural evidence for language competition and control during bilingual language comprehension.

F62 The Interaction of Imageability and Word Class During Semantic Retrieval

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Authors: Yvonne K. Ralph, Julie M. Schneider & Mandy J. Maguire Introduction: During semantic retrieval multiple features of a word influence how it is processed. For example, when studying ERPs, nouns elicit a larger N400 than verbs (Barber et al., 2010; Kellenbach et al., 2002). Similarly, high imageable words elicit a larger N400 than low imageable words (Nittono et al., 2002; Kouinos & Holcomb, 1994). This has caused some debate concerning how related or dissociable word class and imageability are in word retrieval (Kellenbach et al., 2002). The current study uses EEG to study this interaction, however instead of ERPs we used time frequency analysis of the EEG. Recent research of the neural oscillations underlying language comprehension has found that increases in theta (4-8 Hz) are related to effortful retrieval of semantic representations. Specifically increases in theta exist for verbs compared to nouns (Maguire et al. 2015). The current study focuses on theta band activity to investigate the interaction between word class and imageability. Methods: Eighteen right-handed, monolingual English speakers between 18-31 years old had their behavioral and EEG responses recorded during an imageability rating task involving word-by-word presentation of 180 high and low imageable nouns, verbs, and adjectives (30 of each condition). After each word, participants indicated whether the word was easy or difficult to visualize. Analysis The EEG corresponding to each condition was epoched from -500 msec to1000 msec. Data were averaged across trials and subjects, and computed using the log power values minus the baseline (Delorme & Makeig, 2004). Within EEGLAB, an interactive Matlab toolbox, we performed random permutation statistical analysis of the EEG data, computing p-values for both the time and frequency

points for each comparison of interest. To perform the cluster correction we removed clusters of fewer than three electrodes. Clusters had to remain significant in 50 msec bins for 250 msec across the theta frequency band. 150 msec windows chosen based on past ERP research regarding changes in the P2 and N400 due to imageability and word class (Kotchoubey & Lang, 2003; Kellenbach et al., 2002). Results A 2 x 2 ANOVA on changes in theta activity occurring between 150 msec to 1000 msec identified multiple electrodes over the frontal and posterior areas that exhibited significant differences between word class for low imageable words, however no significant electrode clusters exhibited differences for high imageable words ($p<0.05$). For the low imageable words, verbs showed widespread theta synchrony, while nouns exhibited desynchrony. From 150-300 msec adjectives showed increased theta synchrony which was overall characteristic of verbs; however, adjectives exhibited desynchrony similar to nouns from 400-600 msec. Conclusion These findings suggest that when a word is difficult to visualize, word class matters. Specifically imageability does not seem to impact each word class in the same way. Although the nouns, verbs and adjectives were matched for imageability, the low imageable verbs elicited the greatest theta activity indicating that they were the most difficult to image. Interestingly, we found that adjectives seemed to fall between nouns and verbs, exhibiting more theta synchrony than nouns but significantly less than verbs.

F63 Contextual modulation of hippocampal activity during picture naming

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Plain picture naming is a standard task used to probe language processes in healthy and impaired speakers. Picture naming performance recruits a broad neural network of language related areas, among which hippocampus is typically not included. In published studies, hippocampus is not frequently associated with word production deficits, and its activation is rarely reported in imaging data of word production. However, hippocampus can be reasonably expected to play a role in picture naming, and its activity be sensitive to repeated naming. Picture naming can be thought of as an implicit associative task, where a naming event links a particular stimulus (picture or object representation) with a response (the picture's name). Hippocampus would then drive incremental or associative learning (Gluck et al., 2003; Meeter et al., 2005) from the first time an item is named to its subsequently repeated naming. Such learning mechanism has been proposed as a unitary cognitive cause for two robust contextual effects observed in picture naming behavior (Oppenheim et al., 2010): generic priming from repeated use (Bartram, 1973, 1974), and specific interference from semantically related material (Howard et al., 2006). To test this hypothesis, we probed hippocampal activity during an overt plain picture naming, without any memorization requirement; we further assessed whether this activity was modulated by contextual factors such as repetition priming and semantic interference. The data were recorded from intracerebral electrodes that had been directly implanted for clinical diagnosis in 'healthy' hippocampi of six epileptic patients. The electrophysiological responses revealed a specific and reliable pattern of activity that was markedly modulated by repetition priming and semantic context. The first presentation of a picture elicited a large positivity peaking around 400 ms (P4). Its latency and amplitude diminished as function of the number of presentations of the same picture. In contrast, repetitions promoted the progressive emergence of a negative component peaking around 600 ms (N6). This N6 was the only component sensitive to semantic context, with smaller peak amplitude during semantically homogeneous contexts. Such involvement of hippocampus does not solely reflect repetition-suppression or increased efficiency but presumably reveals incremental learning, as predicted from models of hippocampal function (Gluck et al., 2003; Meeter et al., 2005) and of psycholinguistic processes (Oppenheim et al., 2010). We suggest that the contextual factors we manipulated induce differential hippocampal processes subtended by different sub-circuits in hippocampus.

F64 Why is a piece of cake difficult for L2 learners?—An ERP investigation of processing nominal metaphors in L2

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Understanding figurative speech in a second language (L2) is a bottleneck for L2 learning. However, little is known about the nature of these difficulties. Studies done with native speakers have shown that metaphor understanding involves retrieving metaphorical meanings shortly after or concurrently with literal meanings from semantic memory and additional controlled processes to resolve the conflict between literal meaning, figurative meaning and the context (indexed by a more negative N400 and a late positive component, or LPC, to metaphors relative to literal expressions respectively)(De Grauwe et al. 2010). Understanding which aspect(s) the challenge for L2 learners' metaphor comprehension lies is therefore of pedagogical value. We assessed event-related brain potentials (ERPs) from proficient Taiwanese learners of English while comprehending English nominal metaphors familiar to native speakers as well as literal and anomalous sentences (e.g., Metaphorical: Unemployment is a plague that affects many people. Literal: Cholera is a plague that affects many people. Anomalous: Metal is a plague that affects many people.). Sentences were taken from Experiment 2 of De Grauwe et al. (2010), and were presented word by word on the screen (duration: 400ms; ISI: 100ms; same presentation speed was used for

native speakers in De Grauwe et al.). Participants had to judge whether the sentence made sense at the end of each sentence. Thirty proficient Taiwanese learners of English were tested (mean age: 23.4, range 21-29, 16 males); all scored 100 or above on a TOEFL test taken within 2 years. Participants were 78% accurate on average in the plausibility judgment test (Literal: 82%, Metaphorical: 72%, Anomalous: 79%). ERP results from correct trials showed anomaly effect similar to what was previously observed in native speakers—compared to metaphor and literal conditions, anomalous condition elicited, on the critical words underscored in the examples, reliably more negative N400s (300-600ms) and more positive LPC responses (800-1000ms), and on sentence final words, more negative N400s. By contrast, ERP responses to metaphors were reliably more positive than literal sentences only on the sentence final words. Further analysis on critical words showed that, compared to the literal condition, metaphors that have a corresponding expression and therefore an existing conceptual mapping in Chinese did elicit more negative N400s and larger LPCs, as was seen before in native speakers. These effects were reliably correlated with proficiency indices such as self-rated proficiency and TOEFL scores, with higher proficiency correlated with larger N400 and LPC effects. These results suggest that L2 speakers may be less sensitive to the semantic relations between the source and target concepts and the literal and metaphorical interpretations so as not to show differential responses on the critical words but delay the conflict resolution process till the end of a sentence. However, existing conceptual links in the native language aid the comprehension process and enable L2 speakers to engage qualitatively similar mechanisms as do native speakers. Our results thus suggest that emphasizing the conceptual mappings between the literal and metaphorical interpretations may facilitate metaphor understanding in L2, which in turn can help build higher L2 proficiency.

F65 Differential Impairments of Upper and Lower Limb Movements Influence Action Verb Processing in Parkinson Disease *Ken McRae[1], Angela Roberts[1], JB Orange[1], Peter Nguyen[1]; [1]University of Western Ontario*

Theories of grounded cognition emphasize the role of sensorimotor simulation in conceptual knowledge. The motor system is hypothesized to play a central role in the representation and processing of action concepts. fMRI and TMS studies provide evidence that areas of the brain that are responsible for planning and executing motor movements also are involved in processing action verbs such as kick. However, some researchers have argued that activation of corresponding cortical motor areas during language tasks may be an ancillary consequence of understanding an action concept, rather than a core functional component of the concept itself. One potential way to tease these hypotheses apart is to study individuals with motor impairments. Several studies have shown that persons with Parkinson disease (PD) are impaired on processing action verbs, particularly as compared to concrete nouns. We used a novel approach to investigate verb processing in PD. In previous research, PD participants were treated as a homogeneous group, even though the motor presentation of PD is quite variable relative to limbs and core body regions involved. We used clinical measures (UPDRS) and self-report ratings to classify PD participants as experiencing primarily upper or lower limb motor impairments. We investigated whether persons with PD who have greater upper versus lower limb motor impairments show different patterns of performance when processing action verbs. Participants made action go-no decisions ("say 'Go' if the word refers to a physical or mental action") on upper limb (reach) and lower limb (kick) verbs (as well as psych verbs such as consider). Verbs were chosen using undergraduates' ratings of upper ("the extent to which the action involves the hands and arms") and lower ("involves the legs and feet") limb relatedness. The verb sets were equated for mean decision latency in a pilot study with undergraduate participants. The primary result was a significant interaction between motor dominance (PD upper vs. PD lower limb motor impairments) and verb type (upper vs. lower limb verbs). Decision latencies for PD participants with greater upper motor limb impairments were significantly longer for upper (926 ms) than for lower limb verbs (870 ms). In contrast, PD participants with greater lower limb impairments performed similarly on upper (850 ms) and lower limb verbs (849 ms). When the PD participants with greater upper limb motor impairments were analyzed with the age and education matched controls, the same interaction was found, due to PD participants having significantly longer latencies for upper limb verbs, but controls showing a nonsignificant 14 ms difference. Our results suggest that the connections between the basal ganglia and frontal regions are sufficiently fine-grained such that disturbances to the basal ganglia that lead to greater motor impairments of the arms and hands also lead to selective impairments in processing upper-limb verbs. Connections between the basal ganglia and motor cortex that are involved in carrying out specific physical actions overlap with those involved in processing selective physical action verbs. Thus, these data support a relatively fine-grained functional role of the motor system in processing action verbs.

F66 Visual vs. Linguistic Narrative Processing in Autism Spectrum Disorders *Emily Coderre[1], Neil Cohn[2], Sally Slipher[1], Mariya Chernenok[1], Kerry Ledoux[1], Barry Gordon[1,3]; [1]Cognitive Neurology/Neuropsychology; Department of Neurology; Johns Hopkins University, [2]Center for Research in Language; University of California, San Diego, [3]Department of Cognitive Science; Johns Hopkins University*

Individuals with autism spectrum disorders (ASDs) exhibit core deficits in higher-level language processes requiring semantic integration, such as sentence or narrative comprehension. However, these difficulties appear to

be restricted to the linguistic domain: individuals with ASD show intact semantic processing for simple pairs of non-linguistic stimuli (e.g. pictures or auditory sounds). Given that individuals with ASD show deficits in lexico-semantic but not visuo-semantic integration, it is an open question whether the processing of narrative information presented visually, in the form of comics, is impaired or not in individuals with ASD. We investigated this question using the N400 and P600 evoked potentials as markers of semantic processing. HFAs and NCs were presented with narratives consisting of short sentences (linguistic narratives) or sequential images (visual narratives). In both modalities, the last word or panel was either congruent or incongruent with the preceding narrative context. Based on previous research, we predicted that NCs would show N400 and P600 effects in response to incongruities in both types of narratives (sentence-final words and sequence-final images). Also based on prior findings, we predicted that HFAs would show reduced or absent N400 effects but enhanced P600s compared to NCs for linguistic narratives, suggesting difficulties with contextual integration and alternative strategies for semantic comprehension. For visual narratives, similar N400 effects for both groups would suggest that semantic processing deficits are localized to the linguistic domain, whereas reduced N400 effects for HFAs relative to NCs would suggest that domain-general narrative comprehension is impaired in ASD. Preliminary results (n = 9 in each group) showed that, in linguistic narratives, NCs had a centro-parietal N400 that was larger to incongruent than congruent conditions, followed by a small P600 effect to incongruent conditions. An N400 effect was also observed for linguistic narratives in HFAs, but the effect had a smaller scalp distribution than in NCs, which could suggest processing difficulties in HFAs. In contrast, a large P600 was observed in HFAs. The reduced N400 but larger P600 for HFAs compared to NCs is consistent with previous findings suggesting differences in integration strategies between the groups. In the visual narratives, both groups showed a robust positivity for incongruent conditions although this effect had different scalp topographies in each group. NCs showed a widespread left centro-parietal positivity for the incongruent condition, beginning approximately 200 ms post-stimulus and a right frontal N400. In contrast, HFAs showed a centro-parietal positivity but not an anterior N400. This could suggest different neural mechanisms are used by HFAs for semantic integration of visual narratives. Overall, these data show differences in narrative comprehension between HFAs and NCs not just in language-based stimuli but also in visually-based stimuli, suggesting that domain-general narrative comprehension may be altered in ASD.

F67 Dissociable intrinsic functional networks support noun and verb processing *Huichao Yang[1], Qixiang Lin[1], Zaizhu Han[1], Hongyu Li[1], Luping Song[2], Yong He[1], Yanchao Bi[1]; [1]State Key Laboratory of Cognitive Neuroscience and Learning & IDG/McGovern Institute for Brian Research, Beijing Normal University, Beijing 100875, China, [2]Rehabilitation College of Capital Medical University, China Rehabilitation Research Center, Beijing 100068, China*

The neural circuits supporting noun (entity) and verb (event) processing are a central issue underlying language research, with robust evidence indicating widely distributed regions showing different preference for these two classes of items. We conducted two experiments to examine the intrinsic network organizations of these regions and their corresponding behavioral relevance. Experiment 1 exploredwhether the brain regions previously shown to be selectively activated by noun or verb are intrinsically organized into different functional networks using resting-state fMRI data of 146 healthy adults. Noun- and verb-preference nodes were identified by the activation likelihood estimate (ALE) meta-analyses from 22 imaging studies, resulting in 19 verb nodes and 15 noun nodes. The modularity analysis over these nodes showed that they could be reliably subdivided into three modules across a range of network sparsity (sparsity = 0.4, Q = 0.3, Z = 13.8). The majority (76%) of the nodes converged onto the distinct word-class preferences in the ALE analyses. Furthermore, when evaluating the functional connectivity strength (FCs) within the regions labeled for the two word classes based on the ALE analyses, the average within-class FCs was significantly greater than the average between-class FCs [t (143) = 24.52, $P < 0.01$; t (143) =18.51; $P < 0.01$], suggestion that the regions showing activation differences for the two classes are indeed intrinsically organized into different functional networks. Experiment 2 examined the behavioral relevance of the intrinsic noun and verb networks using data from 88 brain-damaged patients. We found that across patients the relative mean FCs based on network identified in Experiment 1 significantly correlated with the relative behavioral performance in the picture associative matching task for verb (action) and noun (tool): modularity-analyses defined network: r = 0.37, $P < 0.01$; ALE-analyses defined network: r = 0.31, $P < 0.01$. The correlation remained significant even after controlling for the extent of the relative anatomical damage of the two networks, measured by number of voxels being lesioned in the nodes within each network (r = 0.37, $P < 0.01$). In summary, we found that noun and verb preference regions from prior studies are intrinsically organized into segregated functional networks and the integrity of such networks could significantly account for relative noun or verb selective deficits as consequences of brain lesion, indicating that noun and verb processing are supported by dissociable large-scale functional networks.

F68 Category influences on semantic error production in aphasia. *Hilary J. Traut[1], Denise Y. Harvey[1,2], Erica L. Middleton[1]; [1]Moss Rehabilitation Research Institute, [2]The University of Pennsylvania*

The phenomenon that naming pictures from the same semantic category hinders subsequent naming from that category (i.e., semantic interference) provides insight into the mechanisms modulating lexical access. In the continuous naming paradigm, subjects name pictures from various semantic categories, where categorically related pictures appear interleaved with several unrelated pictures. Results from this task reveal that performance increasingly worsens with successive same-category picture naming, independent of the number of intervening unrelated trials. That semantic interference persists across naming several unrelated trials indicates that the effect arises due to an experience-dependent learning mechanism that dynamically changes connection weight strengths between semantic and lexical levels of representation [1,2]. While semantic interference in the continuous naming task is well-documented in healthy populations, to our knowledge, this has not been explored in people with aphasia (PWA) secondary to left-hemisphere stroke. Consequently, it remains unclear whether aphasics with word retrieval deficits exhibit impaired categorical naming in a similar fashion to that observed in healthy populations. We conducted a retrospective analysis examining naming accuracy in 15 PWA (with a primary impairment in word retrieval) who named 615 pictures presented once each in a random order as part of a previous study [3]. We identified 19 semantic categories (range of items per category = 16 – 37), resulting in the categorization of 87% of the pictures. "Critical trials" consisted of semantically related items that appeared within 15 or fewer intervening unrelated items, a criteria chosen to maximize the likelihood of observing an effect. We compared performance on critical trials with that of trials appearing in close proximity to, but bearing no semantic relationship with, the critical trials (i.e., "control trials"). We analyzed the first-complete response, and coded errors as either "semantic" or "other". We used a mixed logistic regression to examine whether the proportion of semantic errors (out of all errors) was greater for critical vs. control trials. As predicted, we found a greater proportion of semantic errors for critical compared to control trials ($p < .001$), evidencing semantic interference. To our knowledge, these results are the first to demonstrate that PWA exhibit semantic interference in an unstructured continuous naming paradigm. That semantic interference persisted across naming unrelated pictures supports the notion that a learning mechanism modulates word retrieval in an experience-dependent fashion. In turn, our findings shed light on how this learning mechanism operates in errorful word retrieval as a result of stroke. [1] Howard, D., Nickels, L., Coltheart, M., & Cole-Virtue, J. (2006). Cumulative semantic inhibition in picture naming: Experimental and computational studies. Cognition, 100, 464-482. [2] Oppenheim, G. M., Dell, G. S., & Schwartz, M. F. (2010). The dark side of incremental learning: A model of cumulative semantic interference during lexical access in speech production. Cognition, 114, 227-252. [3] Middleton, E. L., Schwartz, M. F., Rawson, K. A., & Garvey, K. (2014). Test-enhanced learning versus errorless learning in aphasia rehabilitation: Testing competing psychological principles. Journal of Experimental Psychology: Learning, Memory, and Cognition, http://dx.doi.org/10.1037/xlm0000091.

F69 An eyetracking investigation of semantic access for action concepts: Effects of representational input modality and concurrent motor execution

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Much remains to be learned about the neurobiology of action processing and its relation to language. Here, we investigated two attributes of action verb processing. The first involves the moderating effects of representational format on modality-specific semantic access for actions relative to objects. Specifically, we investigated whether the standard picture superiority effect that applies to objects (i.e., pictures are more rapidly identified and better recalled than words) also impacts actions. The second topic relates to the extent to which action concepts are embodied within cortical motor representation. A strict embodied view predicts that overt motor tasks and verbs that share the same body part effector (e.g., producing a hand verb while tapping one's finger) will engage the same cortical cell assemblies and thus produce interference. We examined these domains in an action semantic judgment task with and without a concurrent motor tapping task using eyetracking paradigm. 35 young adults (μ = 20 yrs) were instructed to judge the relatedness of pairs of stimuli (e.g., wiping-rubbing, spinning-rocking). The semantic judgment task employed pictorial and orthographic presentation of the same items, allowing modality performance contrasts. Furthermore, we manipulated the types of action concept (i.e., physical vs. non-physical) and task conditions (i.e., semantic vs. semantic + motor task composed of sequential finger tapping of a number pad) to examine the effect of first-person motor execution on performance. Both behavioral and eyetracking measures revealed slower and less accurate performance for actions relative to objects. With respect to input modality, participants showed a reversal of the picture superiority effect for actions, whereas objects elicited comparable patterns of performance. These results challenge the conventional finding that object pictures enjoy privileged access to the semantic system. With respect to motor embodiment, participants did not show motor interference in that there was no processing difference between physical vs. non-physical actions. Furthermore, the concurrent motor task induced a dual task effect regardless of conceptual domain and action category. Although there was a greater processing delay and lower response accuracy in the action concepts in the semantic + motor dual task condition, it did not attain statistical significance. These results suggest that the picture superiority effect reverses for action verbs (i.e., words > pictures) and that a concurrent motor task does not interfere with action semantic categorization indices.

F70 Neural correlates of processing categorical relatedness in youths with autism spectrum disorder *Ciao-Han Wong[1], Susan Shur-Fen Gau[1,2,3,4], Tai-Li Chou[1,3,4]; [1]Department of Psychology, National Taiwan University, Taiwan, [2]Department of Psychiatry, National Taiwan University Hospital and College of Medicine, Taiwan, [3]Neurobiology and Cognitive Science Center, National Taiwan University, Taiwan, [4]Graduate Institute of Brain and Mind Sciences, National Taiwan University, Taiwan*

Introduction: To understand the cognitive mechanism of forming categories is important to know the nature of lexical representations. Previous studies have shown developmental changes of categorization processes in typically developing (TD) youths. However, it is little known whether processing categorical relatedness would differ between youths with autism spectrum disorders (ASD) and TD youths. Methods: Functional magnetic resonance imaging (fMRI) was used to examine the neural correlates of semantic judgments while processing categorical relatedness. Thirty-two male youths with ASD (mean age = 12.7 years) and twenty-five age-, sex-, and handedness-matched typically developing (TD) youths (mean age = 12.3 years) participated in this study. Participants were asked to decide if two visually-presented Chinese characters were semantically related. For the related pairs, the categorical relatedness (categorical rating) was an item-level parametric modulator that served as a continuous variable to determine if brain activation was systematically correlated with categorical relatedness. Results: For the ASD group, the lower categorical relatedness produced greater activation in the left middle temporal gyrus (BA 21) as compared to the TD group. For the TD group, the higher categorical relatedness produced greater activation in the left precuneus (BA 30) as compared to the ASD group. Conclusion: Our findings imply differential neural mechanisms of processing categorical relatedness between the two groups. The ASD group may more rely on semantic information for abstract semantic concepts, suggesting an atypical organization of categorical concepts. In contrast, the TD group may use mental imagery to search overlapping perceptual features for comparing semantic similarity between two characters.

Motor Control, Speech Production, Sensorimotor Integration

F71 Enhancement for memory of non-words over words during recruitment of the auditory dorsal stream *Keith Doelling[1], Andrew Heusser[1], Bijan Pesaran[1], David Poeppel[1,2]; [1]New York University, New York, NY, [2]Max Planck Institute for Empirical Aesthetics, Frankfurt, Germany*

A range of controversies surround the role of activity in motor and sensorimotor brain regions in perceiving speech. Despite claims for a causal role of motor activation in speech perception, most studies that argue for motor effects in clear speech use non-words or single syllables. These therefore reflect unusual examples of speech processing. Here we test the hypothesis that the dorsal sensorimotor pathway is specifically engaged to process such nonwords – phonotactically legal speech sequences for which the subject has no lexical-semantic entry – even in pure listening tasks. Such a role, while not necessary for typical speech perception, would be crucially important for both development of language and the learning of new words in adulthood. To test this hypothesis, we ran participants on a memory test in a 2x2 design, contrasting conditions involving words vs. nonwords and heard vs. spoken items. In the listen condition, participants hear an item twice contiguously, whereas in the speak condition, participants hear the item once and then immediately repeat it out loud – overtly engaging the dorsal stream pathway. They are subsequently tested on their memory of the presented items. Unsurprisingly, we show a main effect of word type (words remembered better than non-words) and source (spoken remembered better than listen). We also predicted an interaction. If non-words are primarily processed in the dorsal stream, then actively engaging this pathway (through overt repetition) should result in a stronger (i.e. longer-lasting) representation in the case of nonwords. Our data confirm this prediction: the performance benefit from speaking an item is larger in nonwords than in words. This effect is consistent with the hypothesis that the dorsal sensorimotor stream is more relevant to non-word compared to lexical processing.

F72 Auditory predictions of self-produced speech are task-dependent *Caroline Niziolek[1], Srikantan Nagarajan[1], John Houde[1]; [1]University of California, San Francisco*

When we speak, what do we expect to hear? An action's sensory consequences, such as the auditory feedback heard while speaking, are thought to be predicted by the motor system. If the feedback matches the prediction, the neural response in sensory cortices is suppressed, a phenomenon known as speaking-induced suppression (SIS). However, it is unclear how this suppression occurs neurally, and what sensory parameters are compared to evaluate a "match." For example, when speaking English, the pitch of the voice has much more freedom to vary than when singing; is pitch encoded in the auditory prediction in the same way during these two tasks? Here, we used natural speech production to probe the nature of internal predictions and how they are encoded in auditory cortex. We used magnetoencephalography (MEG) to measure how SIS varied over repeated word productions in two different contexts. In Experiment 1, ten subjects produced 200 repetitions of three different words; in Experiment 2, ten subjects were cued by tonal prompts to produce 150 repetitions of a single word on three different pitches. These productions were then played back to the subjects. SIS was defined as the suppression of the auditory M100 response to spoken or sung words relative to the playback condition. When the prediction does not encode pitch, SIS should not change across pitch space: every production

will be equally accurate. However, when the prediction does encode a pitch target, then SIS should be strongest at the center of the pitch distribution (most accurate pitches) and attenuated at the periphery (sharpest and flattest attempts at producing a pitch), where the feedback least matches the prediction. We found that pitch encoding depended on task context: SIS varied across utterances only in Experiment 2, in which pitch was an explicit target. This is consistent with a forward model in which the auditory prediction is weighted by acoustic parameters that contribute to a higher-level goal.

F73 Shared and unique neural involvement in natural speech production and perception *Anna Maria Alexandrou[1,2], Timo Saarinen[1,2], Sasu Mäkelä[1,2], Jan Kujala[1,2], Salmelin Riitta[1,2]; [1]Department of Neuroscience and Biomedical Engineering, Aalto University, Espoo, Finland, [2]Aalto NeuroImaging, Aalto University, Espoo, Finland*

Current knowledge of the cortical mechanisms of language function stems mostly from studies of production or perception of single words or sentences. Such studies have emphasized the role of the left hemisphere in language processing. However, it has been suggested that production and perception of complex, natural speech, as encountered in real life, may rely on partly different cortical mechanisms (Silbert et al., 2014; Koskinen et al., 2013). In the present study, we examined the spatiospectral cortical representation of natural speech production and perception with magnetoencephalography (MEG). Cortical signals during speech production and perception, on separate days, were recorded with a whole-head 306-channel Elekta MEG device from 20 healthy Finnish-speaking participants. In the production experiment, participants generated continuous natural speech at three speaking rates: normal/spontaneous, slow and fast. As a control task, they additionally produced a /pa/ syllable repeatedly at normal rate. In the perception experiment, participants listened to their own speech (produced in the speech production experiment) and speech of an unknown male, at all three speaking rates. Furthermore, participants listened to rhythmic, amplitude-modulated white noise with the same envelope and spectral content as in the normal-rate speech samples. Cortical distribution of bandpass signal power was determined for each condition and each participant. Power differences between conditions were estimated on spatially equivalent grid points across participants in eight frequency bands spanning the range 1-90 Hz. Statistical significance was determined using group-level cluster-based statistics and three parameters: speaking rate, speech complexity (in production, speech vs syllable repetition; in perception, speech vs noise) and speaker identity (listening to own speech vs unknown speaker's speech). In speech production, more neural activity was observed in the right posterior temporal and temporo-parietal regions for fast compared to normal or slow speaking rates across a wide range of frequencies (4-90 Hz). More activity for speech than syllable repetition was found in those same areas bilaterally across the examined frequency range (1-90 Hz). In speech perception, low-gamma band power (35-45 Hz) in the left middle superior temporal cortex was enhanced for slow and fast speaking rates compared to the normal rate. Listening to an unknown speaker rather than own speech increased alpha- and beta-band power (8-30 Hz) in right temporal regions and the temporo-parietal junction. Increased power in this same frequency band (8-30 Hz) was observed for listening to speech vs noise, slightly more dorsally in the right parietal cortex. The present findings show that right-hemisphere areas are remarkably involved in natural language processing. An increased rate of speech production shows as increased power of cortical activity, particularly in the right hemisphere. In contrast, increased activity in the left superior temporal cortex was observed when the rate of perceived speech deviated from normal. Speech production and perception thus seem to use different neural substrates in processing temporal aspects of speech. However, increasing complexity in both speech perception and production seems to rely on spatially comparable cortical representations, with bilateral activation in production and right-hemisphere involvement in perception.

F74 Following and Opposing Responses to Perturbed Auditory Feedback *Matthias K. Franken[1,2], Frank Eisner[1], James M. McQueen[1,2,3], Peter Hagoort[1,2], Daniel J. Acheson[1,2]; [1]Radboud University Nijmegen, Donders Institute for Brain, Cognition and Behaviour, [2]Max Planck Institute for Psycholinuistics, Nijmegen, [3]Radboud University Nijmegen, Behavioural Science Institute*

The role and importance of auditory feedback during speech production has been widely investigated using perturbations to auditory feedback. Most studies have shown that manipulations of pitch or speech formant frequencies lead to vocal responses in the opposite direction of the feedback manipulation, suggesting that the audio-vocal system works as a negative feedback control system. However, responses in the same direction as the perturbation have also been observed (termed "following" responses), which suggests that current neurobiological theories of the speech motor control system do not suffice. To date, it remains unclear why responses sometimes follow vocal feedback perturbation, or why people would make following responses at all. There has been surprisingly little research to following responses, leading to an incomplete picture of how auditory feedback is used in speech production. The present study systematically compares following and opposing responses to perturbed or unexpected feedback, in order to investigate why people sometimes follow unexpected feedback. Participants performed a pitch matching task in which they heard a low, mid or high tone, and were instructed to hold the pitch while uttering the Dutch vowel /e:/. Feedback through headphones allowed participants to hear themselves, and feedback was randomly perturbed on half of the trials. During perturbation trials, participants'

feedback was briefly perturbed, starting 500 to 1500 ms after speech onset, by shifting pitch upward by 25 cents. The perturbation lasted for 500ms and then returned to normal feedback. Post-processing of the data allowed us to categorize trials as either opposing or following. Analyses revealed some striking differences between these trial types. Following responses tended to have a smaller and earlier peak response compared to opposing responses. This result may be explained by the fact that following the perturbed feedback is inherently unstable, leading participants to return earlier to baseline in these trials. In addition, higher tones tended to elicit a higher proportion of opposing responses compared to lower tones. A possible explanation is that the higher tone leads people to vocalize further away from their conversational pitch, so an unexpected perturbation might cause them to shift somewhat closer to their familiar pitch range, resulting in this case in opposing responses. Importantly, we found that the slope of the average pitch contour in the baseline period (i.e., before perturbation had started) was related to whether the current trial would be opposing or following. Across subjects, following trials were preceded by an upward trend before perturbation, where the opposite was observed for the opposing trials. This result suggests some inertia in participants' pitch response: when participants' pitch was already increasing, a perturbed feedback would lead to an even stronger increase, whereas an ongoing decrease would lead to an even stronger decrease. In conclusion, this study shows that multiple factors can influence participants' responses to unexpected auditory feedback. The effect of pitch slope suggests that the response to altered feedback is partly dependent on the system's current state, which is not accounted for in many of the current neurobiological models of auditory feedback processing.

Author Index

D

E

F

G

H

I

J

K

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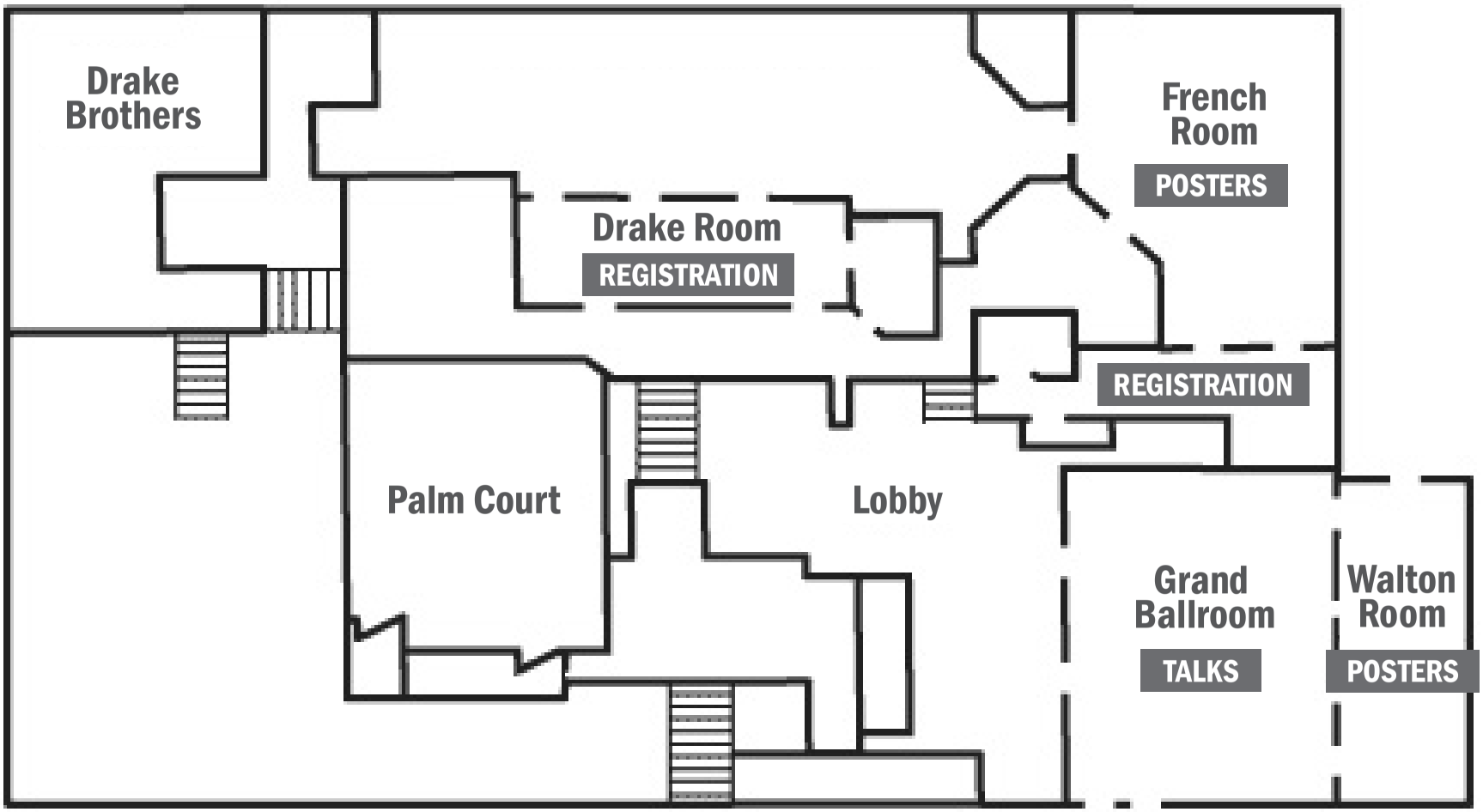

Drake Hotel Lower Level

Mark Your Calendar

August 17-20, 2016