The Fifth Annual Meeting of the Society for the Neurobiology of Language

November 6-8, 2013
San Diego, California

SNL 2013

www.neurolang.org

Abstracts

Welcome to SNL 2013, San Diego, California

Welcome to the 5th Annual Meeting of the Society for the Neurobiology of Language. You may have noticed that this year the meeting, formerly known as the Neurobiology of Language Conference, has been officially renamed to recognize the continued growth and vitality of SNL as an independent society. SNL in turn reflects the dramatic growth in neurobiological research on basic language mechanisms that has occurred over the past few decades, and the need for an organization dedicated to sharing and integrating this knowledge. SNL is indebted to Steve Small and Pascale Tremblay, who presciently recognized this need and organized the first NLC in 2009. The results were overwhelmingly positive, and SNL became a non-profit incorporated entity in 2010. Membership continues to grow, this year reaching nearly 600. For this year's meeting there were 382 abstract submissions, a 30% increase over last year.

As our fledgling society continues to develop, we need your input to ensure that the meeting is what you want it to be. A major change requested by attendees and instituted this year is an increase in the length of the meeting to two and a half days. This has allowed additional poster and slide sessions and a third keynote address. Following the success of last year's meeting in San Sebastián and favorable input from the membership, the SNL Board has decided to continue the pattern of alternating meetings between North America and Europe. Membership feedback has had a profound impact on the content of this year's meeting, and content of the keynote addresses and debate sessions is a topic of ongoing active discussion. Please attend the open business meeting on Wednesday at 5:45 pm to discuss these and other issues concerning the future of SNL.

Organizing the SNL annual meeting is a huge undertaking, made possible by the combined work of the Board of Directors, the Program Committee, the Nominating Committee, Society Officers, and our meeting planner, Shauney Wilson. Please join me in expressing a sincere thanks to them all. Thanks are also due once again to Steve Small and Greg Hickok for securing support from the NIDCD in the form of an education grant, and to the NIDCD for this award. A profound thank you also goes to the many abstract reviewers who generously gave their time to ensure a high quality of scientific content at the poster and slide sessions.

Finally, the Board thanks all SNL members and meeting attendees for making the Society possible. It goes without saying that you are the reason SNL was formed and will flourish. Please join as a member if you haven't done so, please nominate officers and vote for them, and please submit abstracts for posters and talks. Word of mouth is the best advertising, and we appreciate your spreading the news. SNL is for you, and it will be what you make it.

On behalf of the SNL Board, welcome to San Diego! We hope you have an inspiring and rewarding meeting.

Jeff Binder
Chair, Society for the Neurobiology of Language

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SNL Founders

Steven L. Small, Ph.D., M.D.,
University of California, Irvine, US

Pascale Tremblay, Ph.D.,
Universite Laval, Quebec, Canada

Schedule of Events

All events are held at the Westin San Diego.

Wednesday, November 6th

11:00 am – 5:30 pm	Pre-Registration Check-in and Onsite Registration *Ballroom Foyer*
1:00 – 1:30 pm	Opening Remarks - Jeff Binder, SNL President and Marta Kutas, SNL Past President *Crystal Ballroom*
1:30 – 2:30 pm	**Keynote Lecture - Janet F. Werker** The Elizabeth Bates Memorial Lecture: Initial Biases and Experiential Influences on Infant Speech Perception Development *Crystal Ballroom*
2:30 – 3:00 pm	Coffee Break *Emerald Ballroom*
2:30 – 4:30 pm	Poster Session A *Emerald Ballroom*
4:30 - 5:50 pm	Slide Session A – Speech and Auditory Perception *Crystal Ballroom*
5:50 – 6:20 pm	Business Meeting *Crystal Ballroom*
6:20 – 7:50 pm	Welcome Reception *Pool Deck*

Thursday, November 7th

7:30 am – 7:00 pm	Pre-Registration Check-In and Onsite Registration *Ballroom Foyer*
8:00 - 8:30 am	Continental Breakfast *Ballroom Foyer*
8:30 - 9:50 am	Slide Session B – Speech Production and Phonology *Crystal Ballroom*
9:50 - 10:20 am	Coffee Break *Emerald Ballroom*
9:50 – 11:50 am	Poster Session B *Emerald Ballroom*
11:50 am – 1:15 pm	Lunch Break (Lunch on your own)
1:15 – 2:15 pm	**Keynote Lecture - Terry Sejnowski** The Dynamic Brain *Crystal Ballroom*
2:25 – 3:45 pm	Slide Session C – Language Development and Bilingualism *Crystal Ballroom*
3:45 - 4:15 pm	Coffee Break *Emerald Ballroom*
3:45 - 5:45 pm	Poster Session C *Emerald Ballroom*
5:45 – 7:15 pm	**Discussion Panel - Max Coltheart vs Mark Seidenberg** The Role of Semantic Information in Reading Aloud *Crystal Ballroom*

Friday, November 8th

7:30 am – 7:00 pm	Pre-Registration Check-In and Onsite Registration *Ballroom Foyer*
8:00 - 8:30 am	Continental Breakfast *Ballroom Foyer*
8:30 - 9:50 am	Slide Session D – Lexical Semantics *Crystal Ballroom*
9:50 - 10:20 am	Coffee Break *Emerald Ballroom*
9:50 – 11:50 am	Poster Session D *Emerald Ballroom*
11:50 am – 1:15 pm	Lunch Break (Lunch on your own)
1:15 – 2:35 pm	Slide Session E - Lexical-Sentential Cognitive Control *Crystal Ballroom*
2:45 – 4:15 pm	**Discussion Panel - Miriam Faust vs Alexander M. Rapp** The Role of the Right Hemisphere in Figurative Language Processing *Crystal Ballroom*
4:15 – 4:45 pm	Coffee Break *Emerald Ballroom*
4:15 - 6:15 pm	Poster Session E *Emerald Ballroom*
6:15 – 7:15 pm	**Keynote Lecture – Robert Knight** Language Viewed from Direct Cortical Recordings *Crystal Ballroom*
7:15 – 7:30 pm	Closing Remarks - Peter Hagoort, SNL President Elect *Crystal Ballroom*

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

Anna Beres, Bangor University, UK

Sung-Joo Lim, Carnegie Mellon University, US

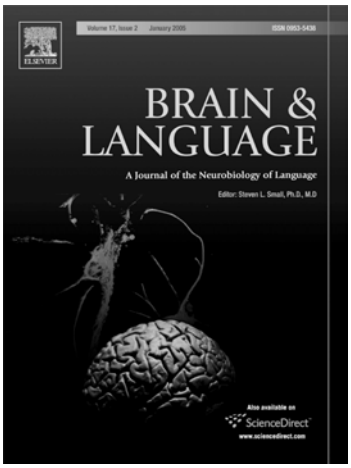
Alicia Rawling, Centre for Clinical Research, University of Queensland, Herston, Australia

Post Doctoral Merit Award Winners

Adeen Flinker, New York University, US

Tineke M. Snijders, Radboud University, Nijmegen, Netherlands

Thank You to Our 2013 Sponsors



Brain & Language (Elsevier)

Rogue Research

Travel Awards

This year, the Society for the Neurobiology of Language granted twenty Travel Awards. The awards, funded by the National Institutes of Health (NIH), help to cover travel and registration costs for the 2013 Society for the Neurobiology of Language Meeting in San Diego, US.

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

The 2013 Travel Awards were given to:

Anna Beres, Bangor University, UK

Teon Brooks, New York University, US

Emily Connally, University of Oxford, UK

Isabelle Deschamps, Université Laval, Canada

Mandy Faretta-Stutenberg, University of Illinois at Chicago, US

Alona Fyshe, Carnegie Mellon University, US

Sharon Geva, University College London, UK

Ajay Halai, University of Manchester, UK

Amanda Jaimes Bautista, Instituto Nacional de Neurología y Neurocirugía de México

Fernanda Loureiro, Pontifical Catholic University of Rio Grande do Sul (PUCRS), Brazil

Catherine Norise, University of Pennsylvania, US

Ōiwi Parker Jones, University College London, UK

Angel Ramirez-Sarmiento, University of Delaware, US

Aurora I. Ramos Nuñez, University of Houston, US

Laura Skipper, Temple University, US

Bethany Sussman, Indiana University, US

Maryse Thomas, McGill University, Montreal, Canada

Rubén Torres Agustín, University of Mexico, Mexico

Jorge Valdes Kroff, University of Pennsylvania, US

Khaing Win, University of Pennsylvania, US

Keynote Lectures

The Elizabeth Bates Memorial Lecture

INITIAL BIASES AND EXPERIENTIAL INFLUENCES ON INFANT SPEECH PERCEPTION DEVELOPMENT

Wednesday, November 6, 1:30 – 2:30 pm, Crystal Ballroom

Chair: Marta Kutas, University of California, San Diego, US

Janet F. Werker
Department of Psychology, University of British Columbia, Canada

Language involves a cascading interplay between biology and experience. Initial perceptual biases and core neural systems support learning any natural language. Development begins by tuning these systems to the native language. In this talk, I will review the rapid changes in auditory, visual, and multimodal speech perception that occur in the first months of life as infants establish a foundation for language acquisition. I will then present evidence that, while under typical circumstances the timing of perceptual attunement seems to be constrained by maturation, there are identifiable variations in experiences that can accelerate or slow down this developmental trajectory. Finally, I will introduce new questions about whether studies to date on the timing of plasticity have considered all the relevant input systems. The implications of this work for a fuller understanding of the neurobiology of language development will be highlighted.

In my talk, I'll present new data on MR-visible tracers and esfMRI that show the capacity of these methods for the study of the organization of cortical microcircuits and effective connectivity. I shall also show first results from studies mapping network topologies by triggering imaging at structure-specific events, e.g. hippocampal ripples or cross-frequency coupling events.

THE DYNAMIC BRAIN

Thursday, November 7, 1:15 – 2:15 pm, Crystal Ballroom

Chair: Joe Devlin, University College London, UK

Terry Sejnowski
Howard Hughes Medical Institute, The Salk Institute for Biological Studies, and University of California, San Diego, US

Brains need to make quick sense of massive amounts of ambiguous information with minimal energy costs and have evolved an intriguing mixture of analog and digital mechanisms to allow this efficiency. Spike coincidences occur when neurons fire together at nearly the same time. In the visual system, rare spike coincidences can be used efficiently to represent important visual events in the early stages of visual processing. This can be implemented with analog VLSI technology, creating a new class of cameras.

LANGUAGE VIEWED FROM DIRECT CORTICAL RECORDINGS

Friday, November 8, 6:15 – 7:15 pm, Crystal Ballroom

Chair: Peter Hagoort, Max Planck Institute for Psycholinguistics, Nijmegen, Netherlands

Robert Knight
University of California, Berkeley
and the Helen Wills Neuroscience Institute

Since the 1920's, neurophysiological dogma suggested that the human cortex did not generate neural oscillations above 50-60 Hz. However, research in the last decade reports neural activity up to 250 Hz in the human necortex in multiple tasks. Indeed, every cognitive process examined including language, attention, perception, memory and motor control generates high frequency oscillatory activity in the range of 70-250 Hz (high gamma, HG). For instance, the HG response in the human electrocorticogram (ECoG) precisely tracks auditory processing in the neocortex and can be used to assess sound, phoneme and word representation as well as the flow of information during linguistic processing. We have used ECoG recordings to address the neural mechanisms of speech suppression, categorical representation and the timing of speech perception and production in peri-sylvian language regions. Importantly, the high gamma response provides a potential tool for development of neural prosthesis for disabling language deficits and work on speech reconstruction and imagined speech will also be reviewed.

Thursday Discussion Panel

THE ROLE OF SEMANTIC INFORMATION IN READING ALOUD

Thursday, November 7, 5:45 – 7:15 pm, Crystal Ballroom

Chair: Jeffrey Binder, Medical College of Wisconsin, US

Max Coltheart

Centre for Cognition and its Disorders at Macquarie University, Australia

I will consider evidence from cognitive neuropsychology, computational modelling and experimental psychology which I take to support the view that there are distinct lexical and nonlexical routes from print to speech that subserve reading aloud, and that within the lexical reading route one can distinguish a lexical but nonsemantic processing route (direct communication from visual word recognition to spoken word production) and a lexical-semantic processing route (communication from visual word recognition to the semantic system followed by communication from the semantic system to spoken word production). According to this framework, any word can be read aloud without any contribution from the lexical-semantic processing route, so the question of the role that semantic information actually plays in reading aloud is an empirical one; I will discuss evidence relevant to this open question.

Mark Seidenberg

Department of Psychology at the University of Wisconsin, US

Reading involves learning to compute the meanings of words from print; being able to read aloud is just a by-product. Characteristics of reading aloud are therefore determined by how people solve the reading problem, as well as by characteristics of the orthography-phonology mapping, which vary across writing systems, and individual differences, which may be constitutional or experiential in origin. These factors determine the "division of labor" between different components of the lexical system relevant to tasks such as reading aloud, giving rise to a variety of effects, including semantic influences on reading aloud. I'll consider relevant empirical evidence and related issues concerning the adequacy of competing computational models of word naming and reading.

Friday Discussion Panel

THE ROLE OF THE RIGHT HEMISPHERE IN FIGURATIVE LANGUAGE PROCESSING

Friday, November 8, 2:45 – 4:15 pm, Crystal Ballroom

Chair: Christine Chiarello, Cognitive Psychology Lab, Department of Psychology, University of California, Riverside, US

Miriam Faust
Gonda Multidisciplinary Brain Research Center and Bar-Ilan University, Israel

While the role of the right hemisphere (RH) in processing nonliteral language is highly controversial, there is much evidence indicating that the comprehension of novel metaphoric expressions requires strong RH involvement. The findings of a series of studies using a variety of experimental techniques, including behavioral, fMRI, MEG, ERP and TMS, provide convergent evidence linking the RH, particularly right posterior superior temporal areas, with the ability to integrate the meanings of two seemingly unrelated concepts into a meaningful novel metaphoric expression. These findings indicate that semantic processing in the intact brain is associated with distinct and flexible patterns of hemispheric interaction that is characterized by higher RH involvement for processing novel metaphors taken from poetry compared to literal, conventional metaphoric and meaningless expressions (Faust, 2012). Furthermore, research on persons with Asperger and with Schizophrenia support RH unique contribution to the comprehension of novel conceptual combinations by demonstrating the negative effects of either reduced or excessive RH involvement on the ability to understand novel metaphors. The findings on novel metaphor processing thus suggest that the expert, rule-based semantic mechanisms of the left hemisphere are not sufficient for coping with the rule- violating, emergent and more creative aspects of this type of nonliteral language. This claim has significant implications for understanding the neurobiological processes involved in word meaning extension and is consistent with several models, including the Fine-Coarse Semantic Coding Theory (e.g., Jung Beeman, 2005) and the Graded Salience Hypothesis (Giora, 2007).

Alexander M. Rapp
Department of Psychiatry, University of Tuebingen; Germany

The right hemisphere processing hypothesis for metaphors and figurative language is popular and somewhat plausible, but how about the evidence for right hemisphere involvement in figurative language comprehension? In this debate, I will take the position against a pre-eminent role of the right hemisphere for figurative language. The most-cited study in the context of right hemisphere figurative language is a PET-study from the 1990´s with only 6 subjects. However, until now, approximately 40 functional magnetic resonance imaging studies have investigated figurative language comprehension. Although a substantial number has the hypothesis of a predominant role of the right hemisphere, there is a substantial number of studies with negative findings. A quantitative, coordinate based-analysis fails to indicate a pre-eminent role of the right hemisphere. Findings from lesion studies are heterogeneous.

General Information

ATM

An ATM machine is located in the Office Tower Lobby, directly below the Ballroom Foyer.

Abstracts

The poster and slide abstracts can be found in the PDF, which is downloadable from the neurolang.org website.

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 Westin, are welcome to check their bags at the front desk.

Business Center

The Business Center is open 24 hours a day and is located in the Office Tower Lobby, directly below the Ballroom Foyer. The Center is fully automated. Boarding passes may be printed free of charge. Guests may also browse the internet or use the fax machine. There is a minimum charge of $7.00 for the first ten minutes of internet use, and $.70 for each additional minute.

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.

Black and white printing is $.65 per page. Color printing is $1.00 per page.

Black and white copying is $.50 per page, with a $2.00 minimum. Color copying is $1.00 per copy, with a $4.00 minimum.

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

The fitness center is currently closed, while it is undergoing renovation. The hotel will provide complimentary passes to nearby athletic clubs. Please inquire at the front desk.

Food Service

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

Wednesday

Afternoon Coffee, 2:30 – 3:00 pm, *Emerald Ballroom*
Welcome Reception, 6:20 – 7:50 pm, *Pool Deck*

Thursday

Continental Breakfast, 8:00 - 8:30 am, *Ballroom Foyer*
Coffee Break, 9:50 - 10:20 am, *Emerald Ballroom*
Afternoon Coffee, 3:45 - 4:15 pm, *Emerald Ballroom*

Friday

Continental Breakfast, 8:00 - 8:30 am, *Ballroom Foyer*
Coffee Break, 9:50 - 10:20 am, *Emerald Ballroom*
Afternoon Coffee, 4:15 – 4:45 pm, *Emerald Ballroom*

Future Meetings

SNL 2014 will be held at the Beurs van Berlage, Amsterdam, August 27 - 29, 2014.

Hotel Outlets

Dining

The Coast restaurant features an open breakfast buffet, as well as an a la carte menu for breakfast, lunch and dinner. It is open daily from 6:30 am - 9:30 pm.

Bar Service

The hotel bar is located within the Coast Restaurant. Bar hours are from 1:00 pm - 11:00 pm. Happy Hour is from 3:00 pm - 6:00 pm.

Coffee

The hotel features a coffee-to-go stand open every morning from 6:30 am - 11:00 am. Coffee is $2.00.

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 in 1/2 hour increments by obtaining a code from the front desk agents. There is free internet in the meeting rooms.

Local Dining

The Concierge Desk maintains photo albums containing menus for area restaurants. The Desk is open from 8:00 am - 8:00 pm.

Lost & Found

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

Meeting Rooms

All general sessions (Keynotes, Discussion Panels and Slides) will be held in the Crystal 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 Ballroom Foyer. The Registration Desk hours are:

Wednesday, November 6, 11:00 am – 5:30 pm
Thursday, November 7, 7:30 am – 7:00 pm
Friday, November 8, 7:30 am – 7:00 pm

Parking

Valet parking is $32 per night or $4 per 30 minutes. Enjoy in/out privileges with overnight valet parking. There are also 3rd party parking lots surrounding the hotel. These lots generally do not have in/out privileges.

Phone Charging Station

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

Pool

A heated outdoor lap pool is located on the 3rd floor of the hotel. Hours of operation are from 6:00 am - 10:00 pm.

Poster Sessions

Posters are located in the Emerald Ballroom.

Reception

The Welcome Reception will be held on Wednesday, November 6th on the Pool Deck, from 6:20 – 7:50 pm.

Smoking

Smoking is not permitted at The Westin San Diego.

Speakers

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

Transportation - Airport

Airport Shuttle

The Westin San Diego offers a complimentary airport shuttle 7 days per week from 6:00 am - 11:00 pm (based upon availability). Reservations are required. To reserve the shuttle van from the airport, call the hotel (1-619-239-4500) from the baggage claim kiosk. To reserve the shuttle van to the airport, sign up at the luggage desk in the lobby 24 hours in advance or call service express.

Taxi

The San Diego Airport is located at 3225 N. Harbor Dr., a 5-10 minute drive from the Westin San Diego. Taxi service to the airport costs approximately $10.00 - $15.00.

Bus

The "992 Flyer" leaves every 15 minutes from the bus stop outside of the hotel on Broadway. The fare is $2.50 one way. The Santa Fe Depot is located one block from the hotel.

Slide Sessions

Slide Session A

Wednesday, November 6, 4:30 - 5:50 pm, Crystal Ballroom

Speech and Auditory Perception

Speakers:Edward Chang, Stephen M. Wilson, Isabelle Deschamps, Daniela Sammler

4:30 pm

A1 Phonetic feature selectivity in the human temporal lobe *Edward Chang[1], Nima Mesgarani[1], Connie Cheung[1], Keith Johnson[1]; [1]UC San Francisco*

Speech perception is the process by which we hear and interpret the sounds of language. The superior temporal gyrus (STG) has been implicated in the auditory processing of speech, but how this brain region encodes phonetic information has not yet been determined. Here, we used multi-electrode cortical surface recordings in human subjects while listening to natural continuous speech to demonstrate the STG representation of English speech sounds. At single electrodes, we found evidence for response selectivity to phonetic feature categories (e.g. plosives, fricatives, vowels, and nasals), which was related to tuning for specific spectrotemporal acoustic cues. Selectivity for manner of articulation was stronger than for place of articulation (lips, tongue tip, tongue body). A more continuous encoding for secondary acoustic features (e.g. spectral peak, formants, pitch) was mediated by a distributed representation across electrodes as well as tuning for nonlinear complex acoustic parameters. These findings reveal a specialized multidimensional representation of the acoustic-to-phonetic transformation in human STG that underlies our ability to perceive speech.

4:50 pm

A2 The impact of vascular factors on language localization in the superior temporal sulcus *Stephen M. Wilson[1]; [1]University of Arizona*

The left superior temporal sulcus (STS) has been shown in numerous functional imaging studies to be a critical region for language processing, as it is reliably activated when language comprehension is compared to acoustically matched control conditions. Studies in non-human primates have demonstrated several subdivisions in the STS, yet the precise region(s) within the STS that are important for language remain unclear, in large part because the presence of draining veins in the sulcus makes it difficult to determine whether neural activity is localized to the dorsal or ventral bank of the sulcus. The aim of this study was to localize language regions in the STS more precisely by accounting for vascular factors. We identified language regions in four healthy participants by contrasting auditory narrative comprehension to reversed speech in a sparse sampling paradigm. Functional images were acquired at 3 Tesla with high spatial resolution (1.72 x 1.72 x 1.96 mm), and no smoothing was applied. We used a breath-holding task to induce hypercapnia in order to normalize voxel-wise differences in blood oxygen level-dependent (BOLD) responsivity, and we masked out veins identified on susceptibility-weighted imaging (SWI) and T2*-weighted BOLD images. All participants showed activations for language comprehension in the left STS as expected. Prior to any corrections, most activations were colocalized with veins and were centered on the sulcus itself; it was not initially possible to determine whether they reflected activity on the dorsal or ventral bank. However, these vascular influences were successfully ameliorated by hypercapnic normalization and vein masking. After these corrections were applied, in each participant the majority of regions activated by language processing were localized to the dorsal bank of the STS, with fewer activations on the ventral bank. Our results are consistent with anatomical findings in non-human primates, where the subdivisions of the STS with auditory or multimodal connectivity are all located on the dorsal bank.

5:10 pm

A3 The relationship between cortical thickness and the processing of statistics in the auditory signal: insights from speech and non-speech sounds *Isabelle Deschamps[1,2], Uri Hasson[3,4], Pascale Tremblay[1,2]; [1]Université Laval, Département de réadaptation, Québec, Canada, [2]Centre de Recherche de l'Institut Universitaire en santé mentale de Québec, Canada, [3]Center for Mind/Brain Sciences (CIMeC), University of Trento, Italy, [4]Department of Psychology and Cognitive Sciences, University of Trento, Italy*

As adults, we effortlessly segment words from fluent speech to derive meaning. However, during language acquisition, children face the challenge of identifying word boundaries without being able to profit from word form familiarity. In such cases, they must rely on statistical cues, such as transitional probabilities between syllables to segment speech. Of particular interest is that conditional statistics are not unique to speech—adults are able to parse complex auditory signal by "chunking" parts of the signal into components based on their statistical coherence. This suggests that extraction of auditory statistical information might be a general auditory competence, not specific to speech. We previously demonstrated using fMRI that several parts of the posterior supratemporal plane are sensitive to statistical structure in both speech and non-speech inputs (Tremblay et al., 2012), suggesting that these areas are sensitive to statistical information independently

of the type of auditory category (i.e. speech, bird), thereby supporting the hypothesis of a general auditory mechanism. To further examine the neurobiological underpinning of statistical information processing, here we examined the relationship between a morphometric feature -- cortical thickness -- and performance on a behavioral task targeting the coding of statistical structure of sounds which is described in Tremblay et al., (2012). We hypothesized that cortical thickness in different brain regions may provide an indication of the degree to which specific brain regions mediate the coding of statistical features. T1-weighetd anatomical MRIs were acquired for twenty healthy right-handed native speakers of Italian using a 4T Bruker MRI system. The behavioral experiment consisted of listening to low-, mid- and highly-ordered series of speech syllables or bird chirps. The task was to (1) estimate the number of discrete elements perceived in each series (numerosity ratings) and (2) rate the perceived statistical order (regularity ratings). Cortical thickness was computed using FreeSurfer. We correlated variations in thickness against inter-individual differences in perception of numerosity and regularity at the whole brain level. Group results demonstrate that cortical thickness is correlated with both perceived numerosity and perceived regularity. Participants that were more sensitive to the regularity manipulation (for speech and non-speech series) had greater cortical thickness in several regions within the bilateral superior temporal sulcus, superior frontal gyrus, and supramarginal gyrus. Increased thickness in the left inferior frontal gyrus and postcentral gyrus was associated with greater perceived regularity, though for speech series only. A different structural network was identified where thickness was associated with more efficient segmentation as indicated by more accurate numerosity perception, and consisted of (a) the left superior parietal lobule and cuneus, the right insula and occipital sulcus for non-speech sounds and (b) the left middle frontal gyrus, and anterior cingulate and the right superior parietal lobule for speech sounds. Our results are consistent with our previous study that identified regions within the supratemporal plane in the processing of statistical information. Investigating the correlation between cortical thickness and the ability to process statistical information offers novel insights that can help characterize the neural mechanisms that underlie processing of statistical information.

5:30 pm

A4 Prosody perception in the laryngeal premotor cortex: A TMS study *Daniela Sammler[1,2], Pascal Belin[1,3,4], Marie-Hélène Grosbras[1]; [1]School of Psychology and Institute of Neuroscience and Psychology, University of Glasgow, Glasgow, UK, [2]Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany, [3]BRAMS, University of Montréal and McGill University, Montréal, Canada, [4]Institut des Neurosciences de La Timone, UMR 7289, CNRS and Université Aix-Marseille, France*

There is much more to human communication than the (de)coding of the overt semantic meaning of a vocal speech signal. Often between the lines, much of the speaker's intended meaning is conveyed by the "manner of saying", i.e. the speech prosody, that can change the consequences of an utterance in socially very relevant ways. A recent fMRI study of our group suggested a motor-simulation mechanism involving the laryngeal premotor cortex in the right hemisphere to be involved in decoding the communicative intentions (i.e. question or statement) conveyed by speech intonation (i.e. rising or falling pitch contour). It was suggested that this mechanism mirrors the vocal fold movements typically needed for the production of different pitch contours and thus aids speech comprehension. The present transcranial magnetic stimulation (TMS) study tested if the categorization of subtle prosodic modulations indeed relies on vocal motor-simulation and the integrity of laryngeal premotor cortex. Therefore, we assessed participants' performance in a question-statement categorization task after application of 15 minutes of low frequency (1 Hz) repetitive TMS over the larynx representation in right premotor cortex, compared to their performance after 15 minutes of sham stimulation. A lexical categorization task after rTMS and sham served as behavioral control. Stimuli consisted of 7-step continua of monosyllabic English words that either varied in their prosody (statement --> question) or their lexical meaning (/bear/ --> /pear/). Continua were obtained from 4 speakers by means of auditory morphing between prototypical exemplars of each category (i.e. "Bear.", "Bear?", "Pear.", "Pear?"). Participants performed a 2-alternative forced-choice classification task on either prosody or lexical meaning after rTMS or sham stimulation in counterbalanced order. Repetitive TMS over the laryngeal premotor cortex, compared to sham stimulation specifically reduced the slope of the logistic curve fitted to the participants' categorization responses and did not affect the control task. Thus, it reduced the consistency of participants' responses to subtle prosodic modulations but not lexical category. We speculate that this is due to a reduced sensitivity of participants to the pitch glides in the stimuli caused by a TMS-induced temporary inhibition of the larynx area and a disruption of the vocal motor-simulation mechanism for pitch. In line with modern variants of the motor-theory of speech perception, the combined fMRI and TMS findings lend support for the involvement of the laryngeal premotor cortex and the motor-simulation of vocal pitch in the decoding of speaker's intentions from intonation in speech.

Slide Session B

Thursday, November 7, 8:30 - 9:50 am, Crystal Ballroom

Speech Production and Phonology

Speakers:Dirk Den Ouden, Sara Berentsen, Karthik Durvasula, Thomas Pieters

8:30 am

B1 Neural representations of segments and syllables as phonological domains *Dirk Den Ouden[1], Emily Garnett[1], Adina Raizen[2], Victoria Sharpe[1]; [1]University of South Carolina, [2]University of Illinois at Urbana-Champaign*

Introduction During phonological encoding, sequencing of phonemes and syllabification into larger units for production take place in steps (Levelt et al., 1999), supported by neural networks (Bohland et al., 2010). Though behavioral and formal linguistic evidence for phonological domains exists, less is known about their neural correlates, i.e. the areas that subserve their role in speech planning and production. Based on earlier experiments showing particular sensitivity to features of individual phonemes in nonfluent aphasic speakers and greater sensitivity to syllable structure in fluent aphasic speakers (Den Ouden, 2004), we hypothesize that access to syllabic units is supported by posterior superior temporal brain regions, while access to phoneme-sized units is supported by inferior frontal regions. This runs counter to the idea that access to syllables would be exclusively supported by inferior frontal regions underlying a syllabary of stored syllable-sized chunks for speech motor planning. Methods 19 Right-handed English speakers (10 females; mean age 24) performed phoneme and syllable monitoring tasks in two fMRI experiments. In the first, stimuli were presented as pictures, and participants performed a production monitoring task by monitoring their speech plan for specific sounds or syllables. In the second experiment, stimuli were presented auditorily, so this constituted a perceptual monitoring task. Eighty disyllabic words with a (C)(C)VC.CV(C)(C) structure were chosen as target stimuli, forty in each experiment. Imaging data were acquired with a Siemens 3T TIM Trio scanner, and analysis was performed with SPM8. Results In both production monitoring and perception monitoring, differential activation contrasts show greater activation associated with syllable over phoneme targets primarily in temporal cortex (superior/middle temporal gyrus) and greater activation associated with phoneme over syllable targets in frontal cortex (a.o. anterior insula, supplementary motor area). Furthermore, contrasts of syllable monitoring over nonsense-string monitoring consistently show increased angular gyrus activation across the modalities, left-lateralized in visual presentation, versus right-lateralized in auditory presentation. Conclusion Monitoring for functional phonological domains, rather than for equally-sized strings that violate syllable phonotactics, is associated with access to phonological word forms (angular gyrus). In a task that requires lexical access and monitoring of the covert speech string, as well as in an auditory monitoring task, we show that monitoring for syllable units, which depends on syllabic segmentation, is supported by posterior brain areas more than phoneme monitoring, which is supported by frontal cortex. This is in line with previous observations that paraphasias by aphasic speakers with posterior brain damage show greater effects of syllable structure, while the paraphasias of speakers with frontal damage appear to be shaped to a greater extent by phonemic characteristics. References Bohland, J. W., Bullock, D., & Guenther, F. H. (2010). Neural representations and mechanisms for the performance of simple speech sequences. Journal of Cognitive Neuroscience, 22(7), 1504-1529. Den Ouden, D. B. (2004). Multi-Level OT: An argument from speech pathology. Linguistics in the Netherlands, 21, 146-157. Levelt, W. J. M., Roelofs, A., & Meyer, A. S. (1999). A theory of lexical access in speech production. Behav Brain Sci, 22(1), 1-38.

8:50 am

B2 Lesion Correlates of Phonological Access Impairment: Voxel-Based Lesion-Symptom Mapping *Sara Berentsen[1], Benjamin Stengel[1], Megan Rozman[1], Diane Book[1], Jeffrey Binder[1]; [1]Medical College of Wisconsin, Milwaukee, WI, USA*

Computation of a pre-articulatory phonological representation (phonological access, or phonological code retrieval) is an essential process in speech production whose neural localization is not entirely clear. Indefrey and Levelt (Cognition 2004; 92: 101-144) localized phonological code retrieval to the posterior middle temporal gyrus, a region also associated with lexical-semantic processing. We studied this process using a silent rhyming task, in which 35 chronic left hemisphere stroke patients (17 men, 18 women; all native English speakers; all right-handed pre-stroke; all at least 180 days post-stroke) were required to decide which of two written words rhymes with a third written word. An orthographic matching strategy was precluded using alternative spellings of the same rime (shoe > crow/knew) in half of the trials and alternative pronunciations of the same grapheme (frown > drown/grown) in half of the trials. Patients also performed a task requiring matching of words based on similarity of meaning (knife > jar/fork) to control for orthographic, lexical-semantic, and working memory impairments, and an auditory word-picture matching task to control for speech perception impairments. Lesions were labeled on high-resolution T1 MRI volumes using a semi-automated image segmentation method, followed by diffeomorphic registration to a common template. Voxel-based lesion-symptom mapping used a logistic regression model incorporating the three task performance measures, age of the patient, and days since stroke onset as explanatory

variables. T-maps were thresholded at a corrected p <.05. The only region where damage correlated significantly with phonological access impairment was a contiguous volume of cortex and white matter surrounding the posterior sylvian fissure, which included most of the supramarginal gyrus and planum temporale, as well as a portion of the posterior superior temporal gyrus. No areas in the frontal lobe, insula, or middle temporal gyrus showed a significant association with phonological access impairment. This is the first demonstration of a specific lesion correlate for phonological access impairment. This processing impairment is distinct from articulatory, speech perception, orthographic, and lexical-semantic processes. It is a core processing stage in all speech production tasks, including sentence production, naming, reading aloud, and repetition. Isolated damage to this region produces the classical syndrome of conduction aphasia, consisting of fluent phonological paraphasia reflecting impaired computation of pre-articulatory phonological codes. Although this posterior perisylvian region overlaps with some versions of the classical Wernicke area, the present results demonstrate its involvement in pre-articulatory phonological production rather than speech perception or lexical-semantic processes.

9:10 am

B3 Speaking beats listening: Evidence that motor activity out-primes auditory activity during speech perception

Karthik Durvasula[1], Arild Hestvik[2]; [1]Michigan State University, [2]University of Delaware

INTRODUCTION: There has been a renewed interest in the Motor Theory of speech perception (Liberman et. al., 1952; Liberman & Mattingly 1985) due to recent mirror neuron discoveries (Rizzolatti & Sinigaglia, 2010). This has led to a series of experiments that suggest motor areas are recruited during speech perception (Pulvermuller et al 2006, D'Ausilio e al 2009, Sato et. al., 2011). For example, Sato et al (2011) examined whether listeners could be primed by motor activity. They found that lip-movement induced a /p/-bias in a /p/-/t/ discrimination task, and tongue-movement a /t/-bias. However, it could be that auditory priming could have the same effect, which would neutralize Sato et al's inference. The aim of the current study was to test both motor priming and auditory priming with the same forced choice d/t identification task. If both tasks induce a bias during perception, then there is no evidence for a privileged status of the motor system during speech perception. On the other hand, if the motor system has a privileged status, then we should observe (at least) an interaction between bias and type of priming (motor-priming vs. auditory priming). METHODS: Two equal groups of subjects (total N=38) participated. The "motor group" silently articulated a list of 100 /t/-initial words, exaggerating mouth gestures, while the "auditory group" listened to the same list passively. Subsequently, all subjects participated in a d/t identification task. A 21-step /dæ/-/tæ/ continuum (5ms VOT increments, from 0-100ms VOT) were synthesized, and presented in random order with 6 repetitions each. Data from 158 subjects who had participated in another large study without any priming was used as a baseline control (providing a solid estimate of the true discrimination function for the stimuli). RESULTS: The discrimination function for the motor group differed from the auditory group by having a 5-10ms bias towards /t/ in the threshold region. A mixed-effects model was fitted to the percentage of /t/ identification rates of the threshold values (25-55ms VOT) with Group (motor vs. auditory), and VOT values as fixed factors, and subjects as crossed random factor (Pinheiro & Bates, 2000). The motor group showed a significant increase in /t/-identification rates compared to the auditory group ($b = 7.39$, $t(258) = 2.098$, $p = 0.037$). In addition, the discrimination function for the auditory primed group exactly matched that of the no-priming control group. DISCUSSION: Priming of the abstract articulation system induced a perceptual bias by shifting the VOT threshold and allowing for more /t/ identifications in the threshold region, but priming of the auditory system had no such effect when compared to the no-priming group. While the Motor Theory predicts that auditory priming should in principle lead to priming, just like articulation, the results suggest that the effect size of motor priming is significantly greater than that of auditory priming. This cannot be explained under the Auditory theory, but is easily understood under Motor Theory: Performing actual articulatory gestures "super-primes" identification of /t/ in comparison to listening.

9:30 am

B4 Spatial probability of essential language sites: Cortical stimulation density map in a population

Thomas Pieters[1], Cihan Kadipasaoglu[1], Vatche Baboyan[1], Nitin Tandon[1]; [1]Vivian Smith Department of Neurosurgery, UT Houston

The mapping of cortex using electrical stimulation - cortical stimulation mapping (CSM) – is widely viewed as the gold standard technique for the localization of eloquent language sites. Despite its widespread use for several decades, these data are typically represented schematically, referenced to cortical surface landmarks, or to imaginary grids on a representative surface. This has precluded the creation of useful population maps that could be used to create apriori predictive models to decipher the probability of language in specific cortical sites, to delineate the probability of language deficits with focal lesions, or for comparison with functional imaging data. Fifty-one patients scheduled for intra-operative (awake craniotomy) or extra-operative (with implanted subdural electrodes) language mapping, underwent pre-operative hi-resolution anatomical data acquisition on a 3T scanner. Mesh models of the pial surface were generated for each patient. After warping each subject's spherical mesh to align with the folding patterns of a population averaged

brain, a standardized mesh with invariant node numbers was created, enabling a one-to-one comparison across subjects. Patients were asked to perform object naming, using both auditory and visual cues, and repetition tasks. Stimulation currents ranged from 3 mA to 10 mA. Sites of stimulation associated both with (positive-sites) and without (negative-sites) disruption in language were localized on the pial mesh-model using intra-op video and in-house software. To depict CSM data in 3D cortical space, we generated a model of cortical depolarization from direct current spread in the human brain, fitted by experimental data from surface stimulation of primate cortex. Indirect effects of the stimulation were disregarded. We then computed the point probability of the presence of linguistic function for the entire cortical region per subject. Using the standardized surfaces, a t-test was run to compute subject z-scores in common space. A total of 610 positive ELS (Figure 1) and 1089 negative sites were localized using this method. Positive sites were further classified by deficits produced: naming based on auditory cues (106 sites), naming based on visual cues (141 sites), repetition (132 sites), full speech arrest (71 sites), comprehension (69 sites) and sites that caused both comprehension and repetition deficits (91 sites) Thresholding of positive language sites to significance was performed ($p<.001$, corrected). ELS were found to be exclusively located in STG and Broca's area. Two clusters (minimum 100 nodes each) were found, centered around (56.84, 15.69, 3.16), and (54.42, -13.54, 17.08). Contrary to papers that suggest immense inter-subject variability of language sites, we show that there is indeed a great degree of overlap in essential language sites. Spatially, probability maps of language, like this one, allow for direct comparison of CSM data with studies derived from functional imaging and lesion analysis. Additionally, the availability of larger numbers of ELS and negative stimulation sites may allow for empiric estimates of risk to language during cortical resections and various brain lesions.

Slide Session C

Thursday, November 7, 2:25 – 3:45 pm, Crystal Ballroom

Language Development and Bilingualism

Speakers:Monika Molnar, Tali Bitan, Michael Bonner, Anna Beres

2:25 pm

C1 Different neural specializations support native speech processing of young monolingual and bilingual infants *Monika Molnar[1], Marcela Peña[2], Cesar Caballero[1], Martijn Baart[1], Ileana Quiñones[1], Manuel Carreiras[1]; [1]Basque Center on Cognition, Brain and Language (BCBL), [2]Catholic University of Chile*

By 4 months of age, both monolingual and bilingual infants learn a great amount of information about their native language(s). At this age, monolingual infants are able to discriminate their native (familiar) input from an unfamiliar language even if those belong to the same rhythm class (e.g., Nazzi et al., 2000), and bilingual infants are able to perceptually distinguish their two rhythmically similar native languages (Bosch and Sebastian-Galles, 1997; 2001). Behavioral experiments have also suggested that even though bilingual infants recognize both of their inputs as familiar already at birth (Byers-Heinlein et al., 2010), by 4 months of age, they attend to their native languages differently as compared to their monolingual peers (e.g., Bosch and Sebastian-Galles, 1997). It is unclear why young bilingual and monolingual infants exhibit dissimilar behaviors when attending to their native languages. Recent neuroimaging findings that revealed different neural mechanisms for processing specific phonetic contrasts across 1-year-old monolingual and bilingual infants (Petitto et al., 2012) have raised the possibility that the neural underpinning of monolingual and bilingual infants' speech processing are shaped differently from an early age. Therefore, in the current study, we have used near-infrared spectroscopy (NIRS) to ask how monolingual and bilingual language experience might shape the brain response to native languages at 4 months of age. Using NIRS, changes in the concentration of total hemoglobin in response to auditory stimulation in temporal areas of the right hemisphere (RH) and the left hemisphere (LH) were assessed in Spanish-Basque monolingual and bilingual infants. Brain activation was recorded during the presentation of 10-second long Basque or Spanish connected speech samples (language conditions), and backward versions of Basque or Spanish speech (auditory baseline conditions), as well as silence (baseline). Monolingual infants have demonstrated clear left-lateralized responses to native (familiar) speech in comparison to non-native speech, backward auditory stimuli, or silence. This current finding is in line with prior NIRS studies that illustrated LH dominance in response to normal speech vs. backward speech in monolingual neonates (Peña et al., 2003), and that measured different (although bilateral) activation in monolingual newborns for processing familiar vs. unfamiliar languages (May et al., 2011). Importantly, however, 4-month-old bilingual infants in the current study exhibited no LH advantage in processing either of their native languages. Although bilingual infants demonstrated different processing of Basque and Spanish as compared to the baseline conditions (backward speech and silence), the effect was equally observed in both hemispheres. Additionally, no differences in the bilingual responses to Spanish and Basque were observed. Our overall results suggest that the development of neural networks specializing for native (familiar) spoken language processing follows different patterns in monolingual and bilingual infants; and that this difference

is present as early as 4 months of age that represents an important period during cortical development related to language processing.

2:45 pm

C2 Do children and adults learn a new linguistic skill in the same way? Effects of age and sleep on learning morphological inflections in an artificial language *Tali Bitan[1], Michael Nevat[1], Qamar Daher[1], Karin Levenberg[1]; [1]University of Haifa*

Introduction: Learning of a second language has been suggested to rely more strongly on procedural learning in children compared to adults [1]. Adults' performance on procedural learning tasks improves after the end of training, depending on sleep [2], while children do not benefit from sleep [3]. For declarative learning tasks sleep may prevent deterioration of performance. In a previous neuroimaging study with adults we showed that learning of plural inflections in an artificial language involves statistical learning of distributional factors and brain regions associated with procedural learning. In the current study we examine differences between adults and children in the consolidation of the acquired knowledge after the end of training. Method: 34 Adults and 36 children (9-10 yrs) received one session of training on new words and their plural inflections, which varied in frequency. Their performance was tested immediately after training as well as after 12 and 24 hours. In each age group half of the participants were trained in the morning and the other half were trained in the evening. Results: Our results show that children's performance improved during the 12 hours period immediately after the end of training, regardless of sleep, while adults did not show any improvement. However, for adults sleep provided protection against the decay inflicted by time awake for the high frequency inflection. Moreover, for the generalization of the acquired knowledge to new words adults show a sleep dependent increase in the reliance on phonological cues after the end of training. Conclusions: Our results are consistent with the notion that children are less susceptible to interference during wakefulness [4], and generalizes it to the language domain. Our results also suggest that when learning new linguistic skills children rely more on procedural learning mechanism compared to adults.

3:05 pm

C3 Structural covariance of the semantic memory network in healthy adults *Michael Bonner[1], Jonathan Peelle[2], Amy Rose Price[1], Murray Grossman[1]; [1]University of Pennsylvania, [2]Washington University in St. Louis*

How do individual differences in the semantic memory performance of healthy adults relate to differences in the structure of their brains? Previous studies have identified a relationship between behavior and brain anatomy in healthy adults in the domains of visual perception and spatial memory, but few such findings have been reported for basic lexical-semantic behaviors. We performed two experiments to examine how the cortical anatomy of a hub in the angular gyrus relates to: 1) individual differences in performance and 2) structural variability throughout the semantic memory network. In these experiments, we examined cortical thickness using structural MRI in healthy, young adults. We first tested the hypothesis that anatomic variability in the angular gyrus predicts individual differences in lexical-semantic performance. We examined 21 subjects who performed a simple lexical decision task in which they viewed single words on a screen and identified if they were real. The stimuli included real words such as "apple" and pronounceable pseudowords such as "dranby." We previously found, in an fMRI study, that the heteromodal association cortex of the left angular gyrus was consistently activated for the processing of real words in this task. For the current study, we performed a regression analysis to determine whether subjects' response times on the lexical decision task were related to anatomic differences in the left angular gyrus. We were specifically interested in response times to real words, and we accounted for non-specific differences in processing speed by including a covariate for pseudoword response times. As predicted, we found that subjects with faster responses to real words had increased cortical thickness in the left angular gyrus ($p<.05$, corrected for multiple comparisons). This demonstrates that increased cortical thickness in a central hub of the semantic system predicts better lexical-semantic performance in healthy adults. We next tested the hypothesis that cortical anatomy in the semantic memory network covaries across individuals. In 186 healthy adults, we identified regions that covaried in cortical thickness with the left angular gyrus while controlling for global mean thickness. This revealed a network of structural covariance corresponding to the semantic memory network identified in a recent meta-analysis of fMRI studies ($p<.05$, whole-brain corrected) (Binder et al., 2009: Cereb Cortex 19[12]:2767-2796). Interestingly, this network also corresponds to the "default-mode network" identified in resting-state fMRI. These findings demonstrate that the cortical anatomy of a large-scale network implicated in semantic memory and resting-state activation covaries across healthy adults and relates to individual differences in behavior.

3:25 pm

C4 Translanguaging: Boosting the acquisition of new knowledge using bilingualism. *Anna Beres[1], Manon Jones[1], Bastien Boutonnet[1], Nick Davis[1], Guillaume Thierry[1]; [1]Bangor University*

Bilingual education has witnessed a major shift towards mixing two languages in the classroom. However, adequate methods taking into account the needs of today's highly multicultural world require scientific testing. Garcia (2009) argues that children engage in 'translanguaging'; that is the production of an output of

their learning in a language different to that of instruction. So far, insights into the potential benefits of this method have been qualitative and have focussed mainly on language learning. Here we aim at quantifying the benefits of translanguaging for semantic integration beyond the realm of language learning. We tested Welsh-English bilinguals on a novel-object learning task and manipulated the learning context. Information about the novel objects was presented in English and participants named familiar, related picture from an array of four objects, either in English (monolingual context) or Welsh (translanguaging context). After completing a staircase learning procedure, the efficiency of semantic integration was measured using a nonverbal picture-picture priming paradigm and event-related brain potentials, involving related and unrelated picture pairs according to the learnt definitions. As expected, we found a semantic priming effect indexed by amplitude reduction of the N400 wave when novel objects were followed by their learnt related as compared to unrelated picture. Moreover, we found that novel objects learnt through translanguaging induced more priming than those learnt in a monolingual context, which suggests that translanguaging successfully heightens the level of engagement of the conceptual system. Such results provide neuroscientific, quantitative evidence of the benefit of using language alternation in teaching new concepts and extend the 'bilingual advantage' commonly observed in the domain of executive functioning to the general domain of learning.

Slide Session D

Friday, November 8, 8:30 - 9:50 am, Crystal Ballroom

Lexical Semantics

Speakers:Paul Hoffman, Liuba Papeo, Ajay Halai, Alona Fyshe

8:30 am

D1 Anterior temporal contributions to single-word reading revealed using distortion-corrected fMRI *Paul Hoffman[1], Matthew A. Lambon Ralph[1], Anna M. Woollams[1]; [1]University of Manchester*

Connectionist models of reading predict that word meaning plays a critical role in mapping written words to speech sounds, particularly for words with irregular spelling-to-sound mappings. In line with this prediction, patients with semantic dementia show impairments in irregular word reading, which are associated with atrophy to the anterior temporal lobe (ATL): a critical site for conceptual knowledge representation. However, neuroimaging studies provide limited evidence for ATL activation during single-word reading. We scanned subjects while they read words aloud, using distortion-corrected spin-echo fMRI to maximise signal in the ATL. We identified two ATL sites that were activated by word reading. (1) A ventral ATL site (fusiform and inferior temporal) that was active for regular and irregular words and modulated by word frequency. We hypothesised that this represented automatic activation of word meaning that occurs for all words. (2) A more dorsolateral and polar ATL site whose activation was greater for words with irregular spelling-to-sound mappings, relative to regular words, and also greater in individuals who rely heavily on semantic knowledge to read (as measured by an independent behavioural test outside the scanner). We hypothesised that this site was involved in mapping from word meaning to phonology, hence its modulation by word-level and subject-level variation in semantic reliance. Interestingly, the opposite pattern was found in premotor regions associated with phonological processing. In addition, dynamic causal modelling indicated that connectivity between the premotor region and occipitotemporal (OT) cortex was significantly greater during regular word reading, while connectivity between OT and ATL was greater for irregular words. These data support the view that reading is underpinned by the joint operation of two neural pathways. They reveal (a) that the ATL is an important element of the ventral pathway and (b) that the division of labour between the two routes can be predicted both by the properties of the words being read and by individual differences in the degree to which participants use each route.

8:50 am

D2 The origin of word-related motor activity *Liuba Papeo[1,2], Angelika Lingnau[2], Sara Agosta[3], Lorella Battelli[3], Alvaro Pascual-Leone[4], Alfonso Caramazza[1,2]; [1]Department of Psychology, Harvard University, [2]Center for Mind/Brain Sciences, University of Trento, [3]Center for Neuroscience and Cognitive Systems, Istituto Italiano di Tecnologia, [4]Berenson-Allen Center for Noninvasive Brain Stimulation and Department of Neurology, Beth Israel Deaconess Medical Center, Boston*

The representation of events is fundamental to human thought. Because verbs carry information about event structures, they are fundamental to human communication. Conceptual processing of verbs is reliably associated with activity in left posterior middle temporal cortex (lpMTG). Left precentral motor regions also respond to verbs, with a pattern characterized by differential activity to action and non-action items. The timing of this motor effect, within (and not after) the interval for lexical-semantic access, is taken as evidence for a direct access from the acoustic/visual recognition of the word to the semantic representation of its motor components, bypassing the access to more abstract, conceptual representations. Alternatively, verb-related motor activity could be the consequence of conceptual processing of verbs in the temporal cortex, thus implying connectivity between the two sites. Using functional magnetic resonance imaging we identified in each participant the verb-preferring site in lpMTG, using a verbs>nouns contrast. We then targeted

the individual lpMTG with repetitive transcranial magnatic stimulation (rTMS) for perturbation. We found that, relative to baseline (no rTMS), perturbation of this site (but not of a left control site) through rTMS impoverished the semantic processing of verbs (but not nouns). In a second experiment, we addressed the following question: what happens to verb-related motor effects if we interfere with verb processing in the verb-related region of the temporal cortex? Verb-related motor activity was indexed by motor-evoked potentials induced in peripheral muscles with single-pulse TMS over the left primary motor cortex. We found that lpMTG perturbation through rTMS disrupted the action-non action verb distinction in motor activity, that we instead observed in the baseline condition (no-TMS to lpMTG). These findings show that functional connectivity between lpMTG and precentral cortex is established during the semantic analysis of verbs. In particular, lpMTG carries a core semantic information that is necessary to process verbs and to drive more specific (e.g., motor) representations of their meanings in other regions, including the precentral gyrus. This research reconciles two thus-far independent lines of research, focusing on verb-related processed in the temporal and in the frontal regions respectively, thereby contributing to integrate in a single neurobiological model the multiple phenomena related to word processing.

9:10 am

D3 Combining EEG-fMRI to investigate brain networks involved in spoken word comprehension. *Ajay Halai[1], Laura M Parkes[2], Stephen Welbourne[1]; [1]Neuroscience and Aphasia Research Unit, School of Psychological Sciences, University of Manchester, UK, [2]Centre for Imaging Sciences, Institute of Population Health, University of Manchester, UK*

Simultaneous EEG-fMRI recordings have the potential to probe whole brain networks, due to complementary spatial (fMRI) and temporal (EEG) sensitivities. Neurobiological models of speech comprehension generally outline either the spatial organisation (Hickok & Poeppel, 2007, Rauschecker & Scott, 2009, Spitsyna et al, 2006) or the temporal profile (Friederici, 2002, Pulvermuller et al, 2007), and tend not to provide both pieces of information (although recent attempts have been made, Friederici, 2011). Furthermore, in contrast to strong evidence for the role of the inferior temporal fusiform (ITF) in semantic processing (Visser et al, 2010; Spitsyna et al, 2004, Sharp et al, 2004; Marinkovic et al, 2003; Hodges et al, 1992), the speech comprehension literature regularly omits the ITF region. It is important to know if the ITF is involved during passive speech comprehension and how the network of activated regions changes over time. The current study aims to use simultaneous EEG-fMRI to provide both spatial and temporal information during an auditory speech comprehension task. Twenty participants passively listened to single words that were either intelligible or unintelligible (based on stimuli used in Scott et al, 2000). In order to obtain sufficient signal to noise within the ITF, a dual-echo fMRI protocol was implemented - this has been shown to detect activity in magnetically susceptible regions (Halai et al, under review; Poser et al, 2006). The fMRI results showed activity within bilateral superior temporal sulcus (STS) and left inferior frontal gyrus (IFG) related to intelligibility. Furthermore, a region of interest (ROI) analysis showed significant involvement of the ITF. The fMRI data provided five ROIs or nodes in the speech comprehension network; anterior STS, posterior STS, middle STS, IFG and ITF. A virtual dipole was placed at each node and EEG time series were extracted. The activity was segmented into 100ms time bins, which were analysed to test for activity related to the intelligibility of the stimuli. The temporal profile of these nodes showed 4/5 nodes active between 300-400ms, interestingly the ITF was consistently active across the entire epoch (starting within the first 100ms window). Functional connectivity analysis across the epoch showed the middle STS was connected to posterior and anterior STS and IFG, while the anterior STS was connected to IFG and ITF. The localisation of intelligible speech along the anterior STS is consistent with some current models of speech comprehension (Rauschecker & Scott, 2009). However, ITF is omitted from current models, presumably due to magnetic susceptibility problems. We postulated that this region performs the same role in speech comprehension as during other semantic tasks, namely providing meaning. The temporal profile confirmed activation of intelligible nodes around 300-400ms, which is consistent with the well-established belief that the N400 is a marker for semantic processing. The connectivity profile of the anterior STS, suggests that this region acts as a central node during intelligible speech processing. The involvement of ITF at early time periods could reflect very early top-down processes in speech comprehension.

9:30 am

D4 Semantic Representations from a Joint Model of Brain and Text Based Meaning *Alona Fyshe[1], Brian Murphy[1], Partha Talukdar[1], Tom Mitchell[1]; [1]Carnegie Mellon University*

One of the fundamental questions in linguistics is "What features comprise the primitive or base set with which we encode word semantics?" Advances in Machine Learning and signal processing now allow us to detect fine differences in semantic representation (e.g. tomato vs celery) based on recordings of brain activity, which could allow us to detect these primitive semantic elements in vivo. However, brain imaging data is costly to collect and so the coverage of brain data over words is very sparse. One can also identify primitive semantic features with the statistical analysis of word usage patterns in text (via vector space models, latent semantic analysis, distributional semantics). While word coverage in large text collections is good, it is unclear to what extent these text-based features

reflect the true brain-based reality of semantics. We introduce a new method, based on a matrix factorization algorithm, that automatically detects semantic features by joining text corpora with brain imaging data into one model. We show that, for the task of single word prediction from both MEG and fMRI data, our technique produces semantic features that outperform semantic features made with only corpus data. Our technique can generalize across imaging modalities (models trained with fMRI perform well on MEG and vice versa), between human participants (models trained on one participant perform well for other participants), and across words (models trained on a subset of words improve performance on unseen words). These results show that we need not collect data for the same words in all participants, leading to an improvement in word coverage. Our semantic vectors also have the advantage of interpretability. Unlike other methods like SVD (Singular Value Decomposition, a popular method for compressing the statistics calculated from text), our method creates vectors with highly interpretable dimensions. For example, we have identified a semantic feature that corresponds to building-related words (towers, edifices). Because our model incorporates brain activation data while learning these features, we can directly map them onto the brain. We see that the "towers" dimension implicates brain activation in areas of the fusiform and precuneus. This joint model of word usage data and brain activation patterns is the first of its kind, and illustrates how large bodies of electronic text can be joined with brain activation data to develop a better understanding of semantics in the human brain.

Slide Session E

Friday, November 8, 1:15 – 2:35 pm, Crystal Ballroom

Lexical-Sentential Cognitive Control

Speakers:Corey McMillan, Sylvia Vitello, Ladan Ghazi Saidi, Tineke M Snijders

1:15 pm

E1 A dual network account for pronoun resolution in Parkinson's disease. *Corey McMillan[1], Nicola Spotorno[1], Jenna Haley[1], Robin Clark[1], Murray Grossman[1]; [1]University of Pennsylvania*

Individuals frequently encounter pronouns in daily language. Recent BOLD fMRI evidence suggests that healthy individuals use dual networks for pronoun resolution. A core language network in inferior frontal and peri-Sylvian cortex is hypothesized to support the grammatical and semantic resources for sentence comprehension. A decision-making network in frontal cortex is hypothesized to support additional processing resources including probabilistic evaluation in dorsolateral prefrontal cortex, assessment of risky referents in orbitofrontal cortex, and maintenance of alternative choices in rostral prefrontal cortex (McMillan et al., 2012). We hypothesize that the core language network is sufficient to resolve a pronoun's referent in simple sentences (e.g. "The king chased the queen. She fell."), in which there are two opposing gender-biased nouns. However, we hypothesize that the decision-making network must be upregulated to support the resolution of more complex sentences (e.g. "The king chased the visitor. She fell."), in which there are gender-biased and gender-neutral nouns. For example, the reader must consider the probabilistic likelihood that "visitor" is a male or female and consider alternative genders of "visitor". Parkinson's disease (PD), Parkinson's disease dementia (PDD), and Dementia with Lewy Body (DLB) patients have common Lewy body pathology that is distributed throughout frontal cortex. PD patients typically have decision-making limitations with preserved language, while PDD/DLB patients have comparatively greater cognitive limitations that may include both decision-making and language. In this study we evaluated the relative contribution of language and decision-making networks for pronoun resolution in PD and PDD/DLB. We presented PD (N=19), PDD/DLB (N=18), and healthy seniors (N=15) with 80 sentence pairs. Each item contained a simple sentence with two nouns followed by a sentence containing a pronoun. Half of the sentences were Simple and half were Complex, as above examples. A Kruskal-Wallis test revealed a significant difference for both Simple ($X2=28.93$; $p<0.001$) and Complex ($X2=18.82$; $p<0.001$) sentences. Post-hoc Wilcoxon tests (Bonferroni corrected) revealed that PD patients were more impaired on Complex than Simple sentences ($Z=-3.28$; $p<0.005$), while PDD/DLB patients were equally impaired across both sentence types ($Z=1.07$; ns). Seniors also did not differ across sentence types ($Z=2.37$; ns) and had an overall higher accuracy than PD and PDD/DLB patients (all $p<0.005$). To further evaluate the source of the PD and PDD/DLB patients' limitations we performed correlations with Boston Naming semantic task and a Visual-Verbal mental flexibility task. PD patients' performance on Complex sentences was highly correlated with a measure of mental flexibility [$r=0.76$; $p<0.005$], but did not correlate with a semantic measure [$r<0.1$; ns]. PDD/DLB patients' performance on the other hand correlated with both mental flexibility [$r=0.69$; $p<0.05$] and semantic measures [$r=0.73$; $p<0.005$]. These findings suggest that PD patients have selective difficulty with complex pronoun resolution and this appears to be related to decision-making limitations. PDD/DLB patients on the other hand had difficulty with both sentence types and this appears to be related to neuropsychological measures of language and decision-making. Together, these findings support our hypothesized dual network model of pronoun resolution.

1:35 pm

E2 Neural responses to semantic ambiguities encountered during spoken sentences *Sylvia Vitello[1], Jane E. Warren[1], Joseph T. Devlin[1], Jennifer M. Rodd[1]; [1]University College London*

Previous research has highlighted the importance of the left inferior frontal gyrus (IFG) and the left posterior inferior temporal cortex (ITC) in processing sentences that contain semantically ambiguous words (i.e., words with multiple meanings such as "bark"). There is, however, uncertainty regarding the mechanisms underlying these ambiguity-elevated neural responses, the functions they serve and the extent to which these regions are engaged consistently across individuals. Here, we used fMRI to investigate the neural responses to a new set of well-matched ambiguous and unambiguous sentences to explore these uncertainties. 20 native British English monolinguals were scanned whilst listening to sentences containing an ambiguous word that was disambiguated to its less frequent meaning (e.g., "the teacher explained that the bark was going to be very damp") in addition to unambiguous sentences and signal-correlated noise (low-level unintelligible baseline). Participants were asked to listen carefully to the meaning of each sentence. To ensure attention, on occasional trials, a visual word was presented after the sentence that required a semantic relatedness decision. Ambiguous sentences produced more activation than unambiguous sentences in the left IFG (centred in pars triangularis) and in the left posterior ITC (centred in the occipitotemporal sulcus). To explore the mechanisms underlying these ambiguity-elevated responses, an 8mm spherical region of interest (ROI) was defined around the IFG and ITC group peaks and average parameter estimates were calculated for two key contrasts. First, we examined these regions' responses to the unambiguous sentence condition. Both regions did not show a significantly greater response to unambiguous sentences than to unintelligible speech (SCN), suggesting they are not always engaged during speech comprehension and, therefore, serve functions that are more relevant to semantic ambiguity processing than to auditory sentence comprehension in general. Second, we assessed whether these responses were also modulated by the dominance of the ambiguous word's meaning. The results showed that sentences in which the ambiguous word's meaning was either strongly subordinate (i.e., infrequently used) or weakly subordinate produced significantly greater activation than sentences in which the meaning was one of two equally frequent meanings. As these regions were especially engaged for subordinate-biased sentences, this suggests that they may support processes involved in semantic reanalysis that requires integrating a less frequent meaning and suppressing dominant meanings. Furthermore, importantly, all subjects (except one) showed ambiguity-related local maxima within both the IFG and ITC, demonstrating that the group-level results are driven by high inter-subject consistency. Together, these findings inform us about the neural mechanisms underlying semantic ambiguity resolution, demonstrating a set of frontal and temporal regions that responds when the meaning of a sentence is (temporarily) ambiguous, whose response is modulated by meaning dominance and and whose involvement is highly consistent across individuals.

1:55 pm

E3 It Is Never Too Late: The Neural Substrate of Interference Control in Elderly Late Bilinguals

Ladan Ghazi Saidi[1], Daiel Adrover Roig[2], Ana-Ines Ansaldo[1,3]; [1]Centre de recherche de l'Institut Universitaire de Gériatrie de Montréal, Canada, [2]University of the Balearic Islands, Departamento de Pedagogía Aplicada y Psicología de la Educación, [3]École d'orthophonie et d'audiologie, Faculté de médecine, Université de Montréal, Canada

Bilingualism has been considered to boost interference control, and it has been associated with dementia onset delay. However, the neural correlates of the 'bilingual advantage' are largely unknown. The purpose of this study was to examine the neural correlates of interference control in monolingual(M) and English-French bilingual (B) elderly populations. Ten healthy elderly late bilingual participants were compared to their peer monolinguals on the Simon task (congruent and incongruent trials) during fMRI scanning. Participants were matched for age (M = 74.5 (7.1), B = 74.2 (7.4)), and years of education (M =16.1 (3.28), B = 17.2 (3.1)). Their performance on the MoCA test was normal (M= 27.7 (1.2), B= 27.5 (1.5)) and they presented no mood disorders. The degree of bilingualism was assessed by a questionnaire and partC of BAT(M= 21.4 (2.3), B= 40.5 (1.4), $p<.0001$). During fMRI scanning, participants had to respond to neutral, congruent, and incongruent trials of the Simon Task. Both groups showed equivalent response times and accuracy scores for all trial types of the Simon Task, and both groups showed a trial x run interaction, with faster response times only for the incongruent condition and as the task progressed (i.e. with runs 2 and 3). A modulation analysis of brain activity according to the evolution of response times across trials (incongruent condition) was significant only for bilinguals, whose smaller response times were indexed by decreased BOLD-fitted response in the right-frontal cortices. Distinct neural substrates supported equivalent performance on the Simon Task across groups. Thus, monolinguals recruited the prefrontal cortex (PFC) network, which is known for its participation in the control of interference, whereas bilinguals recruited brain regions associated with visuo-spatial namely left inferior parietal lobule (BA40). The evidence suggests that, long-time bilingualism may have induced neuroplastic changes to develop more efficient control processes, in particular enhanced proactive inhibition. Furthermore, for the first time, a reduction of the PASA effect (posterior-anterior shift in ageing) is observed in elderly bilinguals. All together, the evidence supports the idea that long term bilingualism can boost cognitive capacity and compensate for cognitive decline in aging and can modulate age-related brain adaptation (such as PASA). Moreover, the evidence suggests that even when learnt late in life, speaking more than one language on a daily basis has an impact on brain functioning, particularly with regards to cognitive control processing.

2:15 pm

E4 Temporal dynamics of word-category ambiguity resolution depend on CNTNAP2 genotype: an MEG study

Tineke M Snijders[1,2], Giovanni Piantoni[3], Gerard Kempen[4,5], Theo Vosse[1,5], Jos JA van Berkum[4,6], Mark Rijpkema[1], Barbara Franke[1,7], Guillen Fernandez[1,7], Robert Oostenveld[1], Peter Hagoort[1,4]; [1]Radboud University Nijmegen, Donders Institute for Brain, Cognition and Behaviour, Nijmegen, the Netherlands, [2]Radboud University Nijmegen, Centre for Language Studies, Nijmegen, the Netherlands, [3]Netherlands Institute for Neuroscience, Amsterdam, the Netherlands, [4]Max Planck Institute for Psycholinguistics, Nijmegen, the Netherlands, [5]Leiden University, Cognitive Psychology Unit, Leiden, the Netherlands, [6]Utrecht University, Utrecht Institute of Linguistics OTS, Utrecht, the Netherlands, [7]Radboud University Medical Centre, Nijmegen, the Netherlands

In an earlier fMRI study, using word-category (noun/verb) ambiguous words in a sentence or word-list context, we showed left inferior frontal and posterior temporal brain regions to be associated with syntactic unification processes (Snijders et al, 2009). Due to the low time resolution of fMRI, it remained unresolved whether this brain activation is due to competition processes at the ambiguous word, or to the resolution of the ambiguity (selection) at the disambiguating word. We used the superior temporal resolution of magnetoencephalography (MEG) to clarify this issue. For 32 participants MEG was measured while they were reading sentences and word-lists. Both the sentences and the word sequences contained a critical word that was either word-class (noun/verb) ambiguous or unambiguous. The critical word in the sentences was disambiguated to either a noun or a verb reading by the immediately following word. Enhanced event-related fields (ERFs) were observed over bilateral frontotemporal regions for words in sentences compared to words in random word lists. Additionally, word-category ambiguities within sentences resulted in increased response over left frontotemporal regions at the disambiguating word (400-700 ms). Thus, the left frontotemporal brain activation is related to the selection part of the unification process (ambiguity resolution). We did not find any group-level difference between ambiguous and unambiguous sentence conditions before the disambiguating word. However, this null-effect at the word-class ambiguous word was due to opposite effects, within the same left frontotemporal network, for subjects with differing genotypes of a common CNTNAP2 polymorphism (rs7794745, A>T; previously associated with sentence processing in the brain (Snijders et al, in revision, Kos et al, 2012, Whalley et al, 2011)). While subjects with an AA genotype showed enhanced ERFs over left temporal regions for sentence-ambiguous compared to sentence-unambiguous conditions, T allele carriers showed reduced ERFs for sentence-ambiguous conditions. This means that a common polymorphism in CNTNAP2 mediates inter-individual variability as to which syntactic processing route is used in the face of word-category ambiguity.

Poster Schedule

Poster sessions are scheduled on Wednesday, November 6 through Friday, November 8. Poster sessions are 2 hours, and presenting authors are expected to be present the entire time. Posters are located in the Emerald Ballroom. You may post your materials on the board assigned to you starting at the scheduled "Set-up Begins" time shown below. Please note that any posters not removed by "Teardown Complete" time will be discarded. Do not leave personal items in the poster room.

Date & Time	Posters	Topics
Poster Session A Wednesday, November 6 2:30 - 4:30 pm Setup Begins: 12:30 pm Teardown Complete: 6:30 pm	A1 - A8 A9 - A21 A22 - A27 A-28 - A31 A-32 - A36 A37 - A45 A46 - A55 A56 - A63 A-64 - A72	Gesture, Prosody, Social and Emotional Processes Auditory Perception, Speech Perception, Audiovisual Integration Motor Control, Speech Production, Sensorimotor Integration Orthographic Processing, Writing, Spelling Signed Language Language Development, Plasticity, Multilingualism Lexical Semantics Syntax, Morphology Language Disorders
Poster Session B Thursday, November 7 9:50 - 11:50 am Setup Begins: 8:00 am Teardown Complete: 1:00 pm	B1 - B12 B13 - B18 B19 - B24 B25 - B35 B36 - B46 B47 - B57 B58 - B63 B64 - B72	Auditory Perception, Speech Perception, Audiovisual Integration Motor Control, Speech Production, Sensorimotor Integration Orthographic Processing, Writing, Spelling Language Development, Plasticity, Multilingualism Lexical Semantics Discourse, Combinatorial Semantics Syntax, Morphology Language Disorders
Poster Session C Thursday, November 7 3:45 - 5:45 pm Setup Begins: 1:00pm Teardown Complete: 7:15 pm	C1 - C6 C7 - C16 C17- C22 C23 - C27 C28 - C37 C38 - C47 C48- C53 C54 - C62 C63 - C73	Gesture, Prosody, Social and Emotional Processes Auditory Perception, Speech Perception, Audiovisual Integration Motor Control, Speech Production, Sensorimotor Integration Orthographic Processing, Writing, Spelling Language Development, Plasticity, Multilingualism Lexical Semantics Syntax, Morphology Control, Selection, Working Memory Language Disorders
Poster Session D Friday, November 8 9:50 - 11:50 am Setup Begins: 8:00 am Teardown Complete: 1:00 pm	D1 - D 11 D12 - D19 D20 - D23 D24 - D32 D33 - D39 D40 - D46 D47 - D51 D52 - D62 D63 - D72	Auditory Perception, Speech Perception, Audiovisual Integration Motor Control, Speech Production, Sensorimotor Integration Orthographic Processing, Writing, Spelling Language Development, Plasticity, Multilingualism Lexical Semantics Discourse, Combinatorial Semantics Syntax, Morphology Control, Selection, Working Memory Language Disorders
Poster Session E Friday, November 8 4:15 - 6:15 pm Setup Begins: 1:00 pm Teardown Complete: 7:00 pm	E1 - E7 E8 - E18 E19 - E23 E24 - E29 E30 - E34 E35 - E44 E45 - E53 E54 - E58 E59 - E69	Gesture, Prosody, Social and Emotional Processes Auditory Perception, Speech Perception, Audiovisual Integration Motor Control, Speech Production, Sensorimotor Integration Phonology, Phonological Working Memory Orthographic Processing, Writing, Spelling Language Development, Plasticity, Multilingualism Lexical Semantics Syntax, Morphology Language Disorders

Poster Sessions

Poster Session A

Wednesday, November 6, 2:30 – 4:30 pm, Emerald Ballroom

Gesture, Prosody, Social and Emotional Processes

A1 Neural responses during perception of naturally produced, meaningful co-speech gestures *Jill Weisberg[1], Amy L. Hubbard[2], Karen Emmorey[3]; [1]San Diego State University Research Foundation, [2]Carnegie Mellon University, [3]San Diego State University*

Meaningful manual gestures are an integral component of spoken language perception1, yet little is known about how the brain integrates these gestures with the co-produced speech signal. Previous studies presenting manipulated gestures made by actors in carefully scripted stimuli revealed that meaningful gestures increased activity in inferior frontal and posterior lateral temporal cortices2. In addition, perception of natural, prosodically-linked co-speech gestures (i.e., beat gestures) implicated the planum temporale as a possible locus of multisensory integration3. However, it is unclear whether similar results occur for meaningful gestures. For example, does the semantic content of meaningful gestures shift the locus of integration from a sensory association region to a more posterior semantic processing region? Using fMRI, we examined this question using naturally occurring, unscripted audiovisual communication. We also investigated whether knowledge of a visual-gestural language (i.e., ASL) impacts neural responses to co-speech gesture. During scanning (GE 3T gradient-echo EPI scans, 40 3.5mm axial slices, 2s TR, 22.4cm FOV), 14 hearing, English-speaking monolinguals (7 female, mean age = 25.14) and 14 hearing native ASL-English bilinguals (7 female, mean age = 22.36) watched unscripted videos of a native English speaker, visible from the hips to the neck. Each of 18 clips (14-19s each) selected from 3-hours of recorded free-flowing speech contained 2-7 meaningful gestures (meaningfulness determined by ratings from an independent group of 20 subjects). Participants passively viewed each clip under one of four conditions: 1) BOTH: co-speech gesture with concurrent speech; 2) GESTURE: co-speech gesture without audio; 3) SPEECH: motionless speaker with speech signal; 4) STILL: the motionless speaker without audio. Using AFNI, individuals' fMRI response estimates and corresponding t-scores for contrasts of interest (generated by 3dREMLfit) were entered into group-level 3dMEMA analyses. We found no reliable group differences, suggesting relatively separate neural systems for processing ASL and gesture in hearing signers. Across groups, clips of speech with gesture (vs. either alone) elicited increased activation in regions associated with perception of biological motion (bilateral STG), language (IFG), and action (precentral gyri). No regions responded more during speech alone than during speech with gesture. However, regions demonstrating increased activity for gesture alone, relative to speech with gesture, included, most notably, bilateral inferior parietal cortex (BA 40), perhaps indicating less effortful processing of meaningful gesture in the presence of related speech. Critically, in bilateral posterior STG (inferior to the planum temporale), the response to speech with gesture exceeded the combined responses of speech alone and gesture alone, implicating pSTG as an important site for multimodal language integration of meaningful gestures with accompanying speech. Overall, our findings indicate that perception of natural, meaningful gestures accompanying speech enhances activation in a network of sensory, language, and action processing regions. Further, the locus of multisensory integration for meaningful gestures with speech may be distinct from that of co-speech beat gesture.

A2 Investigating age-related differences in neural systems supporting the processing of emotion vocalizations *Cesar Lima[1,2], Nadine Lavan[1], Zarinah Agnew[1], Samuel Evans[1], Pradheep Shanmugalingam[1], Carolyn McGettigan[3], Sophie Scott[1]; [1]University College London, [2]University of Porto, [3]Royal Holloway, University of London*

In social interactions, we get information about others' emotional states through a multitude of nonverbal cues, such as facial expressions, body postures, touch, and voice cues. Being effective at perceiving these cues is crucial for everyday interpersonal functioning at any age. A number of behavioural studies have consistently shown that advancing age is associated with decreased accuracy in emotion recognition. However, the majority of these studies have examined still facial expressions, much less being known about the auditory expression of emotions. Additionally, it remains largely unexplored how ageing affects the neural mechanisms supporting emotion recognition. In this study, we focussed on nonverbal emotion vocalizations, such as laughs, screams and sighs, and combined behavioural and neuroimaging (MRI) techniques to examine the processing of these emotion signals across the adult life span. A cross-sectional sample of 61 healthy adults aged between 20 and 81 years was tested (younger, 20-39 years, n = 22; middle-aged, 40-59 years, n = 21; older, 60-81 years, n = 18). Participants were also assessed for hearing ability and general cognitive functioning. The emotional stimuli consisted of a set of vocalizations previously validated to communicate two positive emotions, amusement and pleasure, and two negative ones, disgust and fear. Behaviourally, in a multi-dimensional emotion recognition task, aging was associated with decreased sensitivity to the intended vocal expressions, as indicated by decrements in ratings

and in a derived measured of accuracy. Decrements were observed both for positive and negative emotions, and they were significant in older adults only (60+ years), with no differences being observed between younger and middle-aged ones. These effects were not reducible to general cognitive decline and hearing loss. In the scanner (Siemens Avanto 1.5 Tesla system, including 32 channel head coil), participants underwent a passive listening task (a sparse-sampling acquisition was used). Functional results reveal the neural systems showing age-related modulations in response to vocalizations. We examine the relationship of behavioural decrements in emotion recognition to structural integrity using voxel-based morphometry analyses. The fact that behavioural decrements were not attenuated for positive emotions indicates that they cannot be explained by a top-down positivity effect in older adults. The alternative hypothesis that age-related differences in emotion recognition are linked to deterioration in neural systems involved in emotion processing is discussed.

A3 Recruitment of neural networks to understand emotional meaning is contextually modulated *Serena Klos[1], Jean Decety[1], Howard C. Nusbaum[1]; [1]The University of Chicago*

Language understanding has been attributed to processing within a perisylvian network that has increased in complexity of description with recent research. However, an alternative theory to a fixed neural network of specialized language processing regions is a more dynamic view in which patterns of neural activity depend on the processing demands of the situation. Speech conveying an emotional message is a particularly interesting example, because there is a general view that the affective tone and impact of a sentence is conveyed by paralinguistic information such as prosody, facial expressions, and gestures. While listeners can understand emotional meaning from the lexical-sentential patterns of speech absent paralinguistic information, it is not clear whether there is any emotional impact of these patterns. Although some theories suggest that meaning is gained through a bottom-up procedure by which the literal interpretation of each component of a sentence is determined before contextually based interpretations are considered (e.g., Searle, 1979), other scholars posit that language is immediately understood at a much more global level, in which contextual knowledge plays a direct role in comprehension without being limited by the literal meaning of a sentence (e.g., Gibbs, 1989). Moreover, it is unclear whether understanding simple declarative sentences without particular emotional prosody should produce emotional responses. Using functional magnetic resonance imaging (fMRI) this study was designed to examine changes in brain activity resulting from understanding sentences with positive and negative valence regarding evaluation of an individual. Sentences spoken with neutral prosody and ending in a positive, negative or neutral adjective were presented to participants while in an MRI scanner. Each sentence was presented twice, once in which the subject of the sentence was "you" and another with the subject of either "he" or "she". Participants were not instructed to consider the sentences to be directed at them and did not know the speakers. Analysis of the functional scans revealed that "you"-directed positive and negative sentences elicited activity in the limbic system, including the insula, amygdala and ventral striatum. Emotionally valenced sentences directed at a third person, however, evoked activity in networks involved in attention and cognition, such as precuneus, intraparietal sulcus and anterior cingulate. Thus, sentences with emotionally salient adjectives were associated with activity in limbic neural networks associated with reward and punishment, but only when those sentences seemed to be directed at the listener. Interestingly, the presence of these positively and negatively valenced words in sentences directed at a third person did not elicit a similar emotional response in the listener. Such results indicate that, even without the use of emotional prosodic cues or knowledge of the speaker, there are specific neural responses to sentences with personal relevance and potential emotional impact that are different from the responses to sentences directed at an unknown third person. Furthermore, these results suggest that neurobiological theories of language comprehension should be broadened to include a malleable connection between the well-established perisylvian network and other contextually relevant neural structures in the limbic system and basal ganglia.

A4 Neurophysiological differentiation between preattentive and attentive processing of emotional expressions on French vowels *Mathilde Carminati[1], Delphine Breuillard[1], Nicole Fiori[1], Charlotte Kouklia[2], Nicolas Audibert[2], Jacqueline Vaissière[2], Frédéric Isel[1,2]; [1]Paris Sorbonne Cité - Paris Descartes University, [2]Sorbonne Nouvelle Paris 3 University*

The present study aimed to better understand the neurodynamics of the emotional speech processing by combining an oddball paradigm with electroencephalographical measures of event-related potentials (ERPs). We wanted to differentiate two components of the orientation of attention, namely the automatic and the voluntary ones. Precisely, our goal was to study whether discrimination between different emotional speech prosody gives rise to two specific brain responses, i.e. an early response assumed to reflect the automatic orientation of the attention (i.e. the mismatch negativity or MMN, a fronto-central ERP component peaking around 100-250 ms poststimulus onset, thought to reflect detection of phonetic changes) followed by a later brain response thought to sign the voluntary orientation of the attention (i.e. the P300a). Critically, in order to avoid confound effects of emotional information and lexicalsemantic information potentially conveying emotional information too, our stimuli were vowels

rather than word or pseudoword as usually found in the literature. Two professional actors, a female and a male, produced several times the three French vowels /a/, /i/ and /u/ with happy, sad, fear and neutral prosody. The best exemplars of these stimuli were selected by conducting a categorization experiment with 33 native speakers of French that performed a rating for emotionality (i.e. happy, sad, fear or neutral) accompanied by a judgment of certainly on a scale from 1 (doubt) to 5 (know). An experimental session was constituted of 24 blocks with 82 standards and 14 deviants in each block. For example, in one block, neutral stimuli were presented as standards and one type of emotional stimuli (e.g happy) were presented as deviants and conversely in the other blocks. The stimulus onset asynchrony (SOA) was 1200 ms. Nine participants (4 men), all righthanded native speakers of French, aged from 21 to 38 years participated in this study. They were told that they would hear a sequence of spoken vowels, but that these vowels were unimportant and should be ignored. They were asked to attend to a silent movie. During the movie the stimuli were delivered over headphones. The sound volume was set at a comfortable level and kept constant throughout the experiment. The ERPs were online recorded from 64 electrodes mounted in a cap. The results revealed that the MMN amplitude was larger in response to deviant than to standard stimuli, independently of the type of deviant stimuli. Critically, in a later time windows, we showed that the latency of the P300a was delayed in response to the processing of emotional deviant in comparison to neutral deviant. Taken together, our findings suggest that whereas in an early stage of processing, the brain might automatically differentiate emotional speech, in a later stage of processing a voluntary orientation of the attention might take place for performing a deeper analysis of the emotional properties of the stimuli.

A5 Effects of Valence, Arousal and Age in Incidental Encoding of Words and Subsequent Recognition Memory Processing

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Emotional words are widely accepted to be processed differently and recognized more accurately than neutral words. While emotionality enhances recognition accuracy, it also induces a more liberal response bias. In this study, the effects of arousal (highly and medium arousing) and valence (positive, neutral and negative) axes of emotion on recognition memory accuracy and liberal bias were examined for emotional words. Stimuli: Verbal materials consist of 180 written concrete words selected from the Turkish Affective Norms Database (TUDADEN). In order to eliminate frequency effect, high and low frequency words are excluded. The words are also controlled for length so that they are restricted to 4-7 letters and 2-3 syllables. On a scale of 1-9, mean valence of the positive words is 7.58; mean valence of the negative words is 2.46; mean arousal of the highly arousing words is 6.76; mean arousal of the medium arousing words is 4.90. Participants: 113 volunteers participated: 60 young adults (mean age 20.77, 30 F, 30 M) and 53 older adults (mean age 77.13, 33 F, 20 M). Method: In the study session, the words were presented one at a time at the center of a computer screen for 1 second. The participants were instructed to count vowels within a word in 2 seconds under incidental encoding. Since vowels constrain lexical selection less tightly than consonants, deciding how many vowels each word contained is compatible with the idea that there exists a dissociation between consonants and vowels: the vowels are processed faster. After 30 min of retention interval, memory was assessed with a surprise old/new recognition task. As for experimental design, a 2 (age: young, old) x 2 (arousal: high, medium) x 3 (valence: positive, negative, neutral nonarousing) mixed ANOVA was conducted. Data were analyzed based on Signal Detection Theory; and d' scores and criterion values were calculated accordingly. Results: The results of the surprise recognition session showed that young participants recognized more accurately (M=1.48) as compared to older participants (M=.92) replicating the age effect (p=.000). Valence differences of words showed significant effect on memory performance, such that positive words were recognized better in both age groups (p<.05). When response bias was taken into account, it was observed that the response bias of age groups were different. In the old-age group, there was a significant bias to respond as 'old' only to positive words (p=.000), but in the young-age group a significant liberal bias is detected for only negative words (p<.05). Conclusion: Older participants showed a strong liberal bias for positive words indicating that better recognition of positive words in this group is attributable to the confounding factor of bias. On the other hand, younger participants exhibited emotionally modulated recognition memory such that positive words were recognized better despite liberal bias was detected for negative words. Our findings implicate that incidental word processing contain differentiable effects of emotion for different age groups. Spontaneously, older participants regulate their emotion in favour of maintaining well-being, while younger participants tend to carry a negative focus.

A6 Coordinating on the oddball in behavioral variant frontotemporal dementia

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Many social interactions require that individuals reach the same conclusion in contexts of limited or ambiguous verbal exchanges. This phenomenon, formalized in game theory as "coordination", has been shown to rely on strategic decision-making mechanisms and is supported in part by a fronto-temporal cortex network. In a recent coordination task participants were asked to generate the name of an item belonging to a semantic category so as to match the

responses of other participants, which lead controls to select responses that were prototypical for the specified category (McMillan et al 2011). However, patients with behavioral variant frontotemporal dementia (bvFTD), a neurodegenerative disease characterized by deficits in social cognition associated with prefrontal cortex atrophy, exhibited reduced coordination, failing to use typicality as a means to evaluate the other's participants' most probable response. What constitutes the players' most "probable" response, however, may vary depending on the specific nature of the game. Evidence for reduced coordination in bvFTD in a task in which the most "probable" response could be determined on the basis of a criterion besides typicality would further support the existence of a coordination deficit in bvFTD as well as the implication of atrophied cortical regions in the behavior. We, therefore, developed an oddball coordination task in which atypicality could serve to guide participants' selection of a "focal point," defined as a source of salient information external to the structure of the game and which can attract both players' responses. We hypothesized that while controls would be drawn to oddballs in attempting to coordinate their responses, bvFTD patients would be unable to do so. We presented bvFTD patients (N=15) and comparable Seniors (N=11) with 32 pictorial triads. In a counterbalanced design half of the items were presented in a "survey" condition (e.g. choose any bird) and half were presented in a "coordination" condition (e.g., choose a bird that someone like you would choose). Each triad contained two typical items (e.g., robin, sparrow). In half of the trials the third picture was a conceptual oddball item (e.g., bat looks like a bird but is a mammal) and this condition was treated as a semantic control: participants should not never choose "bat" since it is a category violation. In half of the trials the third picture was a perceptual oddball item (e.g., a toucan): participants should choose this item when coordinating because it provides a salient focal point. We measured rate of oddball item choices. We observed that bvFTD patients and controls both selected conceptual oddball items at a rate statistically below chance suggesting they do not have a semantic deficit. However, in the perceptual condition only 8% bvFTD patients coordinated by selecting oddballs compared to 57% percent of Seniors ($p=0.03$). This finding provides evidence that bvFTD patients have difficulty choosing a focal point. Together, these findings extend prior work by suggesting that bvFTD patients have difficulty associated with identifying the most probable focal point. We suggest that these limitations are related in part to diminished frontal cortex resources.

A7 Gesture Comprehension Recruits Sensori-Motor Systems

Ying Choon Wu[1], Seana Coulson[1], Scott Makeig[1]; [1]UC San Diego

Ethnographers and psychologists have demonstrated how depictive gestures have been used to communicate a wide range of semantic content, from indicating the direction of a block's rotation to mimicking the operation of a forklift at a loading dock. The human capacity to communicate simply through body orientation and movement suggests that some aspects of our conceptual knowledge are represented in highly schematic form. What neurocognitive systems mediate this ability to understand gestures? EEG was recorded from neurotypical adults as they passively viewed short video segments of spontaneous depictive gestures preceded by either congruent or incongruent cartoon contexts (e.g. a gesture showing an object being raised overhead paired with a cartoon showing a cat trapping a mouse with a flowerpot). To encourage semantic processing, each cartoon-gesture pair was followed by a probe word (e.g. flowerpot) that participants classified as either related or unrelated. After preprocessing, underlying brain and non-brain source activities were decomposed by independent component analysis (ICA), which learns from the statistics of time-series EEG a set of linear spatial filters that return maximally distinct estimations of source signals whose contributions sum to the original scalp-recorded data (Makeig, Bell, Jung, & Sejnowski, 1996). Each non-artifact IC scalp topography was modeled as the projection of a single equivalent dipole representing activity in a nearby cortical patch. Event-related spectral perturbations (ERSPs) visualized spectral modulations (3-122 Hz) of IC activations across 200 equally spaced time points during the 2.5 s intervals when gestures were on screen. Measure projection analysis (Bigdely-Shamlo, Mullen, Kreutz-Delgado, & Makeig, 2013) identified a subspace of brain voxels with reliable levels of local correlation between ERSP measures and IC dipoles. This subspace was further divided into three domains by affinity clustering based on local ERSP similarity. A domain in and near the right superior parietal lobule and right post-central gyrus exhibited sensitivity to cartoon-gesture congruency. Relative to their incongruent counterparts, congruent gestures elicited greater event-related desynchronization (ERD) in the 7 to 12 Hz (alpha) and 17 to 20 Hz (beta) ranges from approximately 500 ms after video onset to video offset. Congruent gestures were also accompanied by intermittently increased power (ERS) near 70 Hz relative to incongruent items. This cortical source domain overlaps areas known to respond to the perception of meaningful body movement and implicated in the human mirror system (Calvo-Merino, et al., 2005). The left hemisphere homologue to this domain has been implicated in the production of meaningful body movements, such as tool-use pantomimes and signed language (Choi, et al., 2000; Emmorey, Mehta, & Grabowski, 2007; Wolpert, Goodbody, & Husain, 1998). This area has also been proposed to mediate proprioceptive monitoring of the body's position in space (Wolpert, Goodbody, & Husain, 1998). Based on an embodied view of language, our results suggest that brain systems recruited during observation (and likely production) of patterned body movements also play an important role in higher cognitive functions, such as establishing conceptual mappings necessary to interpret the meaning of depictive gestures.

A8 Ape Gestural Learning: An evolutionary perspective grounded in dyadic brain modeling

Brad Gasser[1], Michael Arbib[1]; [1]University of Southern California

Elsewhere we have argued that the relative flexibility of gestural communication and inflexibility of vocal communication in apes suggests that the last common ancestor of chimpanzee and human had more robust, flexible manual communication, and that this provides evolutionary insight into neural and cognitive changes in the human language system (Arbib et al 2008). To examine this hypothesis in more detail we have assessed the debate (Halina et al 2013, Hobaiter & Byrne 2011) over learning (or not) of ape gestures, and more specifically have offered a conceptual analysis (Gasser et al 2013) of putative learning stages involved in ontogenetic ritualization, a form of mutual behavioral shaping in socially interacting apes that is hypothesized to provide an avenue towards gestural acquisition. Here we provide details of an extended analysis of our model, and present simulation results of key features of the model. We model putative ape neural systems inspired by macaque behavior and neurophysiology, involved in praxic action production, recognition and decision-making, and chart further evolutionary changes to these systems hypothesized to support the transition from praxic to (flexible) communicative behavior generally. The resulting ape model incorporates aspects of processes attested in the macaque but postulates greater availability of proprioceptive information, as well as greater ability to track distal and perceptual goals, thus offering explicit suggestions as to how the brains of chimpanzees may differ from those of macaques so that only the former can support flexible gestural communication. In particular, we show how these changes in neural processing support emergence of postural, intransitive manual movements (gestures), and complementary action recognition systems, as a means to make contact with comparative data on social learning, and data on apraxia and sign language usage in humans. We simulate a 'dyad' of ape brain systems (for a child and a mother) engaged in repeated interaction within a specific context. We go beyond past work emphasizing the ontogeny of response properties of mirror neurons to hypothesize their interaction with decision-making networks to yield adaptive behavior. We additionally demonstrate rapid behavioral changes in each agent – and thus changes in the interactions between the agents – as each learns role-specific qualities of the past interactions, eventually resulting in a postural gestural form 'understood' by both parties, whose 'meaning' is derived from the goal it achieves. Crucially, apes appear capable of supporting the emergence of intransitive gestures from praxic manual actions, something not believed to be true in macaques. We build on this finding to re-assess comparisons between mirror neuron connectivity and along the arcuate fasciculi of macaques, chimpanzees and humans (Hecht et al 2013, Rilling et al 2008). In particular, we endorse a perspective that changes in these tracts for chimpanzee as compared to macaque grant greater kinematic and postural information to mirror systems for learning about the (qualities of the) actions of others. We further discuss the utility of 'dyadic brain modeling' approaches for communicative behavior generally.

Auditory Perception, Speech Perception, Audiovisual Integration

A9 Engagement of the Cingulo-Opercular System Enhances Future Word Recognition

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Speech recognition in difficult listening conditions increases activity in a characteristic pattern of frontal cortex that includes the anterior insula, frontal operculum, and cingulate cortex. This network of frontal regions is referred to as the cingulo-opercular system (COS; Eckert et al., 2009; Wild et al., 2012; Erb et al., 2013) and responds robustly to task difficulty, response uncertainty, and errors across a range of perceptual and cognitive tasks (Dosenbach et al., 2006). Neuroimaging studies involving visuospatial tasks have shown that increased COS activity is also associated with behavioral adjustments and enhanced performance on subsequent trials (Kerns et al., 2004). The current study tested the prediction that elevated COS activity is predictive of word recognition on a subsequent trial. An fMRI experiment was conducted in which healthy adults (N=18, 10 female; 20-38 years of age; mean pure tone thresholds for each participant ≤ 9.2 dB HL from 250 Hz to 8000 Hz) repeated words aloud that were presented in noise. Each word was presented with continuous, multitalker babble at a signal to noise ratio (SNR) of +3 or +10 dB (120 trials in total), in the intervals between sparse acquisitions (TR = 8.6 sec). Consistent with previous neuroimaging studies, activity increased in cingulo-opercular regions in response to the poorer SNR trials and errors. Group results also revealed that increased activity in COS-related cortex was predictive of successful word recognition on the next trial. The influence of cingulo-opercular activity on subsequent word recognition potentially reflects a neural mechanism that mediates adjustments in response caution (Danielmeier & Ullsperger, 2011) or task-directed attention (Weissman et al., 2006). Importantly, these results highlight a neural system that aids speech recognition in challenging listening conditions.

A10 Perception of speech in noise and other maskers by musicians and non-musicians

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Extensive musical training is associated with better speech-in-noise perception. However, here are multiple ways to mask speech with noise, and these various maskers show different behavioural and neural effects. Given that musical experience also seems to offset the age-related decline in speech-in-noise perception, understanding the relationship between musical experience and speech-in-noise perception is of great importance. This experiment uses fMRI and multiple types of speech maskers to determine whether there are differences in speech-in-noise perception between trained musicians and non-musicians, and whether that difference varies across masker types. During the behavioural task, musicians (n=16) and non-musicians (n=16) passively listen to stimuli that consist of simple sentences masked with continuous noise, speech-modulated noise, rotated speech, or another speaker. After hearing each sentence, the subject repeats as much as possible of the sentence. Subjects will be scored based on how many key words they get correct. All subjects will also fill out a questionnaire detailing their musical experience and complete tasks measuring their auditory acuity, executive control, working memory, and nonverbal IQ. In the fMRI task, subjects listen to stimuli consisting of short narratives taken from a British newspaper and masked with either continuous speech, discontinuous speech, rotated speech, speech modulated noise, and continuous noise. Subjects are instructed to report as much as possible from the last phrase of the target speaker. Scoring is based on how many key words subjects correctly report. To determine whether performance differs between the musician and non-musician groups and between conditions, a musician x condition repeated-measures ANOVA will be performed for both the behavioural and fMRI phases of the experiment. A behavioural advantage shown by musicians, relative to non-musicians, will replicate previous studies and extend these findings to include several types of maskers. A difference between the groups only with certain maskers could help determine the mechanism by which musicians are better able to perceive the target stimuli. Although the direction of causality cannot be inferred from this experiment, results could provide further evidence that musical training improves performance on certain linguistic and attentional tasks, as well as help clarify the underpinning neural systems.

A11 Direct influence of sentential context on the perceptual analysis of speech: Evidence from Granger analysis of MRI-constrained MEG/EEG data *David Gow[1,2,3], Bruna Olson[1,2], A. Conrad Nied[1,2]; [1]Massachusetts General Hospital, [2]Athinoula A. Martinos Center for Biomedical Imaging, [3]Salem State University*

Background: This work examines the influence of sentential and semantic context on speech perception. Past work has focused on the relationship between the intelligibility of degraded speech and patterns of BOLD activation. It is unclear however whether this activation reflects top-down influences on speech perception, or the higher levels of processing that are only possible if speech becomes intelligible. Thus, it is not known whether context directly penetrates perceptual analysis of the speech signal. Method: We applied Kalman-filter based Granger causality analysis to high spatiotemporal resolution MRI-constrained MEG/EEG data to examine time-varying patterns of directed causality over a large cortical network during a retrospective probe monitoring task. Subjects heard meaningful sentences and then were presented a visual letter probe for a stop consonant (/t/. /d/. /p/ or /b/). In experimental trials, VOT was manipulated to create voicing ambiguity. The same token of these words was heard in different sentential contexts that supported its voiced (e.g. back) and voiceless (pack) interpretation. In baseline trials perceptually unambiguous targets were heard in similar monosyllabic words and sentential contexts. Results: Subjects showed a strong influence of context on phoneme interpretation, with each subject interpreting at least 85% of all items in the appropriate manner in both voice and voiceless biasing contexts. Subjects reported no awareness of the VOT manipulation. Both tasks recruited a large cortical network in the 100-400 msec interval following the onset of target words that included regions associated with semantic processing including the angular gyrus, middle temporal gyrus, and dorsolateral prefrontal cortex. However, this network showed strikingly different patterns of effective connectivity in the two conditions. In the baseline condition semantic regions showed relatively weak influences on activation of the left posterior superior temporal gyrus (pSTG). In contrast, left pSTG activation was strongly influenced by semantic regions in trials with perceptually ambiguous target phonemes. Conclusions: These results provide direct evidence that sentential, and in particular, semantic constraints directly influence acoustic-phonetic analyses associated with the pSTG during the perception of natural speech with ambiguous feature cues. These effects appear to be non-strategic, and they involve the parallel influences of a broad, distributed semantic network.

A12 Speech processing over multiple time scales: An MEG study of functional connectivity *Maryse Thomas[1,2], Sylvain Baillet[1,2], Vincent Gracco[1,3]; [1]Centre for Research on Brain, Language, and Music, McGill University, Montreal, QC, Canada, [2]McConnell Brain Imaging Centre, Montreal Neurological Institute, Montreal, QC, Canada, [3]Haskins Laboratories, New Haven, CT*

During speech comprehension, the brain processes information over multiple time scales. For instance, word processing occurs on the order of hundreds of milliseconds, while sentence processing may take several seconds. Additionally, as the complexity and duration of the linguistic input increase, cognitive demands related to language processing, such as semantic retrieval, syntactic processing and working memory, grow as well. Due to these increasing demands, it is very likely that neural systems will be differentially engaged

when words are processed in isolation, in the context of a sentence and in the context of a coherent narrative. This hypothesis has previously been investigated using a paradigm in which a narrative is presented from beginning to end, as well as with its word and sentence components shuffled (Lerner, et al. 2011; Xu et al. 2005). Studies using this paradigm have established that words, sentences and narratives differentially engage language areas in a hierarchical fashion, but never before has this paradigm been investigated to the same degree using MEG (magnetoencephalography) (however see Brennan & Pylkkanen, 2012), which offers a superior temporal resolution compared to hemodynamic measures. In this study, our goal was to characterize the brain activity related to speech processing over various time scales using MEG. In doing so, we aimed not only to identify the brain areas involved, but also to assess functional connectivity between language areas as these processes took place. We recorded brain activity from native English speakers as they passively listened to a five minute long narrative: first with its words in a shuffled order, then with its sentences in a shuffled order and finally in its regular format. Phase shuffled words and sentences were also presented as control conditions. Results obtained through source imaging revealed a context-dependent hierarchy of brain activation for each condition. Control conditions produced brain activation limited to the auditory cortex. Word and sentence conditions produced activity in perisylvian language areas, while sentence processing recruited more temporal regions. Brain activity was analyzed at the word, sentence and full-story level for each condition, revealing that words and sentences, when in the context of a narrative, recruited more neural areas bilaterally than words and sentences out of context. Finally, we examined frequency-specific oscillatory coupling as a measure of functional connectivity among activated areas to assess the manner in which words and sentences are integrated into a coherent narrative. These analyses revealed differential connectivity between language areas corresponding with stimulus complexity. Our findings suggest that discrete neural processing within distinct brain regions and neuronal coupling mechanisms across regions are used to integrate different levels of comprehension.

A13 Identifying hub structures of emotional speech in the human brain *Sonja Kotz[1], Sophie K Scott[2], Stuart Rosen[2], Jonas Obleser[3]; [1]The University of Manchester, [2]UCL, [3]MPI for Human Cognitive and Brain Sciences*

Two distinct dimensions convey emotional content of speech: A verbal (segmental) "what" dimension and a non-verbal (prosodic) "how" dimension. As these two dimensions occur in tandem, it necessitates core structures in the brain to fuse them. By now, an extended brain network subserving emotional speech has been suggested[1,2,3]. However, controversy persists as to (i) which of these brain areas are driven by the "what" and "how" aspects of emotional speech, and (ii) which candidate areas support their integration. Relevant hub structures of emotional speech should therefore not only be sensitive to the respective dimensions, but should also exhibit joint sensitivity to both. We applied acoustic manipulations previously employed in speech intelligibility research4 to dissociate segmental from prosodic information. These manipulations entailed rotated speech5 and vocoded speech6 next to intelligible speech. This allows identifying brain areas that dissociate and or fuse the "what" and "how" dimensions of emotional speech, with specific emphasis on the anterior superior temporal gyrus/sulcus (STG/STS) featuring prominently as a hub of emotional speech integrating the "what" and "how" information. Contrasting emotional > neutral speech for (1) intelligible-vocoded speech and (2) intelligible-rotated speech, a conjunction analysis revealed hub structures in the bilateral anterior STS , the right ventrolateral orbitofrontal cortex (OFC), the cerebellum, and the left parahippocampal gyrus. We confirm a clear distinction of "how" (STG) and "what" (STS) dimensions of emotional speech bilaterally. The application of acoustic manipulations allowed identifying hub areas of emotional speech. Next to these core areas, distinct fingerprints of "what" and "how" information were identified. The current results confirm recent evidence on emotional speech[2] and emphasize the importance of the anterior temporal cortex, an area of recent controversy[2,7] in emotional speech. 1. Schirmer & Kotz, TiCS, 2006 2. Wildgruber et al., Prog Brain Res., 2006 3. Kotz et al., Hum Brain Mapp, 2013 4. Scott et al., Brain, 2000 5. Blesser et al., J Speech Hear Res.,1972 6. Shannon et al., Science, 1995 7. Witteman et al., Neuropsychologia, 2012

A14 Discriminating the Intervals of Two-tone Melodic Sequences *Carolyn McClaskey[1]; [1]University of California, Irvine*

Relative pitch processing is an important aspect of both speech and music perception. The current study investigated the extent to which pitch-interval processing differs between intervals of the western musical system and whether these differences can be accounted for by the simplicity of an interval's integer-ratio. Pitch-interval discrimination thresholds were measured using adaptive psychophysics for sequentially presented pure-tone intervals with standard distances of 1 semitone (minor second, 16:15), 6 semitones (the tritone, 45:32), and 7 semitones (perfect fifth, 3:2) at both high (1500-5000 Hz) and low (100-500 Hz) frequency regions. Results show similar thresholds across all three interval distances with no significant difference between low and high frequency regions. Consistent with previous studies, thresholds obtained from musicians were considerably lower than those from non-musicians. Data support enhanced pitch-interval perception by musicians but argue against an effect of frequency-ratio simplicity in the case of pure-tone melodic intervals.

A15 Investigating the role of speech-selective regions during videogame-based non-speech sound category acquisition *Sung-Joo Lim[1,3], Julie A. Fiez[2,3], Lori L. Holt[1,3]; [1]Carnegie Mellon University, [2]University of Pittsburgh, [3]Center for the Neural Basis of Cognition*

A video-game-based training paradigm (Wade & Holt, 2005) has been shown to promote effective learning of both novel non-speech and non-native speech categories (Lim & Holt, 2011). This training is a significant departure from traditional explicit response-feedback paradigms in its implicit, yet active nature. The task does not require directed attention to sounds and feedback is linked to game performance, not categorization per se. Moreover, the training is naturalistic in that listeners experience rich correlations among multimodal cues and the functional use of sounds guides successful game actions. A previous study of nonspeech category learning using this videogame training observed pre- and post-training activity change in putatively speech-specific left posterior superior temporal (pSTS) cortical regions in response to learning to categorize nonspeech sounds (Leech et al., 2009). However, how this region responds during category acquisition and how different sound category input distributions interact with its recruitment are as yet unknown. Using fMRI, we investigate the online recruitment of the speech-selective regions during videogame training as a function of nonspeech category learning and examine subsequent neural signatures for acquired category representations. All participants experienced a pair of unidimensional sound categories differentiable without training and a pair of complex high-dimensional sounds that required training to categorize. One group played the videogame with complex sounds forming categories that were linearly separable in higher-dimensional perceptual space, whereas the other heard similar sounds without an orderly category structure. The different category input distributions evoked differential engagement of a left posterior superior temporal gyrus/sulcus (pSTG/STS) region identified through a speech vs. non-speech localizer contrast. During game play, this region showed greater activation for subjects who experienced an orderly vs. random category structure. Moreover, the activation in the left pSTG/STS was predicted by subjects' behavioral game performance only for the subjects experiencing an orderly category structure, whereas no significant relationship was found among subjects learning random category structure. However, this pattern of activity was not present across other regions in the speech network. The left anterior STG was not recruited as a function of learning nor did it exhibit different activations across groups. This evidence suggests that category learning-related recruitment is specific to the left pSTG/STS; it is recruited by learning distributional regularities of sounds rather than responding differentially for acoustic properties of speech over nonspeech. We conclude that the activity change in the left pSTG/STS for processing nonspeech sounds after the videogame training (Leech et al., 2009) is in fact induced by the direct recruitment of the region online during game play.

A16 Mapping multidimensional phonetic spaces using the acoustic change complex of EEG recordings *Paul Iverson[1], Marta Mulyak[1], Anita Wagner[1]; [1]University College London*

This presentation describes a new technique to map phonetic processing, which combines the Acoustic Change Complex (ACC) of EEG recordings with multidimensional scaling (MDS). In EEG recordings, there is a characteristic P1-N1-P2 complex after the onset of a sound, and the ACC is a related complex that occurs when there is a change within a sound (e.g., a vowel formant change). One advantage of the ACC is that it is very time efficient; long stimulus trains can have frequent acoustic changes (e.g., every 500 ms), and there is no requirement to have repeated presentation of a standard as in oddball/mismatch designs. This time efficiency is important because MDS requires the presentation of every possible pair of stimuli in a set. By combining the ACC and MDS, we can thus obtain a much broader view of phonetic processing (i.e., multiple dimensions, many phonemes) than can be obtained by traditional paradigms that focus on a single phoneme pair (e.g., /i/-/u/). The ACC is a relatively early cortical response, so it produces an assessment of early auditory/phonetic processing that is relatively independent of later lexical processes. In order to demonstrate this technique, we tested 12 native speakers of Southern British English on a set of four voiceless (/f/, /θ̟/, /s/, /ʃ/), and four voiced (/v/, /ð/, /z/, /ʒ/) sustained fricatives. The stimuli were presented in long concatenated stimulus trains, randomly changing between all possible pairs of fricatives, with duration randomly jittered between 400 and 500 ms, and amplitude equated. A 64-channel Biosemi EEG system recorded responses, and the ACC response magnitude was measured at FCz. MDS was used to map the stimuli into a two-dimensional space, with larger spacing between stimuli that had larger ACC responses. This produced an MDS solution with a phonetically realistic configuration of stimuli, organized in terms of voicing and place of articulation. The results thus demonstrate that a combination of ACC and MDS can be effective for mapping multidimensional phonetic spaces at relatively early levels of auditory/phonetic processing, which may be useful for evaluating the effects of language experience in adults and infants.

A17 Infants' audiovisual speech integration does not hinge on phonetic knowledge *Heather Bortfeld[1,2], Martijn Baart[3], Kathleen Shaw[1], Jean Vroomen[4]; [1]University of Connecticut, [2]Haskins Laboratories, [3]Basque Center on Cognition, Brain and Language, [4]Tilburg University*

It is well-established that both the adult and infant brain combine auditory and visual speech into one event (e.g., Burnham & Dodd, 2004; Burnham & Sekiyama, 2004;

Kuhl & Meltzoff, 1982, 1984; McGurk & MacDonald, 1976; Patterson & Werker, 1999, 2003; Rosenblum, Schmuckler, & Johnson, 1997; Sumby & Pollack, 1954). In order to do this, listeners may rely on at least three cross-modal cues in the signal: i) temporal cues, ii) energetic cues, and iii) phonetic cues. Cross-modal temporal cues consist of bimodally shared characteristics such as the speakers' speech rate and the AV onset of syllables. When the unimodal signals are coupled, but presented out of synchrony, both adults and infants are able to detect this asynchrony (e.g., Grant, van Wassenhove, & Poeppel, 2004; Lewkowicz, 2000, 2010; van Wassenhove, Grant, & Poeppel, 2007; Vatakis & Spence, 2006), indicating that they are sensitive to violations in the temporal correlation between them. In fact, as demonstrated with non-speech stimuli, listeners may even rely on this correlation to infer causal relationships (Parise, Spence, & Ernst, 2012). Energetic cues in the AV signal can be defined as the correlation between acoustic energy and the visible articulators (Grant, 2001; Grant & Seitz, 2000) and, in general, there is more acoustic energy when the mouth is open rather than closed. The third cross-modal cue is related to the phonetic correspondence between the visual signal and the sound (e.g., a listener recognizes that a bilabial closure is specific to speech and corresponds to /m/ or /p/, but not to /k/ or /s/). There is some evidence that even infants are sensitive to phonetic information in the AV speech signal (Burnham & Dodd, 1996, 2004; Eimas, Siqueland, Jusczyk, & Vigorito, 1971; Jusczyk & Luce, 1994; Kuhl et al., 2006; Kushnerenko, Teinonen, Volein, & Csibra, 2008; Rosenblum et al., 1997; Swingley, Pinto, & Fernald, 1999), although there is also evidence that the ability to extract phonetic content from visual speech increases with age and continues to develop well beyond puberty (Bruce et al., 2000; Desjardins, Rogers, & Werker, 1997; Hockley & Polka, 1994; Massaro, 1984; McGurk & MacDonald, 1976; Ross et al., 2011; Sekiyama & Burnham, 2004). In the present study, we assessed the relative contribution of the different cues using sine-wave speech (SWS). Adults (N=52) and infants (N=30) matched 2 trisyllabic speech sounds ('kalisu' and 'mufapi'), either natural or SWS, with visual speech information. On each trial, adults saw two articulating faces and matched a sound to one of these, while infants were presented the same stimuli in a preferential looking paradigm. Adults' performance was almost at ceiling for natural speech, but was significantly less accurate for SWS. In contrast, infants matched the sound to the articulating face, irrespective of whether it was natural speech or SWS. These findings are consistent with a multi-stage view of audiovisual speech integration and suggest that infants initially combine audiovisual information based on low-level perceptual cues.

A18 Brain response to a rhythm deviant in adolescent cochlear implant users before and after an intensive musical training program *Bjørn Petersen[1], Ethan Weed[1], Mads Hansen[1], Stine Derdau[1], Pascale Sandmann[2], Peter Vuust[1]; [1]Aarhus University, [2]Hannover Medical School*

Music and prosody share many of the same relevant acoustic features: pitch, rhythm, and timbre. For cochlear implant (CI) users perception of all of these is challenging. While previous studies have primarily examined implant outcome in adult CI-recipients with an acquired hearing loss (HL), few studies have investigated perception of music, prosody, and speech in the growing population of adolescent CI users with a congenital HL. However, recent studies indicate that to keep pace with their normal hearing (NH) peers, supplementary measures of rehabilitation are important throughout adolescence. This study aimed to investigate auditory brain processing of musical sounds relevant to prosody processing in adolescent CI-users who have received their implant in childhood. Furthermore, we aimed to investigate the potential impact of intensive musical training on adolescent CI-users' discrimination of music and speech prosody. Here we present preliminary analyses of ERP responses to rhythmically deviant stimuli and present results from a behavioral rhythm discrimination test. Eleven adolescent CI users (M.age = 17 years) participated in a group-based music training program, consisting of active music making supplemented with daily computer based listening exercises. NH participants received no training. Nine of the CI-users had bilateral implants and two had unilateral implants. The mean implant experience was 9.47 years (range: 1.8-15.2). Ten NH peers (M.age = 16.2 years) formed a reference group. Before and after the training, both groups underwent EEG recordings and behavioral tests for perception of music and speech. EEG was recorded with an adapted version of the musical multifeature paradigm (MuMuFe; Vuust, 2012), presenting a musical standard randomly violated by different musical deviants (pitch, timbre, rhythm and intensity). Difference waves for the rhythm deviant were analyzed in the time window between 300 and 320 ms. Separate mixed-model ANOVAs were performed for left and right fronto-central electrodes. For both left and right electrode sites we found a main effect of group (Left: $F(1,16) = 39{,}859$ $p = 0.000$, Right: $F(1,16)=7.862$ $p = 0.013$), driven by higher mean amplitude in the NH group. There was no main effect of training. Left hemisphere sites showed a significant group by session interaction ($F(1,16)=11.211$ $p=0.004$), driven by a larger difference wave (rhythm deviant - standard) in the CI group following training ($t(7) = 4.05$, $p = 0.016$ (Bonferroni corrected)). Right hemisphere sites showed no significant effect. The rhythm discrimination test showed a significant gain ($t(1,11)=2.434$; $p=0.035$) in the CI group after training. The NH group scored significantly higher than the CI group at both sessions. Our results suggest that adolescent CI users, who have only experienced sound through the implant, show brain responses to musical stimuli resembling those of NH peers, and that this response can be altered by intensive musical training. The finding points toward the possibility of improving appreciation of music in general for adolescent CI users, and using music as a motivating element in speech therapy programs.

A19 Neurophysiological Evidence for the Recruitment of Right Hemisphere Homologues During Speech Perception by Musicians *McNeel Jantzen[1], Bradley Howe[1], K.J. Jantzen[1]; [1]Western Washington University*

Musicians have a more accurate temporal and tonal representation of auditory stimuli than their non-musician counterparts (Kraus & Chandrasekaran, 2010; Parbery-Clark, Skoe, & Kraus, 2009; Zendel & Alain, 2008; Musacchia, Sams, Skoe, & Kraus, 2007). Musicians who are adept at the production and perception of music are also more sensitive to key acoustic features of speech such as voice onset timing and pitch. Together, these data suggest that musical training may enhance the processing of acoustic information for speech sounds. In the current study, we sought to provide neural evidence that musicians process speech and music in a similar way. We hypothesized that for musicians, right hemisphere areas traditionally associated with music are also engaged for the processing of speech sounds. In contrast we predicted that in non-musicians processing of speech sounds would be localized to traditional left hemisphere language areas. Speech stimuli differing in voice onset time was presented using a dichotic listening paradigm. Subjects either indicated aural location for a specified speech sound or identified a specific speech sound from a directed aural location. Musical training effects and organization of acoustic features were reflected by activity in source generators of the P50, N1 and P2. This included greater activation of bilateral middle temporal gyrus (MTG), right superior temporal gyrus (STG), and right precentral gyrus (PrG) in musicians. The findings demonstrate recruitment of right hemisphere in musicians for discriminating speech sounds and a putative broadening of their language network. Musicians appear to have an increased sensitivity to acoustic features of speech that is facilitated by musical training and supported, in part, by right hemisphere homologues of established speech processing regions of the brain.

A20 Optimal design of speech perception fMRI studies for robust quantification of single trial activation patterns *Julia M. Fisher[1], Stephen M. Wilson[1]; [1]University of Arizona*

Several recent studies of speech perception and language comprehension have employed multivariate pattern analysis (MVPA), a promising approach for determining the nature of representations in different brain regions. Because MVPA relies on classification of individual trials, it is important to choose scanning parameters that optimize the robustness of activation patterns for individual trials. Experimental designs that are optimal for traditional event-related analyses may not be optimal for reliably mapping the activation patterns associated with individual trials. Another consideration is that for speech perception and language comprehension studies, sparse sampling is typically used to allow for the presentation of auditory stimuli without interference from scanner noise, consequently reducing the number of data points per trial. The aim of this study was to determine the optimal sparse sampling design parameters to quantify single trial activation patterns for speech perception studies. We presented participants with CV syllables in three different experimental designs. Each design involved sparse sampling with an acquisition time of 2 s, jittered presentation of trials with either 1 or 0 trials per TR, and catch trials (discarded from analysis) to ensure attention to the auditory stimuli. Design 1 was a "slow jittered" design with a mean inter-trial interval (ITI) of 11 s and a TR of 9 s, with long silent periods followed by acquisitions timed to coincide with the peak of the hemodynamic response function (HRF). Design 2 was also a slow jittered design with the same ITI of 11 s, but the TR was 3 seconds, so that multiple volumes were acquired per trial. Design 3 was a "fast jittered" design with a mean ITI of 3.7 s and a TR of 3 s, which would be optimal for a typical event-related study. Individual HRFs were calculated based on a separate run with a TR of 1 s. To quantify the robustness of activations to individual trials, we defined an ROI for each participant comprised of the 20 most activated voxels over the whole experiment. Then we determined for each trial whether the mean activation in this ROI was greater than zero. The proportion of trials with positive responses in the ROI was 81% for design 1, 96% for design 2, and 85% for design 3. The difference between design 2 and designs 1 and 3 was statistically significant. Our results indicate that the robustness of activation to individual CV syllables is maximized when there are multiple volumes acquired per trial, and the ITI is relatively long. It is noteworthy that design 3, which would likely have proved optimal for a standard event-related analysis, was not optimal for detection of individual trial activation patterns. Although design 2 had fewer trials than design 3, this was counteracted by its longer ITI, which facilitated the segregation of individual trial responses.

A21 MEG correlates of acoustic speech features *Miika Koskinen[1]; [1]Aalto University, Finland*

Introduction. Magnetoencephalogram (MEG) and electroencephalogram (EEG) signals evidently correlate with the intensity variations of the listened speech. In this paper, the aim was to investigate the capability of MEG to reflect other acoustic speech features also, especially mel-frequency cepstral coefficients (MFCC), i.e. features that are sensitive to harmonic frequency components of the audio signal and often used in automatic speech, speaker recognition and music information retrieval systems. Methods. Ten subjects listened to audiobook stories of classic Finnish novel Välskärin kertomuksia by Z. Topelius. For each subject, two MEG datasets were recorded: 1-hr-long dataset with nonrecurring stories, and a dataset comprising 48 trials of repeated 1-min speech passage. The analysis pipeline contained computation of latent signals common in MEG recordings across all

subjects listening to the same stories, computation of the shared signal components between the acoustic features and the brain responses, and evaluation of the brain sources of these found signals with one subject data. More specifically, 1-min trials were used for training and for evaluation of the performance of the task-optimized spatial filters. The filter parameter estimation was based on the multi-set canonical correlation analysis (M-CCA) resulting in maximally correlating time series between the subjects. The spatial filters were trained separately for 17 Mexican hat wavelet scales corresponding to the wavelet center frequencies between 0.5 and 120 Hz. Then, the spatial filters showing statistically significant inter-subject correlations with 1-min trials were applied to the MEG data corresponding to the listened nonrecurring audiobook stories. As M-CCA attempts to find consistent signal components across the subjects, the spatially filtered signals were averaged over the group. Next, 13.5 min of the resulting multi-dimensional time series were used for finding the shared signal components between the stimulus and the brain response features, and the corresponding time lag where these signals correlate maximally. Here, computations were based on classical canonical correlation. The rest of the data (46 min) were split into 30 s segments to evaluate the stimulus–response correlation with independent data. Finally, anatomical sensitivity maps were constructed for one subject representing the brain areas where the source currents were the most associated with the stimulus features. Results. Combined audio log-energy and 12 MFCC features correlated maximally with (processed) MEG signals delayed 38–110 ms depending on the wavelet scale, and reaching 0.80 (mean; test data) at 0.5 Hz scale. The analysis resulted in 1–6 stimulus-related statistically significant orthogonal time series per wavelet scale between 0.5–86 Hz. The sensitivity maps showed that these time series reflected brain activity selectively in auditory cortices, in the middle and posterior temporal, inferior frontal and parietal regions. Conclusion. The results suggest that the presented methodology is capable of revealing multiple shared signal components between MEG and acoustic speech features. Obtained relatively high correlations were enabled by efficient noise reduction by the novel task-optimized spatial filtering scheme.

Motor Control, Speech Production, Sensorimotor Integration

A22 Title: Convergent transcriptional specializations in the brains of humans and song learning birds *Andreas R. Pfenning[1], Erina Hara[1], Osceola Whitney[1], Miriam Rivas[1], Petra Roulhac[1], Jason T. Howard[1], Ganesh Ganapathy[1], M. Arthur Mosely[1], J. Will Thompson[1], Erik J. Soderblom[1], Alexander J. Hartemink[1], Erich D Jarvis[1,2]; [1]Duke University Medical Center, [2]Howard Hughes Medical Institute*

Vocal learning, essential for human speech, has evolved convergently in a small set of mammals and birds. Vocal learners share a neural circuit composed of a cortico-basal ganglia loop and a direct cortico-brainstem projection. Here, we asked if the brains of humans and vocal learning birds also have molecular parallels. Using high-throughput neuro-transcriptomics and -proteomics, we identified molecular specializations in brain regions of human and avian vocal learners relative to vocal non-learners. An alignment of human and avian brain regions identified analogous components of a vocal learning circuit in the cortex and basal ganglia. Remarkably, we found that the vocal communication areas of vocal learning birds—but not of vocal non-learning birds—share convergent gene expression specializations with laryngeal motor cortex of the human brain that controls speech production and learning. The shared specializations were enriched for genes that control connectivity. These findings suggest that similar behavior and neural connectivity for a convergent complex trait are associated with changes in the same set of overlapping genes.

A23 Internal vs. external deviations from auditory targets in speech *Caroline Niziolek[1], Srikantan Nagarajan[1], John Houde[1]; [1]University of California, San Francisco*

In the control of goal-directed actions such as speech, external feedback is compared with an internal prediction. If the feedback matches the prediction, the sensory response is suppressed, a phenomenon known in the speech domain as speaking-induced suppression (SIS). If, however, auditory feedback is artificially altered in real time, the sensory response is enhanced, and is thought to act as an "error" signal. Do responses to these externally-induced alterations differ from responses to natural, internally-induced deviations from a speech target? We used magnetoencephalography (MEG) and auditory feedback alteration to probe the nature of internal predictions and auditory goals for speech. Ten subjects produced 200 repetitions each of three different vowels in the MEG scanner. These productions were then played back to the subjects. SIS was defined as the reduction of the amplitude of the left-hemisphere auditory M100 response to spoken vowels ("speak" condition) relative to playback ("listen" condition), and was compared across productions in different regions of auditory space. SIS was reduced in productions farthest from the median; that is, natural vowel productions that deviated from the center of the distribution appeared more error-like. Furthermore, the decreased SIS was correlated with later corrective movements, suggesting it has functional significance for changes in vocal motor output. We additionally measured the response to sudden unexpected alterations in vowel formants. Compensatory responses to feedback alteration varied systematically with the distance to the neighboring vowel. Specifically, compensatory changes in output were far greater for productions that lay closer to the vowel

that was being shifted towards. That is, the same auditory alteration had a stronger effect when the perceived formants were farther from the center of the vowel cluster. Our results are consistent with an auditory target model in which productions farther from a stable auditory goal are internally judged to be more error-like: auditory cortex is less suppressed and compensation for compounding formant alterations is enhanced.

A24 Modulations of speaking-induced suppression in speech imitation *Matthias K. Franken[1,2], Daniel J. Acheson[1,2], Peter Hagoort[1,2]; [1]Max Planck Institute for Psycholinguistics, Nijmegen, The Netherlands, [2]Donders Institute for Brain, Cognition, and Behaviour, Radboud University, Nijmegen, The Netherlands*

Recent neuroimaging evidence has demonstrated that activation of the auditory cortex is suppressed to self-produced speech relative to listening without speaking (i.e. speaking-induced suppression, or SIS). This finding has been explained via a forward model that predicts the auditory consequences of speech actions (e.g., Guenther, Ghosh, & Tourville, 2006; Houde & Nagarajan, 2011). When incoming auditory feedback matches this prediction, they cancel out, leading to a suppression of auditory activity. Critically, when the feedback does not match the prediction, an error signal is generated that can be used to guide changes in articulation. The present study was designed to test two critical predictions from these frameworks: First, whether the release from speaking-induced suppression varies as a function of the acoustic distance between feedback and prediction, and second, whether this in turn is predictive of the amount of adaptation in people's speech production. MEG was recorded while subjects (N=32) alternated between blocks of an imitation and a listening task. In the imitation task, subjects always began speaking a single vowel (/e/), and then listened to a subject-specific vowel recording. People were instructed to imitate the vowel they heard, adapting their speech online when their initial production didn't match the target. In the listening task, subjects simply listened to the same stimuli. Each subject heard and imitated five different stimuli, varying in their distance from the original target item on both F1 and F2 (/i/, /ɪ/, /e/, /ɛ/, /a/). Behavioral results revealed that participants adapted their speech as instructed, with more adaptation the farther from the initial speech sound. Event-related fields (ERF) time-locked to stimulus onset replicated the phenomenon of speaking-induced suppression. As predicted, regression analyses demonstrated that the more acoustically distant the stimulus, the less suppression there was in the auditory ERF. Finally, and importantly, correlations across subjects revealed that the average amount of SIS was negatively correlated with imitation performance. The results suggest that when a mismatch occurs between predicted and actual auditory feedback, these two signals do not cancel out completely, leading to a release from suppression. As this release seems to scale with the magnitude of the mismatch, the release from SIS may act as an error signal, potentially driving subsequent adaptations. This view is supported by a correlation indicating that subjects with less SIS showed better imitation performance. These subjects may have been more sensitive to deviations between their speech and the speech target, and thus could adapt more readily in response to mismatches. The present results thus serve to confirm a number of predictions stemming from recent models of speech motor control, and suggest that individual sensitivity in the release from SIS could serve as a marker for subsequent speech adaptation. References: Guenther, F. H., Ghosh, S. S., & Tourville, J. A. (2006). Brain and language, 96(3), 280-301.; Houde, J. F., & Nagarajan, S. S. (2011). Frontiers in human neuroscience, 5, 82.

A25 Covert production of speech and emotional vocalizations: further evidence for a neural dissociation between different complex articulations *Zarinah Agnew[1], Liliya Ward[1], Carolyn McGettigan[1,2], Oliver Josephs[1], Sophie Scott[1]; [1]UCL Institute of Cognitive Neuroscience, [2]Royal Holloway, University of London*

Whilst the neural basis of speech production has been the target of numerous investigations over the last few decades, the neural control of emotional vocalisations has gone relatively under studied. A number of lines of evidence suggest that the neural control of speech production and the production of emotional vocalisations may be distinct, and further, that emotional vocalizations may be more akin to vocalizations made by non-human primates than to human speech. Many emotional vocalizations, for example, are universal, i.e. recognizable across distinct cultures. Conversely, speech sounds are highly over-learnt articulations that are not common across different cultures. Given these differences, it has been suggested that emotional vocalisations may rely on evolutionarily older, or different neural systems. We have previously shown that different cortical regions are active during overt production of the two articulations and that sensory cortices show significantly different responses during the production of speech and emotional vocalisations. Here we investigate responses to covert (imagined) production of speech and emotional vocalisations. Subjects were trained to either overtly or covertly produce an emotional vocalisation or a speech sounds related to a written cue. Four emotional cues (two positive and two negatively valenced) were used: i) disgust, ii) sadness, iii) amusement and iv) relief. Functional data were acquired using a clustered sparse acquisition to deal with head motion using a dual echo protocol. Breathing was monitored throughout in order to investigate neural activity associated with changes in breathing across conditions. Finally a motor localizer run was carried out in order to identify neural structures involved in listening and articulatory movements in general. We report widespread activity in bilateral inferior frontal and parietal cortices during covert production

compared to a silent rest condition. Moreover, the comparison of covert speech production with covert emotional vocalisation production was associated with significantly greater activity in four distinct regions of the left superior temporal gyrus (STG), a single cluster in right STG and in left parietal operculum. These data demonstrate that not only does neural activity differ between overt speech and emotional vocalisation production but also that internal representations for covert production of speech and emotional vocalisations maybe to some extent distinct. These data are discussed with respect to current feedback control models of speech production.

A26 Speech evoked potentials in Parkinson's disease *Francois-Xavier Brajot[1,2], Douglas M. Shiller[2,3], Vincent L. Gracco[1,2]; [1]McGill University, [2]Centre for Research on Brain, Language and Music, [3]Université de Montréal*

Cortical auditory evoked potentials of self-produced and pre-recorded speech were compared in individuals with speech deficits due to Parkinson's disease and age-matched controls. On-line altered feedback of speech intensity was also applied to a subset of subjects' vocalizations to assess the effect of production-feedback mismatch on the evoked responses. Speech-induced suppression of the N1 evoked response was observed in both groups. Altered feedback reduced the extent of suppression among control subjects, but did not similarly affect response amplitude or latency among subjects with Parkinson's disease. The P2 evoked response, which was also characterized by speech-induced suppression in the control group, was either strongly depressed or completely absent in the Parkinson's group. Based on current theory regarding event-related potential source and function, these findings point to involvement of auditory association areas, frontal motor areas and cingulate cortex in speech sensorimotor control deficits present in early clinical Parkinson's disease. This suggests that not only sensory, but also preparatory ("feedfoward") and comparative ("error identification") functions are affected in this disorder.

A27 Energetic and informational masking effects on speech production *Sophie Meekings[1], Samuel Evans[1], Nadine Lavan[1], Sophie K Scott[1]; [1]University College London*

A long-established consequence of producing speech in a noisy environment is the Lombard effect (Lombard, 1911), in which the speaker changes various acoustic features of their voice to enhance audibility. More recently, these changes have been shown to vary depending on the type of masking noise: for example, speakers are able to make more precise alterations to the temporal qualities of their utterances in the presence of informational masking (a competing speaker) than energetic masking (Cooke & Lu, 2010). However, the neural systems underlying the production of speech in noise remain unexamined. This study aims to investigate the behavioural and neurophysiological consequences of speaking in the presence of energetic and informational maskers. Male and female participants were asked to read out sentences presented visually while being presented with different masking stimuli. Masking conditions varied on a continuum from white noise (pure energetic masking) to clear speech (pure informational masking). There were seven conditions: speech production whilst listening to clear speech of a female speaker, clear speech of a male speaker, rotated speech, amplitude modulated noise, continuous noise and a silent baseline condition; and a rest condition where no speech was produced. A behavioural study analysed changes in acoustic and phonetic characteristics such as fundamental frequency, intensity, spectral centre of gravity vowel space and vowel duration, contrasting speech in energetic and informational masking. An fMRI study will identify the neural correlates of these changes.

Orthographic Processing, Writing, Spelling

A28 Are specialized brain areas necessary for perceptual expertise? Insights from a fast letter recognition fMRI experiment. *Marcin Szwed[1,2,3], Evelyn Eger[4], Marianna Boros[1], Justyna Różycka[1], Myriam Chanceaux[2,3], Daisy Bertrand[3], Stephane Dufau[2,3], Laurent Cohen[5,6,7,8], Stanislas Dehaene[4,9], Johannes Ziegler[2,3], Jonathan Grainger[2,3]; [1]Department of Psychology, Jagiellonian University, Krakow, Poland, [2]Laboratoire de Psychologie Cognitive, CNRS, Marseille, France, [3]Aix-Marseille University, France, [4]INSERM-CEA Cognitive Neuroimaging Unit, Gif sur Yvette, France, [5]INSERM, ICM Research Center, UMRS 975, Paris, France, [6]Université Pierre-et-Marie-Curie, Faculté de Médecine Pitié-Salpêtrière, IFR 70, Paris, France, [7]AP-HP, Hôpital de la Salpêtrière, Department of Neurology, Paris, France, [8]CENIR, ICM Research Center, UMRS 975, Paris, France, [9]College de France, Paris, France*

Perceptual systems can achieve remarkable expertise. Fluent reading is a prime example of such expertise. Different approaches yield conflicting evidence on whether reading expertise requires specialized brain areas. On the one hand, reading is shown to rely on an extensive processing hierarchy extending from the Visual Word Form Area downwards into earlier visual areas (e.g. Binder et al., 2006; Vinckier et al., 2007). Some results even suggest that reading might rely on specialized processing in low-level visual cortex (Szwed et al., 2011). On the other hand, it is possible to read words made from motion cues that "bypass" the supposedly specialized ventral stream hierarchy (Rauscheker et al., 2012) and it has been suggested that the key to fluent reading might lie in efficient recruitment of language areas for meaning and phonology (Goswami & Ziegler, 2006; Price and Devlin, 2011) rather than in visual area specialization. fMRI paradigms where the subject sometimes succeeds and sometimes fails to recognize a target are a useful tool to study the mechanisms of perception. In such

paradigms, stronger activations for recognized trials than for non-recognized trials in a given brain region are taken as evidence that this region is involved in the perception of that particular target. Here we applied this method by contrasting the detection of letters – which our subjects saw previously hundreds of millions of times, with the detection of novel false-fonts. fMRI images were acquired at 3T at 2x2x2.5mm resolution. 20 subjects saw 5-character strings of either letters or false-fonts presented for brief (17-200 ms) periods and had to perform a 4-alternative forced-choice task on the central character. The duration of the trials was adjusted by an on-line algorithm to yield 50% correct and 50% incorrect responses. To allow both performance-matched and duration-matched comparisons between letters and false-font trials, we also included "yoked" letter trials with duration identical to false-font trials. We found that in the left-hemisphere ventral occipitotemporal region (Visual Word Form Area) activations for correct letter vs. incorrect letter trials overlapped with activations for correct false font vs. incorrect false font trials. Activation differences between letter detection and false font detection were found between the letter detection and false font detection activations were found in other parts of the visual system. Letter detection activations (correct-vs.-incorrect) extended from the ventral occipitotemporal region to low-level retinotopic visual areas (MNI: y=-96 z=-6). In contrast the network activated preferentially by false font detection was symmetrically bilateral, and included only high-level ventral occipitotemporal regions (no significant voxels posterior to y=-75). Also, correct letter detection, but not correct false-font detection activated the left-hemisphere Superior Temporal Gyrus. Our results provide evidence that efficient recognition of letters – a task practiced daily by readers – specifically recruits 1) early retinotopic areas for fast and parallel recognition and 2) superior temporal areas for efficient mediation between written signs and their phonology. Results thus suggest that perceptual expertise in reading involves both specialization of the visual system and increased long-distance connectivity between visual areas and the general language network.

A29 The hemispheric differences on the optimal viewing position asymmetry *Wen-Hsuan Chan[1], Thomas P. Urbach[1], Marta Kutas[1,2]; [1]University of California, Cognitive Science, San Diego, [2]University of California, Neurosciences, San Diego*

Visual word recognition performance strongly depends on the position in the word at which the eye fixates -- it is faster and more accurate when fixating a position left-of-center position within a word (the optimal viewing position, OVP). Some researchers have attributed the OVP asymmetry to the language dominance of the left hemisphere. OVP asymmetry, however, this explanation assumes that the asymmetry is language specific and not a more general property of early visual processing. Other researchers have attributed the leftward asymmetry of the OVP to a perceptual asymmetry in the left and right visual fields (VFs). Nazir et al (1991) proposed the multiplied letter identification probability (MLIP) model in which word recognition probability is calculated by multiplying individual letter visibility. Given that letter visibility drop-off is steeper in the left than right VF, the MLIP model accounts for the leftward OVP asymmetry, without any assumptions about lexical influences, although it does underestimate overall human word recognition performance. This MLIP model, however, was built on data from a simplified design -- the whole string was either in the left or right VFs, and unlike the traditional OVP paradigm, the fixation did not appear at every possible position in the string. The present study designed to investigate the visual processing asymmetry of stimuli along the horizontal meridian, we obtain measures of letter visibility across all combinations of fixation position and letter-in-string position for non-wordlike letter strings, symbolic strings, and ring (with different orientations of gap) sequences. In each case, participants were asked to detect a target letter/symbol/ring embedded in a non-wordlike letter/symbol/ring string spanning fixation across the VFs. By so doing, we could test the effects not only of the drop-off of letter visibility in the two VFs, but also crowding effect resulting from the interaction between a character's distance from fixation and the number of characters in same visual field as the target, as well as crowding effects modulated by the VFs, to explore possible extensions of the MLIP model. Regression analyses revealed (1) both the letter visibility effect and crowding effect were observed for all stimulus types, (2) recognition probability was significantly worse in the left VF due to the stronger crowding effect for both letter and symbolic strings, although the asymmetry was greater for the letter strings, and (3) for ring sequences, both VFs showed significant crowding effects, resulting in overall symmetric patterns across letter positions in the left and right VFs. These asymmetric patterns observed for the wordlike stimuli (letters and symbols) seem to reflect hemispheric differences that are not specific to words. It seems then that hemispheric differences in the processing of symbolic characters could contribute to the OVP asymmetry.

A30 Diffusion properties of the cerebellar peduncles are associated with reading skills in pre-term and full-term children *Katherine Travis[1], Yael Leitner[2], Michal Ben-Shachar[3], Heidi Feldman[1]; [1]Stanford School of Medicine, [2]Tel Aviv Sourasky Medical Center and Sackler School of Medicine, [3]Bar-Ilan University*

Introduction: Diffuse injuries in cerebral and cerebellar white matter are known complications of premature birth, but the cognitive outcomes of cerebellar white matter injury following prematurity are unknown. Diffusion Tensor Imaging (DTI) is a sensitive method for detecting variations in the microstructural properties of white matter pathways. Using DTI and tractography, we examined the relation between reading measures and fractional

anisotropy (FA) of the cerebellar peduncles in a sample of 9-16 year-old preterm (PT) and full term (FT) children. Methods: We obtained 30-direction DTI (3T, 2x2x2mm voxel resolution) and T1-weighted data in 19 FT and 27 PT children ages 9-16y. Cerebellar peduncles were identified individually using deterministic tractography and manually placed regions of interest (ROIs). Two waypoint ROIs were used to capture each of the major cerebellar tracts: bilateral inferior cerebellar peduncles (ICP), middle cerebellar peduncle (MCP) and bilateral superior cerebellar peduncles (SCP). We calculated FA profiles along the trajectory of each peduncle, and examined the correlation between diffusivity measures along the tracts and two measures of reading performance: decoding and passage comprehension. Results: Within segments of the MCP, FA positively correlated with decoding skills in the combined FT and PT group (r=0.5, p=0.0004), and in PT children (r=0.63, p=0.0005). Passage comprehension skills also positively correlated with FA in the MCP of both FT (r=0.62, p=0.006) and PT children (r=0.59, p=0.002). In left SCP, FA negatively correlated with decoding in both FT (r= -0.61, p=0.005) and PT children (r= -0.43, p=0.02). In right SCP, FA negatively correlated with passage comprehension in FT (r = -0.63, p=0.004) but did not reach significance in PT children. Conclusions: These findings show that reading performance is associated with micro-structural properties of cerebellar white matter tracts in PT and FT children. Specifically, enhanced connectivity between the cerebellar hemispheres contributes positively to reading performance, but enhanced connectivity from the cerebellum to the cortex through the SCP contributes negatively to reading. These findings represent the first evidence implicating the cerebellar peduncles in reading in both PT and FT children.

A31 Using Artificial Orthographies to Study the Neural Correlates and Fusiform Laterality of Writing Systems With Different Grain Sizes *Elizabeth Hirshorn[1], Alaina Wrencher[1], Rob Schwartz[1], Corrine Durisko[1], Michelle Moore[1,2], Julie Fiez[1,3,4,5]; [1]Learning Research & Development Center, University of Pittsburgh, [2]West Virginia University, [3]Department of Psychology, University of Pittsburgh, [4]Department of Neuroscience, University of Pittsburgh, [5]Center for the Neural Basis of Cognition*

Writing systems vary in many ways, making it difficult to understand any observed differences in their neural networks used for reading. For example, Chinese characters have been shown to engage mid-fusiform gyri bilaterally, but English words engage left-lateralized mid-fusiform (corresponding to the VWFA). Since the two scripts vary in both visual processing (holistic vs. analytical) and linguistic mapping grain size (morphosyllabic vs. alphabetic), either factor could account for the observed difference in fusiform laterality. Teasing apart these factors could inform ongoing debate about the role of the VWFA in skilled reading. This study uses artificial orthographies to investigate whether the mapping principle of a writing system affects the lateralization of orthographic processing within the mid-fusiform gyri. Two groups were either taught an alphabetic ("Facefont") or alphasyllabic ("Faceabary") artificial orthography that represents English. Both orthographies use faces as graphemes. Facefont consists of 35 faces-graphs mapped onto phonemes. Faceabary consists of 375 face-graphs such that the face identity represents the consonant part of each syllable and the emotion represents the vowel. Because faces tend to be processed more holistically and tend to be right-lateralized, if the holistic/visual dimension leads to right fusiform engagement (e.g., like in Chinese), we would hypothesize similar levels of right fusiform activation for both artificial orthographies. However, if the mapping principle affects fusiform laterality, we would hypothesize only Faceabary to engage the right fusiform. Equivalent learning, as measured by reading fluency of simple stories, was observed in both groups after a 2-3 week training session. fMRI data from the two groups were compared after training. Several results support the hypothesis that the alphasyllabic mapping principle of Faceabary leads to greater right fusiform engagement. 1) The right fusiform (39, -59, -4; sub-peak: 42, -50, -15), which approximately corresponds to the right homologue of the VWFA, was the only region to show a group X stimulus interaction, such that the Faceabary group had relatively greater activation for face-words compared to patterns. 2) The Faceabary training effect (increase in post- vs. pre-scan) in this region strongly correlated with reading fluency. 3) A laterality index showed a significantly more bilateral fusiform pattern in Faceabary subjects compared to Facefont. The right fusiform is also within the range of the typical Fusiform Face Area, which is known to have increased activation for emotional faces compared to neutral faces, which complicates the interpretation of the greater right fusiform activation for Faceabary. However, no group differences were observed in the 'emotion-sensitive' amygdala, and the amygdala was actually shown to down-regulate for the emotional faces in a post- vs. pre-scan comparison in Faceabary, presumably due to the fact that subjects were learning to associate the facial emotions with non-emotional content (vowel sounds). These novel results suggest that a syllable-based mapping principle of an orthography could be responsible for engaging a greater right hemisphere reading network. They also highlight the utility of using artificial orthographies to study differences in writing systems.

Signed Language

A32 Biological attraction for natural language input in the visual modality *So-One Hwang[1], Stephanie Aguirre[1], Rain Bosworth[1]; [1]UC San Diego*

Humans demonstrate the ability to acquire any natural language, spoken or signed. With spoken languages, hearing infants are immediately drawn to conspecific sounds in the speech frequency range with temporal rhythms such as syllable-sized amplitude-modulated envelopes (Ramus et al., 2000; Rosen, 1992). Here, we ask

what are the features that contribute to the recognition of visual-manual input as natural language (Krentz & Corina, 2008). In Experiment 1, 14 hearing adults without signing experience were asked to view real ASL signs, signs that were produced backwards by a signer and violate phonological rules of ASL, and signs that were recorded naturally but played in reverse. Reversals maintain spatial features of the original actions, such as signing space and handshapes, but alter their natural temporal characteristics. Participants were asked to guess whether or not a video showed a real sign. We found that although participants were only at chance at accepting signed-forward signs as being part of ASL and at rejecting signed-backwards stimuli, they were able to accurately reject, at above chance, played-reversed signs as being part of ASL. No one reported recognizing the video manipulation when asked during an exit interview. The findings suggest that adults without signing experience are sensitive to biological naturalness of body motion in visual language processing but not to phonological parameters. In Experiment 2, we used the Tobii eyetracker to investigate whether hearing non-sign-exposed infants show a change in sensitivity to visual language processing between the ages of 5-6 and 10-12 months of age. They were shown a sequence of blocks containing signs or gestures. Using eye-tracking data, we calculated percent looking time to areas of interest (AOIs) corresponding to the articulation space of the signer. We found that 5-6 mo olds (n=12) look significantly longer at signs than gestures, but that preferences shift with 10-12 mo olds (n=10). Furthermore, 5-6 mo olds look significantly more at the signing space below the face for signs (i.e., the area with highest concentrations of hand locations, the source of linguistic input), showing no distinction in AOI for gestures, but that 10-12 mo olds look more at the face for gestures, showing no distinction in AOI for signs. We further investigated the features that contribute to the recognition of visual language by comparing the infants' responses to forward and reversed signs. In pilot results, 10-12 mo olds showed no difference in eye-gaze behavior with these conditions, but 5-6 mo olds showed a marginally significant difference (p=.08). With further testing, continued differentiation of video direction by the younger group would indicate an innate sensitivity to temporal dynamics of signs, in addition to phonological complexity that distinguish signs from gestures. Future work will analyze which structural properties of the sign signal drive visual language processing in sign-exposed and non-signed-exposed children and adults. Taken with correlates from the acquisition of spoken languages, this knowledge will contribute to a better understanding of modality-free features of language, having implications for the neurobiological foundations of language acquisition and maturational changes.

A33 The relation between perception and action: Evidence from sign language *Kayoko Okada[1], Corianne Rogalsky[1], Lucinda O'Grady[2], Leila Hanaumi[2], Ursula Bellugi[2], David Corina[3], Gregory Hickok[1]; [1]University of California, Irvine, [2]The Salk Institute for Biological Studies, [3]University of California, Davis*

Fueled by the discovery of mirror neurons and by the recent embodied cognition movement, the distinction between perception and action has been blurred in recent years, as has the distinction between action concepts and related motor codes. Here we investigate this issue from a unique perspective, that of sign language. In a sample of 15 native, deaf signers, we used fMRI to map the relation between observing/comprehending signs and executing signs that were either names of objects or names of actions. In a factorial block design experiment, participants were presented with non-linguistic, object-oriented video clips (e.g., swinging a bat) and they were instructed to: name the action, name the object, match the action or match the object. During the execution task, participants overtly named (signed) either the action or the object. During the observation task, participants observed the same video clips, which was followed by a video clip of a sign and participants indicated whether there was a mismatch between the sign and the video. We report three key observations. (1) The main effect of sign task yielded large clusters of execute>observe activation in Broca's area, insula, primary motor cortex, PPC, cerebellum, basal ganglia, among other regions; visual and posterior STS regions showed the reverse effect (observe>execute). (2) The main effect of sign type failed to identify motor-related voxels more active for the action-related signs. (3) A conjunction analysis showed that there was a region of overlap between executing and observing signs in the pars opercularis region of Broca's area (and posterior regions). We conclude the following, respectively. (i) Although perhaps an obvious point, there are major differences in the functional anatomy of action execution and action observation. (ii) There are no obvious differences in the functional organization of access to action- versus object-related signs in naming or observation/comprehension, at least as revealed by our paradigm. (iii) The region thought to contain mirror neurons and to support both action execution and observation for speech and manual gesture, the pars opercularis, is indeed active both during sign execution and observation. This appears to provide rather dramatic support for sensorimotor mirror neuron claims, bridging the gap between manual gesture and language systems, to which mirror neuron function has been generalized. However, while few doubt that this system is important for executing actions and that it has sensorimotor properties, there are serious empirical challenges regarding the role of the pars opercularis in action understanding. Lesion work with deaf signers has shown that damage to Broca's area, while disruptive to sign production, is not associated with sign language comprehension deficits. Thus, while the present research as well as past studies have confirmed the mirror neuron claim that the pars opercularis is an important hub for

sensorimotor integration, its primary role appears to be in the service of motor planning rather than action understanding.

A34 Shared Cortical Representation of the Hands and Face in a Deaf Signer: Evidence form Cortical Stimulation Mapping *David Corina[1], Shane Blau[1], Todd LaMarr[1], Diane Allshouse[1], Matt Leonard[2], Edward Chang[2]; [1]University of California, Davis, [2]University of California, San Francisco*

Functional imaging studies of deaf users of signed languages have shown evidence of activation in the left inferior frontal gyrus area during sign language comprehension and production (Campbell et al 2007). Lesions to Broca's area lead to agrammatic sign language impairment (Poizner et al 1987). These data indicate a re-mapping of a classically defined speech-motor area to accommodate a manually expressed language (Corina et al 1999). However whether such re-mappings occur in regions outside of Broca's area is largely unknown. We present a rare case study of a profoundly deaf life-long user of American Sign Language (ASL) who underwent cortical stimulation mapping as part of a surgical planning procedure for tumor resection. In this presentation we focus on an unusual constellation of effects following motor and somatosensory stimulation, and during an automatized naming task, numeral counting in ASL. During motor and somatosensory mapping, global patterns of disruption were generally consistent with Penfield's(1959) classic homunculus organization of the central sulcus, specifically inferior areas of the precentral gyrus and inferior postcentral gyrus correlated with movement and sensation in the face (i.e. jaw and tongue) respectively, with hand sensation reported following stimulation to more dorsal locations. However this separation was far from discrete, for example we observed that stimulation to a specific site along the dorsal extent of the central sulcus gave rise to face movement and hand sensation. In addition, repeated stimulation to the ventral precentral gyrus resulted in jaw movement, but also resulted in consistent cessation of automatized counting in ASL which requires sequential articulation of discrete handshapes. In addition and consistent with earlier case studies, stimulation proximal to Broca's area resulted in signing arrest. Throughout testing, the deaf subject never attempted nor was requested to speak his responses and all testing was conducted in ASL, his preferred mode of communication. Our study provides compelling evidence for a re-mapping of left-hemisphere motor and sensory cortex in a deaf signer resulting in shared representations of face and hand function used in the service of language. These data suggest that functional organization of motor and somatosensory cortex may not be as discrete in deaf signers for whom both oral and manual articulation may factor heavily in language development. Our study provides compelling evidence that sign language disruption may be observed with stimulation to cortical regions specialized for facial and oral behaviors. The data are compatible with a view that classic motor and somatosensory areas may support overlapping functional fields that allow for the fluid integration of language-related activity (Takai et al. 2010).

A35 The neural circuits recruited for the production of fingerspelling and signing *Karen Emmorey[1], Sonya Mehta[2], Stephen McCullough[1], Thomas Grabowski[2]; [1]San Diego State University, [2]University of Washington*

Fingerspelling is a complex motoric task in which a sequence of handshapes is rapidly produced to spell out a word, with each handshape representing a distinct alphabetic letter. Lexical signs in American Sign Language (ASL) contain at most two distinct handshapes and can be produced with contact on the body, unlike fingerspelled words which are always produced in "neutral space" in front of the body. To investigate the neural circuits recruited for these distinct types of linguistic articulations, we conducted an H2 15O-PET study. Eleven deaf native ASL signers viewed printed English words and performed the following tasks: (a) fingerspelled the word, (b) produced ASL (one-handed) sign translations that were either in neutral space or came in contact with the body ("body anchored" signs), and (c) indicated whether the word contained a descending letter, using the fingerspelled loan signs #YES and #NO (baseline task). The frequency of the English words was matched across conditions. In contrast to the baseline and sign production tasks, fingerspelling yielded greater cerebellar activation, which may reflect the increased number of complex hand configurations required for fingerspelling and/or the execution of less rehearsed motor sequences (handshape sequences are predictable for signs). The production of ASL signs engaged left inferior frontal cortex and middle temporal cortex to a greater extent than fingerspelling or the baseline task, which may reflect the lexical search and selection components of the translation task. Differential activation for signs produced in neutral space and fingerspelled words was not observed in the superior parietal lobule (SPL), suggesting that parietal activation may be primarily associated with signs that move toward the body. Supporting this hypothesis, the one-handed "body anchored" signs engaged SPL to a greater extent than both fingerspelled words and neutral space signs. Overall, the results refine our understanding of the role of superior parietal cortex in sign language production and highlight the critical role of the cerebellum in the complex finger movements required for fingerspelling.

A36 The role of left superior parietal lobule in sign language production: A TMS study with British Sign Language *David Vinson[1], Neil Fox[1], Karen Emmorey[2], Joseph Devlin[1], Daniel Roberts[1], Gabriella Vigliocco[1]; [1]University College London, [2]San Diego State University*

Research comparing signed and spoken language production has revealed that despite fundamental differences between visual-manual and acoustic-oral modalities, similar left-hemisphere language networks are engaged for both. For example, Emmorey et al. (2007) found that producing American Sign Language and spoken English both activate left inferior frontal gyrus and left inferior temporal gyrus. A yet-unexplained difference between signing and speaking is observed in left superior parietal lobule (SPL), where neuroimaging studies repeatedly show activations for sign, but not speech, production (e.g. Braun et al., 2001). Many functions have been attributed to SPL including visual feature-binding (e.g., Baumgartner et al, 1995), visual attention (e.g., Pardo et al., 1991), visually-guided reaching (Rizzolatti et al., 1997) and motor programming of reaches toward a moving target (Striemer et al., 2011). In sign language production Emmorey et al. (2007) has speculated that SPL activation comes from self-monitoring: signers use proprioceptive rather than visual feedback to monitor themselves, while non-signers need not monitor their hand position while speaking. Here we employed transcranial magnetic stimulation (TMS) during British Sign Language picture naming to test the role of left SPL: what aspects of sign production, if any, are affected by TMS? Fourteen fluent BSL signers participated first in a fMRI study, in which they covertly named 40 pictures in BSL. Analysis of covert naming > rest identified activation peaks in left SPL for each individual (mean coordinates: -21, -67, 58) that we then targeted with TMS using frameless stereotaxy to place the TMS coil. Vertex was used as a secondary stimulation site to control for general effects of TMS, and presence/absence of TMS randomly varied between trials. After an initial picture naming phase without TMS the experiment began (208 trials). Participants pressed and held a key to display the picture that remained on screen until they lifted their hand to produce the sign. On TMS trials, four pulses occurred: at picture onset and 100, 200, 300ms post-onset. Video-recordings were coded for different types of errors/dysfluencies (coded blind to the presence/absence of TMS). Analysis revealed highly constrained effects of TMS to left SPL: errors involving selection of phonological features such as incorrect handshape/orientation increased from a base rate of 3% to 9% when TMS was applied to left SPL (significant interaction in 2×2 ANOVA), but only for two-handed signs involving hand-to-hand contact. No effects of TMS were observed for one-handed signs, or two-handed signs without hand contact. Moreover, TMS did not affect other types of errors such as lexical/semantic substitutions, delayed production or other dysfluencies. These findings suggest that activation of left SPL during signed, but not spoken, production is related to the selection of phonological features and motor programming of manual production. Disrupting this area with TMS has specific deleterious effects on retrieval of those phonological features that are already most prone to slip in spontaneous errors, particularly handshape and orientation, when the hands must make contact. It remains to be seen whether this is explicit motor programming, or simulated motor programming for the purpose of self-monitoring.

Language Development, Plasticity, Multilingualism

A37 Neural Correlates Associated with the Perceptual Learning of Synthetic Speech

Shannon Heald[1], Joseph Winer[1], Edward Wagner[1], Brendan Colson[1], Howard Nusbaum[1]; [1]The University of Chicago

Adult listeners quickly adapt to the perceptual challenge of low-intelligibility synthetic speech, which contains degraded and sometimes misleading acoustic information. In order for listeners to adapt, they must change the way acoustic cues define their pre-existing phonological categories. Behavioral research has demonstrated that this perceptual plasticity depends on an individual's ability to adaptively shift attention to the acoustic cues that are more phonetically diagnostic (Francis, 2002; Nusbaum and Lee, 1992; Nygaard, Somers, and Pisoni, 1994). Research on changes in neural activity during speech learning has focused on the brain regions that relate to improved intelligibility of a hard-to-understand speech signal (e.g., Eisner et al, 2010). However studies examining generalization of learning tend to use a uniform acoustic transform (simulating cochlear implant transformation) in which listeners may be learning to recognize speech with this particular distortion. Here we used synthetic speech generated by rule for which no uniform treatment can render the stimuli intelligible. Listeners must learn the acoustic-phonetic properties of the segmental structure of this speech, some of which are similar to natural speech and some differ. Previous research (e.g.. Schwab et al., 1983) has shown that perceptual learning with these stimuli results in generalization for phonological categories to map onto different acoustic patterns. Participants were given a pretest, trained and then immediately retested on their recognition of isolated synthesized words that had not been previously heard. We measured event related potentials on the scalp during both the pretest and then the posttest following training. Behaviorally, listeners showed marked improvement from pretest to posttest. These improvements were accompanied by significant changes in the ERP for spoken words. In particular, changes were observed in the N1-P2 complex, known to reflect changes in attention allocation and focus that coincide with improved speech perception (Tremblay, Kraus, McGee, Ponton, and Otis, 2001; Alain, Snyder, He and Reinke, 2007). Given that the ability to shift one's attention to more informative cues is a key feature of a number of theories of categorization that are not at all specific to speech perception (Nosofsky, 1986; Goldstone & Kersten, 2003), plasticity and learning of speech may reflect the same types of neural plasticity found for learning in other modalities (e.g. Black, Byl & Merzenich, 2002; Schoups, 2002). The demonstration of changes in the N1/P2 complex reflect fast neural responses

to spoken stimuli that have not been heard during training. Moreover, the pattern of change suggests that this reflects a trial by trial shift in attention to stimuli rather than a tonic shift in attention to the speech following training. These results constrain interpretations of the kinds of neural mechanisms that can account for generalized perceptual learning of speech.

A38 Age of L2 Onset Modulates Left MTG Specialization for L1 Lexical Tones *Benjamin Zinszer[1], Thomas Holt[1], Han Wu[2], Hua Shu[2], Ping Li[1]; [1]Pennsylvania State University, [2]Beijing Normal University*

Recent neuroimaging studies have revealed distinct functional roles of left and right temporal lobe structures in the processing of lexical tones in Chinese. In an evoked response potential paradigm, Xi et al (2010) elicited a greater mis-match negativity (MMN) to acoustically varying sets of intonated Chinese syllables when tone variants represented linguistically salient contrasts. Zhang et al (2011) further localized processing of Chinese lexical tones to the left middle temporal gyrus (lMTG) for linguistic processing and the right superior temporal gyrus (rSTG) for acoustic processing of tonal contrasts for native Chinese speakers. In the present study, we ask whether knowledge of a second language (English) modulates this pattern of activation in the perception of tonal contrasts. Twenty-five native Chinese speakers were recruited from undergraduate and graduate students at Beijing Normal University, China. Participants watched a silent film and listened to blocks of computationally manipulated /ba/ syllables which were varied to form within- and between-category deviants at equal acoustic intervals from a standard tone. Oxygenated hemoglobin levels in participants' temporal cortices were measured by functional near-infrared spectroscopy (fNIRS). Three block conditions were presented: standard falling tones, standard falling tones randomly ordered with deviant falling tones (Within Category), and standard falling tones randomly ordered with rising tones (Across Category). Deviant blocks were alternated 10 times each with standard blocks and rest periods of equal duration. Blocks were analyzed for peak oxygenated hemoglobin levels, and a mixed-effects model was fit to these data, including effects of Category (Standard, Within, or Across), age of earliest exposure to English (spoken), and proficiency in English. Functional changes in oxygenated hemoglobin levels indicated a significantly greater response to Within Category contrasts in right STG, consistent with previous findings. However, the effect of Category in left MTG was significantly modulated by the age of participants' earliest English exposure: Across Category activation exceeded Within Category activation only for participants exposed to English after 13 years of age. While previous research has established the importance of left MTG in the categorical perception of lexical tones, our findings suggest that the functional specialization of this region is sensitive to second language experience, even in the processing of native language.

A39 The effects of perceptual distortion, age and proficiency on the functional neural activation for sentence processing *Saloni Krishnan[1], Robert Leech[2], Evelyne Mercure[3], Sarah Lloyd-Fox[1], Frederic Dick[1]; [1]Birkbeck, University of London, [2]Imperial College London, [3]University College London*

In the school years, children become proficient language users. They acquire a larger vocabulary, and start to comprehend and use more complex syntactic constructions. During the same developmental period, perceptual, attentional and cognitive abilities are changing. These changes influence children's language comprehension ability. A gradual refinement of syntactic comprehension occurs in tandem with refinements of perceptual and attentional ability. In adverse listening conditions, this trajectory for sentence processing is extended even further (Leech et al., 2007). The functional neural bases of these protracted behavioural changes in language comprehension are not well understood. In adults, syntactic comprehension is associated with activation in a well defined set of regions. Nonetheless, this activation can vary with relation to sentence complexity & task demands. Only a handful of studies focus on developmental differences in syntactic comprehension (Yeatman et al., 2010; Nunez et al., 2011). These studies focus on neural effects related to syntactic complexity alone. However, despite children's everyday exposure to noisy & distracting environments (such as classrooms/ playgrounds), the effects of perceptual/attentional factors on neural activation for language remain largely unexplored. We compared school-age children (7-13 year olds, N = 38) and adults (N = 18) to characterise developmental differences in the neural activation for sentence comprehension. In our fMRI task, participants had to identify the agent of a sentence. Sentence complexity as well as perceptual/attentional demands were modulated. Complexity was modulated by using simple (active/ subject clefts) & more complex sentences (passives/ object clefts). Perceptual/attentional demands were increased by introducing speech compression plus low-pass filters (Dick et al., 2001). To identify potential interactions, we explored the relationships between neural activation, age, & performance on a range of auditory-motor behavioural tasks. All conditions elicited activation in the superior temporal and inferior frontal regions in both groups. Perceptual distortion was associated with decreased activation in the superior temporal regions. Although overall patterns of activation were similar, group differences were observed when comparing children/ adults. These indicate that the functional organisation of language comprehension in schoolchildren is still undergoing significant change. We also discuss the

complex interplay between individual differences in auditory/ syntactic proficiency on children's neural activation for sentence processing.

A40 Cognate effects on first language word listening in bilinguals *Ana Sanjuan[1,2], Elisenda Bueichekú[1], María-Ángeles Palomar-García[1], Noelia Ventura-Campos[1], César Ávila[1], Albert Costa[3]; [1]Grupo de Neuropsicología y Neuroimagen Funcional, Departamento de Psicología Básica, Clínica y Psicobiología, Universitat Jaume I, Castellon, Spain, [2]Language Group, Wellcome Trust Centre for Neuroimaging, University College of London, UK, [3]Departamento de Psicología Básica, Universitat de Barcelona, Spain*

Introduction. Language studies about bilingualism have demonstrated that both languages spoken by a bilingual become active when they are exposed to their first language (L1) or second language (Costa et al. 1999; Kroll et al. 2008; Thierry and Wu, 2007). It has been shown that the cognateness status of words modulates the language processes in bilinguals. For example, cognate words are recognized and named faster than non-cognate words (Costa et al. 2000, 2005; Van Assche et al. 2009). The present fMRI study aimed to explore the neural differences of cognate and non-cognate word processing during a L1 passive listening task in a group of early, high-proficient Spanish–Catalan bilinguals compared to Spanish monolinguals. Methods. Thirty-seven healthy undergraduates from Universitat Jaume I were recruited, 17 monolinguals (mean age = 19.11±1.78) and 18 bilinguals (mean age = 20.42±1.46). Bilingual participants had learnt Catalan in early life years and had been continuously using it, they used equally Spanish and Catalan, but felt more comfortable using Spanish, thus Spanish was defined as their L1. The passive listening task was performed inside a MRI scanner through compatible headphones. A total of 64 words was presented and they were balanced in cognate status, word length and word frequency. No motor or verbal response was required. A 1.5T scanner was used to acquire a high-resolution structural T1-weighted MPRAGE sequence (TR/TE = 2200/3.8 ms, matrix = 256 x 256 x 160, voxel size = 1 x 1 x 1 mm) and a gradient-echo T2*-weighted echo-planar MR sequence for fMRI (TR/TE = 3000/55 ms, matrix = 64x64, voxel size = 3.5x3.5x3.8 mm). Functional MRI data were processed by means of SPM8 software. Standard preprocessing was performed. Subsequently, the General Linear Model (Friston et al. 1995) was applied for statistical analyses. Results. Neural results revealed that: 1) passive listening of words was neurally related to bilateral activity of the superior temporal cortex in both groups as expected; 2) there were no brain activation differences between bilinguals and monolinguals during the passive listening task; 3) bilinguals hypoactivated the left transverse gyrus when compared with monolinguals while processing cognate words; and 4) bilinguals hyperactivated the right posterior superior temporal gyrus (pSTG) when compared to monolinguals during processing of non-cognate words. Conclusion. Previous studies have related the left transverse gyrus to the processing of phonological information (Jacquemot et al. 2003) and have shown increased volumes in left primary auditory cortex of bilinguals compared to monolinguals (Ressel et al. 2012), consistent with the idea that auditory processing of cognate words is facilitated in bilinguals. Our fMRI results provide support for this idea due to the bilinguals' lesser recruitment of the left transverse temporal gyrus. In addition, the bilinguals' infrequent use of non-cognate words lead to a greater reliance on the right pSTG, a structure related to the process of low word knowledge (Nagels et al. 2012; Sugiura 2011).

A42 Dissociating perceptual processes and language decisions in the bilingual brain – L1 but not L2 recognition affects early processing stages *Yulia Oganian[1,2], Markus Conrad[1], Katharina Spalek[3], Hauke R. Heekeren[1,2]; [1]Freie Universität Berlin, [2]Bernstein Center for Computational Neuroscience, Berlin, [3]Humboldt Universität zu Berlin*

Successful recognition of words from different languages is the basis of bilingual communication. A central aspect of this process is the recognition of the language of ambiguous input. However the neural underpinnings of this ability have received little attention, as previous research concentrated on aspects that are common to processing both languages. Several neuroimaging studies have come to the conclusion that highly proficient bilinguals activate the same neural substrates for both languages (Klein et al., 2006). Behavioral evidence suggests that lexical access in bilinguals is at least partially nonselective, activating possible candidates from both languages (Dijkstra & Van Heuven, 2002). Language-selectivity of sublexical representations has received less attention but orthographic units are even more similar across same-script languages, making non-selectivity a plausible hypothesis. If both languages are activated non-selectively and the neural substrates are shared between them, how then is the language membership of a word recognized and at what level is it represented? The present study investigates the representation of language-typicality at sublexical and lexical levels. We quantified the typicality of meaningless letter-strings (pseudo-words, PW, e.g. "forl") with respect to German and English and created PW with varying similarity to the two languages on the lexical (operationalized through OLD20, a measure of orthographic neighborhood size) and sublexical (bigram frequency) levels. Based on these variables, we defined language-typicality of a pseudo-word at the bigram level as its bigram frequency difference in German and English (diffBG), and at the lexical level as the difference in German and English OLD20 (diffOLD). Additionally, language-comprehensive lexical neighborhoods and bigram frequencies based on a unified lexicon including both languages was computed for all pseudo-words. Highly proficient bilinguals (n=19, mean age=25.5) categorized these PW as German-like or English-like in an event-related fMRI-experiment (Siemens TRIO 3T

scanner, EPI, TR = 2 sec, TE = 30 ms, 3x3x3mm, 0.3 mm gap). Language-comprehensive lexical and sublexical variables correlated with activity in a left-lateralized language-processing network (left inferior occipital cortex and left inferior frontal gyrus for sublexical and left parietal lobe for lexical variables; Price, 2012). Lexical language typicality (diffOLD) correlated with activation in the left occipital lobe as well as medial prefrontal cortex (mPFC). These results suggest that although the language network of bilinguals is primarily organized based on language-comprehensive variables, it also contains information about the language differences at the earliest levels of orthographic processing. Activation in anterior cingulate, mPFC, and dorso-lateral prefrontal cortex was driven more by diffOLD than by language-comprehensive lexical neighborhoods, suggesting a central role of these regions in the language decision process. We further asked whether different responses involved different structures. Contrasts between trials with German and English categorizations showed stronger involvement of the right occipital lobe for German than for English responses, but mPFC was more active for English than for German responses. This result shows that L1 and L2 categorization might imply different mechanisms. Namely, recognition of both languages seems to require involvement of high-level decision processes, whereas L1 recognition additionally affects low-level processing in the occipital lobe, possibly through feed-back loops.

A43 An advantage in switching for some bilinguals over others, but not over monolinguals *Maya Ravid[1], Aurora I. Ramos Nuñez[1], Arturo E. Hernandez[1]; [1]University of Houston*

The bilingual advantage, the finding that bilinguals outperform monolinguals in nonverbal domains, is well documented. However, new research suggests that there are considerable differences in performance within the bilingual population (Festman et al. 2010; Prior and Gollan 2011). The current study sought to examine differences within a bilingual population and then perform a comparison of bilinguals and monolinguals with attention to these inter-population differences. Adult Spanish-English bilinguals (n=101) and English monolinguals (n=53) completed a nonverbal rule-switching task, and the bilinguals performed an additional picture naming task. In the rule-switching task, participants were required to respond as quickly as possible to either the color or shape of stimuli that were presented on a computer screen. The rule for response changed following a number of stimuli by the presentation of a nonverbal cue. In the picture naming task, bilinguals were required to quickly name a series of pictures, alternating between naming in English and Spanish. Errors of interference (EI), in which the participant named a picture using the wrong language, were averaged across 4 runs each consisting of 40 pictures. The bilinguals were divided into two groups based on the number of EI, yielding 52 "switcher" bilinguals with high EI (3.25 or more) and 49 "non-switcher" bilinguals with low EI (3 or less). Following the division, the three groups' (switchers, non-switchers, and monolinguals) performance in the rule-switching task was compared. ANOVAs were used to test reaction time (RT) and accuracy differences between the groups. In terms of accuracy, the non-switcher bilinguals outperformed the switcher bilinguals and the monolinguals did not differ from either one. The RT data indicated that monolinguals were faster than both bilingual groups, who did not differ from one another. No interaction terms were found to be significant. This study sought to examine how differences within the bilingual population affect the discovery of a bilingual advantage. It is among the first to compare monolinguals and bilinguals with attention given to differences within the bilingual population. While no bilingual advantage was discovered, the results indicate that bilingualism affected the way in which participants approached the task. Bilinguals appear to be more focused on response selection and accuracy which is indicated in both bilingual groups' increased reaction time compared to monolinguals. Switcher bilinguals, while as slow as the non-switcher bilinguals, do not perform at the same level of accuracy. Presumably, this is due to differences between the two groups in cognitive control abilities. It is possible that due to the salience of response selection (i.e. language selection) in their daily lives, bilinguals approach this nonverbal switching task with the same underlying strategy. Monolinguals, with no such daily emphasis on response selection, could therefore be hypothesized to respond in a way that maximizes their reaction time. This study suggests that bilingualism in general changes the way individuals approach the task, shifting the focus from speed to accuracy. Additionally, cognitive control differences within the bilingual population lead to a bilingual's advantage, in which certain bilinguals outperform other bilinguals.

A44 Cross-linguistic interference in French/Arabic bilingual gender agreement processing: ERP evidence. *John E. Drury[1], Mariia Kaliuzhna[2], Hakima Guella[3], Anne Cheylus[3], Viviane Deprez[3,4]; [1]Stony Brook University, [2]Ecole polytechnique fédérale de Lausanne, [3]L2C2 CNRS, [4]Rutgers University*

[INTRODUCTION] Bilinguals whose languages both encode grammatical gender present a potentially interesting case for investigating cross-language interference and mechanisms responsible for access/retrieval and combinatorial reflexes of morpho-syntactic features in real-time processing. For example, what happens in bilinguals when they are processing nouns which are connected with opposing gender features across their two languages (e.g., masculine in one language but feminine in the other, or vice-versa)? For example, in contexts requiring gender agreement (e.g., in French: "LA(fem) table(fem)" not "*LE(masculine) table(fem)"), do bilinguals typically succeed in inhibiting the activation of gender features in the irrelevant language? Cases where

the irrelevant (not currently being processed) language assigns an opposing gender to the translation equivalents of the nouns should allow us to probe the nature of the underlying mechanisms involved. [METHODS] We conducted an ERP reading study involving French/Arabic (early/simultaneous) bilinguals and French monolinguals. Participants viewed simple determiner-noun pairs in French. The determiners were definite and either masculine (le) or feminine (la). Subsequent nouns either agreed in gender (correct) or not (agreement violation). In addition to this Correctness manipulation, half of the nouns had Arabic translations that were gender congruent with French (i.e., masculine (or feminine) in both languages) or incongruent (i.e., cases where nouns which are masculine(/feminine) in French are feminine(/masculine) in Arabic). Participants indicated by button press whether the pairs were acceptable or not. EEG was continuously recorded and ERPs for target nouns were extracted and analyzed. Broadly, if cross-language gender incongruity causes processing inference, this should be evident in the behavioral and ERP responses in terms of Correctness x Congruency interactions only for the bilinguals. Previous ERP work studying gender (dis)agreement in native Spanish speakers using similar determiner-noun word pairs reported a relative negativity (interpreted as an N400 effect), possibly superimposed with an anterior negativity (Barber & Carreiras 2005). [RESULTS] Acceptance rates revealed a Group x Correctness x Congruency interaction driven by higher error rates for the French/Arabic bilinguals in the Incongruent/Violation condition (10%) compared to the Congruent/Violation condition (5%). In terms of ERPs, Correctness effects in the monolinguals manifested as a biphasic negative/positive pattern with (as expected) no influence of the factor Congruency. In contrast, Correctness ERP effects in the bilinguals showed a more narrowly distributed (posterior) negativity only. Crucially, Correctness x Congruency interactions were found. Unlike the behavioral data, Congruency mainly influenced ERPs for the correct cases (i.e., the agreeing word pairs), with Incongruent nominals demonstrating a broadly distributed positivity with an anterior maximum compared to Congruent ones. [CONCLUSION] These data reveal a gender clash between the French determiners (though Arabic marks gender on nominals, it does not on the definite determiner) and the Arabic translations of the French nouns. We suggest that the frontal positivity (Congruency effect) in the bilinguals reflects the action of cognitive/executive control mechanisms, and also provide support for models which posit that the representation/processing of gender is independent/dissociable from the handling of the associated nominals themselves. Further implications for our understanding of cross-language processing interference in bilinguals will also be addressed.

A45 Semantic errors in comprehension: A voxel-based lesion symptom mapping study

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Most contemporary theories of semantic processing in the brain assume a widely distributed conceptual system, which is primarily interfaced across a set of crucial brain regions (e.g. Hickok & Poeppel, 2007). While much work has been done using functional neuroimaging to identify semantic networks in healthy individuals, we have also gained much information through neuropsychological investigations. Damage to regions in the semantic network (often by a stroke, or neurodegenerative disease) can have specific effects on the conceptual language system, resulting in symptoms such as category-specific deficits, or increases in semantic errors in speech production (Schwartz et al., 2012). Two left hemisphere areas which have been particularly implicated in semantic processing are the posterior middle temporal lobe, which is thought to play a key role in lexical access, and the anterior temporal lobe/temporal pole, which is thought to function as a "semantic hub", integrating information across contexts and modalities. Recent work has also implicated the anterior temporal lobe in syntactic processing, adding to work that has shown it to be generally involved in the processing of sentences (Magnusdottir et al., 2012, Humphries et al., 2004). In the present study, we tested thirty-two chronic stroke patients with left hemisphere damage on a computerized sentence comprehension task, which we have previously used to study syntax (Magnusdottir et al., 2012). These patients comprised a subset of those whom we previously studied in the acute setting. Participants heard a sentence and were asked to choose the matching picture from a field of three: the target picture, a foil picture that represented a semantic reversal, and an unrelated foil. The sentences were composed of nine syntactic types, and all the sentences were semantically reversible (e.g. the boy kissed the girl), so that accurate comprehension could not be achieved by relying only on semantic knowledge. In order to localize neural modules associated with task performance, we used voxel based lesion symptom mapping (VLSM), a technique that relates structural damage and behavioral performance (Bates et al., 2003). Regions of damage were delineated on native space FLAIR images by a neurologist, and coregistered to high-resolution T1 images for spatial normalization. Standard space lesion maps were then analyzed on a voxel by voxel basis to identify regions in which damage was significantly associated with behavioral performance. We found that semantic errors in comprehension, where participants erroneously chose the semantic reversal of the target sentence, were associated with lesions in both temporal pole and posterior middle temporal gyrus of the left hemisphere. These errors tended to occur more often in sentences with non-canonical structures than in canonical

structures. Furthermore, when using an uncorrected threshold, we replicated our earlier finding that difficulty with syntactic processing is associated with damage to the left temporal pole. These results are compatible with theories suggesting that the anterior temporal lobe functions to integrate semantic information, as damage to this area seems to impair the full extraction of meaning, especially when processing load is increased via syntactic difficulty.

Lexical Semantics

A46 An fMRI study of concreteness effects in auditory lexical decision *Tracy Roxbury[1,2,5], Katie McMahon[2], Alan Coulthard[3,4], Raymond Buckley[4], Christine McHenery[4], David Copland[1,5]; [1]Centre for Clinical Research, University of Queensland, [2]Centre for Advanced Imaging, University of Queensland, [3]Academic Discipline of Medical Imaging, University of Queensland, [4]Royal Brisbane and Women's Hospital, Brisbane, Australia, [5]School of Health and Rehabilitation Sciences, University of Queensland*

Background: Evidence for the brain mechanisms recruited when processing concrete versus abstract concepts has been largely derived from studies employing visual stimuli. The tasks and baseline contrasts used have also involved varying degrees of lexical processing. This study investigated the neural basis of the concreteness effect during spoken word recognition and employed a lexical decision task with a novel nonword condition. Methods: The participants were eighteen healthy young people (10 females and 8 males). The stimuli consisted of 60 real words (30 concrete, high imageability nouns and 30 abstract, low imageablity nouns) and 60 opaque legal nonwords presented in a pseudorandomised, event related design. Activation for the concrete, abstract and nonword conditions was analysed using anatomical regions of interest derived from previous findings of concreteness effects. Results: Behaviourally, lexical decision reaction times for the concrete condition were significantly faster than both abstract and nonword conditions and the abstract condition was significantly faster than the nonword condition (p less than .05). The region of interest analysis showed significantly greater activity for concrete versus abstract conditions in the left fusiform and dorsolateral prefrontal cortex, left posterior cingulate and bilaterally in the angular gyrus. There were no significant differences between abstract and concrete conditions in the left superior and middle temporal gyrus. Conclusions: These findings confirm the involvement of the angular gyrus, posterior cingulate, fusiform and dorsolateral prefrontal in retrieving concrete versus abstract concepts during spoken word recognition. The lack of left superior temporal involvement in this paradigm suggests that previous observations of concreteness effects in this region might not have reflected semantic involvement but rather differential levels of phonological processing. Key words: language, concrete, abstract

A47 The behavioral and neural effects of language on motion perception *Jolien C. Francken[1], Peter Kok[1], Peter Hagoort[1,2], Floris P. de Lange[1]; [1]Donders Institute for Brain, Cognition and Behavior, Radboud University Nijmegen, Netherlands, [2]Max Planck Institute for Psycholinguistics, Nijmegen, Netherlands*

Language does not function as an isolated cognitive system but is actually tightly linked with other cognitive functions. Several studies have described an influence of language on motion perception, but it remains debated at which level of processing this modulation takes place. Some studies argue for an interaction in perceptual areas, by showing that language can impact on perceptual sensitivity as well as modulate neural activity in sensory cortex during a perceptual task. A second possibility would be that the interaction is mediated by 'language areas' that integrate the semantic meaning of the linguistic as well as the visual information. Here, we investigated this issue in a combined behavioral and fMRI study. Moreover, we assessed whether language-perception interactions were specific to the language-dominant left hemisphere, by presenting visual material to the right and left visual field. Subjects (right-handed; behavior: N=22; fMRI: N=25) performed a visual motion detection task. On each trial, the visual motion stimulus was presented in either the left or in the right visual field (RVF). Crucially, subjects were shortly presented with a motion word (e.g., rise) before each trial. The motion word could be congruent, incongruent or neutral with regard to the visual motion stimulus that was presented subsequently. When motion words were congruent with the direction of the visual motion stimulus, subjects were faster, more accurate, and had a more liberal decision threshold compared to the incongruent condition. Interestingly, the speed benefit was present only for visual stimuli that were presented in the RVF. We observed a neural counterpart to these behavioral facilitatory effects in the left middle temporal gyrus (lMTG), an area involved in semantic matching and contextual integration, but not in the visual areas that were sensitive to the motion stimulus. In conclusion, we show that language affects behavioral performance on motion perception, with stronger effects for motion stimuli that are processed in the language-dominant left hemisphere. These interactions were neurally mediated by 'language areas' rather than perceptual areas, suggesting that these form part of the network involved in perceptual decisions about visual motion stimuli.

A48 Frontal and Parietal Cortex Supports Generalized Quantifier Complexity *Christopher Olm[1], Corey McMillan[1], Robin Clark[2], Murray Grossman[1]; [1]Perelman School of Medicine, University of Pennsylvania, Philadelphia, [2]University of Pennsylvania, Philadelphia*

Generalized quantifiers, like "all" and "most," are highly frequent in daily language. There is increasing evidence that quantifier comprehension is supported by a fronto-parietal network. Parietal cortex is hypothesized to

support a numerosity component of quantifiers and frontal cortex is hypothesized to support executive resources required to evaluate a quantifier's meaning. In this study, we comparatively evaluated the selective recruitment of fronto-parietal cortical regions to support distinct mechanisms involved in quantifier comprehension. For example, cardinal quantifiers (e.g. "at least 3 pirates") have an explicit number component and may upregulate parietal cortex, logical (e.g. "some privateers") quantifiers may require frontal resources to evaluate the truth-value of a statement, and majority (e.g. "most buccaneers") quantifiers rely on both quantity and working memory to hold one value in mind (e.g. the total number of buccaneers) while calculating another value (e.g. a subset of buccaneers) and performing a comparison between the two. To evaluate the selective recruitment of these mechanisms we presented healthy young adults (N=18) with 20 color drawings in each of 5 conditions and asked them to judge the truth-value of the sentence-picture combination. Each picture contained a countable number of objects (e.g. horses) in a natural setting (e.g. a field or barn). The experimental "quantifier" sentences contained a logical, cardinal, or majority quantifier. The baseline condition sentences contained a precise number (e.g. "Three horses…") or no quantifier (e.g. "The horses..."). We evaluated BOLD fMRI signal for correct responses. We first identified a fronto-parietal network by comparing quantifiers relative to baselines in a voxelwise whole-brain analysis (height threshold of uncorrected $p<0.0005$ and cluster level threshold of family wise error corrected $p<0.05$). This revealed 5 clusters: superior parietal lobe (SPL/BA7), inferior frontal gyrus (IFG/BA44), ventrolateral prefrontal (VLPFC/BA10), rostrolateral prefrontal (RLPFC/BA10), and thalamus (THL). To evaluate the selective recruitment of these clusters we extracted a 4 mm spherical region of interest (ROI) around each local maximum and measured the mean activation within each ROI for each quantifier type. A ROI X Quantifier ANOVA revealed a significant main effect for ROI [$F=28.6$; $p<0.001$] in which SPL was recruited more than any other ROI. We also observed a main effect for Quantifier [$F=23.86$; $p<0.001$]: majority quantifiers yielded more overall activation than logical or cardinal. Lastly, we observed a ROI X Quantifier interaction [$F=4.54$; $p<0.001$]: IFG was most highly activated for majority compared to cardinal, and IFG was more highly activated for logical compared to cardinal. Together, our results demonstrate that SPL is the most highly recruited mechanism to support quantifier comprehension; this is consistent with the hypothesized role of numerosity in quantifier comprehension. Furthermore, as quantifier complexity increases IFG is selectively recruited to support hypothesized working memory resources. Consequently, the entire fronto-parietal network is upregulated to support the most complex class of quantifiers (majority). These findings emphasize the role of a fronto-parietal network involved in quantifier comprehension.

A49 Fusion and fission of functions in parietal cortex: mapping the functional organisation of parietal cortex in a multi-domain meta-analysis

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The parietal cortex has been implicated in a wide variety of domains including both linguistic and non-linguistic tasks. Yet the principles that govern parietal organisation and function across domains remain unclear. Some theories argue for highly specialised domain-specific processing areas (1), whilst others argue for overarching organisational principles and task-general processing (2, 3). This is the first meta-analysis to functionally and anatomically map the organisation of parietal cortex across all key domains and tasks. A direct comparison across domains/tasks is an essential step in the development of a unified set of parietal organisational principles. Here we conducted a large-scale multi-domain meta-analysis of neuroimaging studies to compare the recruitment of parietal cortex across eight key domains (and several further sub-categories) using the GingerAle meta-analysis technique. Over 4000 foci were included in the meta-analysis from the areas of attention, episodic retrieval, semantic processing, numerical tasks, phonological processing, sentence level processing, tool-related tasks, and the default-mode network. The studies were selected based on those cited by key reviews/meta-analyses in each subject area (supplemented where necessary by Web of Knowledge searches) and thus provide a representative sample of studies from each domain. Within each domain, we also sought to preserve any important sub-divisions that have been highlighted by the literature (e.g. top-down vs. bottom-up attention, top-down vs. automatic semantic retrieval, numerical calculation vs. numerical fact-retrieval). The results suggest task-based (rather than strictly domain-based) segregation of parietal cortex. Specifically, they reveal a dorsal-ventral difference in function, with dorsal parietal cortex (DPC), including intraparietal-sulcus (IPS) and superior parietal lobule (SPL), and ventral parietal cortex (VPC), including angular gyrus (AG) and supramarginal gyrus (SMG)), showing differential task-sensitivities based on executive demands (high- vs. low-executive demand, respectively). Within DPC and VPC a high-degree of spatial overlap was found across domains/tasks thus providing compelling evidence for domain-general processes and support for overarching organisational principles. Within the VPC, a further anterior-posterior gradient between AG and SMG was found, with evidence of functional dissociations in sensitivity to certain tasks. Furthermore, AG (but not SMG or IPS/SPL) showed task-related deactivation. However, the tendency for AG negative activation to occur was found to be task-dependent, occurring only for certain tasks/domains whilst other domains were found to positively activate AG. This distinction is important when developing a theory of AG function. Thus, these data suggest a dorsal-ventral and anterior-posterior gradient of parietal organisation and the presence of three

functionally dissociable parietal networks (IPS/SPL, AG, and SMG). Within each area, recruitment was found to be highly overlapping across domains thus arguing for task-general processing systems. A unified theory that unites these results and further specifies the function of each sub-region will be proposed. This work thus substantially enhances our understanding of parietal organisation and has significant implications for theory and patient work. References 1. Nelson et al. (2012). Trends in Cognitive Sciences, 16, 399-400. 2. Cabeza et al. (2008). Nature Reviews Neuroscience, 9, 613-625. 3. Cabeza et al. (2012). Trends in Cognitive Sciences, 16, 338-352.

A50 The Role of the Inferior Frontal Cortex in Idiom Processing: An rTMS Study

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Understanding the figurative meanings of idioms (kick the bucket = to die) can be challenging, because of the need to use inhibitory control to balance figurative and literal meanings. The inferior frontal cortex (IFG) has often been investigated in idiom processing as a cognitive control site, when one meaning needs to be selected over another (eg., Lauro et al., 2008). However, its precise role remains unclear since previous studies have been unable to determine whether the IFG was activated due to the cognitive load of the task, or specifically in the inhibition of competing meanings. Here, we investigated whether rTMS to the IFG would lead to impaired idiom comprehension in a task that keeps cognitive load demands minimal. We recruited twelve native English speakers, who came to our lab for two sessions of rTMS (stimulation of IFG and of a control site [vertex]). Each time, subjects received 600 pulses at 110% resting motor threshold. After stimulation, participants listened to auditory sentences with verb-determiner-noun idioms, followed by a meaningful or non-meaningful context (Roxy bit her lip and tried to keep the plans for the surprise party a secret; Roxy bit her lip and tried to keep the plans for the control party a secret). They were asked to judge each sentence on its meaningfulness. Literal control sentences (with the same idiom-final noun and a matched verb) were also presented. In addition, participants completed an executive function task to assess their inhibitory skills. We computed linear mixed effects regression models (Baayen, 2008) for two measures of sentence comprehension, reaction times (time-locked to the offset of the sentence) and accuracy. We tested for the effects of stimulation site (IFG vs vertex), sentence condition (idiomatic vs literal), as well as inhibitory cost measure (the accuracy cost score of the Simon color task; Simon,1990). The results showed that meaningfulness judgments were significantly slower and less accurate for idiomatic but not literal sentences, suggesting greater difficulty in the comprehension of idioms generally. Reaction times were also significantly slower following IFG but not vertex stimulation, indicating that IFG stimulation had a detrimental effect on language comprehension. Finally, inhibitory control correlated with comprehension, both globally and depending on stimulation site: bad inhibitors made less accurate meaningfulness judgments for idioms in comparison to literal control phrases in general. However, this was especially true for bad inhibitors following IFG (but not vertex) stimulation. Thus, our data replicate studies showing that figurative language comprehension is more effortful than non-figurative language comprehension generally, presumably because of the increased cognitive load due to two competing meanings. This is supported by our finding that increased inhibitory function predicts how easily idioms are understood figuratively. Importantly, there is evidence that individual differences in cognitive control correlate with the extent to which the IFG is involved in idiom comprehension: Bad inhibitors are more susceptible to the 'noise' introduced by rTMS stimulation, suggesting that in these individuals, the IFG is crucial for idiom comprehension. In good inhibitors, however, the involvement of the IFG is less critical.

A51 Semantic Variability Predicts Neural Variability of Object Concepts

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When cognitive psychologists and psycholinguistics consider the variability that arises when thinking about concepts, it is often understood to arise from the dynamic interactions of concepts and contexts. When cognitive neuroscientists and neurolinguistics think about this variability, it is usually treated as noise. For example, efforts to characterize the neural patterns evoked by thoughts about a chair involve averaging over many chair-evoked patterns or using pattern invariance as a criterion for further analysis. Here, we bridge these two traditions by asking: can variability in the neural patterns evoked by concepts reflect the contextual variation that occurs during conceptual processing? The present study examines the neural variability in concept representations and relates this to semantic variability. We measured each concept's semantic variability using LSA and Topic modeling to analyze word co-occurrence statistics in large text corpuses. To measure neural variability, we conducted an fMRI study and sampled neural activity associated with each concept when it appeared in three separate, equally random contexts. Where other studies might average across stimulus-specific presentations to measure common activation for a given concept, we measured the neural variability amongst these stimulus-specific presentations. We predicted that concepts with low semantic variability would exhibit uniform activation patterns across their three presentations, whereas concepts with high semantic variability would exhibit more dynamic representations over time. We observed that a word's semantic variability predicts the word's corresponding neural variability.

Our findings illustrate the possibility of applying a more dynamic view of concepts to investigations of their associated neural patterns.

A52 The roles of left and right inferior frontal cortex in the comprehension of ambiguous sentences *Jennifer M. Rodd[1], Sylvia Vitello[1], Joseph T. Devlin[1], Jane E. Warren[1]; [1]University College London*

The ability to accurately and efficiently retrieve the contextually-appropriate meaning of ambiguous words is fundamental to speech comprehension. Previous psycholinguistic research suggests that listeners initially retrieve multiple possible meanings of ambiguous words but rapidly select the most appropriate meaning. If subsequent contextual information is inconsistent with this initial meaning, the sentence must then be reinterpreted. Functional imaging research has implicated left inferior frontal gyrus (IFG), posterior inferior temporal cortex and, less consistently, their right hemisphere homologues in processing of ambiguous sentences. The relative contributions of these regions to the processes of initial meaning selection and sentence reinterpretation remain unclear. In this fMRI study, 18 native British English speakers listened to spoken sentences containing an ambiguous keyword, which was preceded by a neutral (non-disambiguating) sentence opening. We manipulated the processing load associated with 'initial meaning selection' and 'sentence reinterpretation' in a factorial design. 'Initial selection' was manipulated by varying the relative frequencies (i.e. dominance) of the keywords' meanings: 'balanced' keywords had two meanings of approximately equal frequency (e.g, nail), making the initial selection of a meaning relatively demanding, while 'biased' keywords had one dominant meaning (e.g., bank), placing less demand during selection. Sentence reinterpretation load was manipulated by comparing 'resolved' sentences that contained a final word that was strongly related to the less frequent keyword meaning, to 'unresolved' sentences where the final word was equally compatible with both meanings (e.g., "David checked that the straw was where he had left it in the barn/box"). Extensive pretesting confirmed that 'resolved' sentences required sentence reinterpretation, while 'unresolved' sentences did not. Subjects also listened to unambiguous control sentences. Subjects were instructed to listen attentively with no explicit task demands: attention and successful meaning selection were confirmed by post-scan memory and comprehension tests. Greater responses to ambiguous than unambiguous sentences were identified in all three anatomical subdivisions of left IFG, left posterior and anterior superior temporal cortex, left basal temporal cortex, right IFG (pars orbitalis) and bilateral insula. Region-of-interest analyses investigating effects of dominance and resolution in these locations (using 2x2 ANOVAs) demonstrated topographically distinct response profiles. All three left IFG subregions, posterior superior temporal sulcus and basal temporal cortex demonstrated greater responses to resolved sentences with no effect of dominance or interaction, indicating that these regions are driven primarily by sentence reinterpretation demands, with no evidence of any additional effect of initial meaning selection load. There was no evidence of region-by-condition interactions across the different left IFG subregions. Right IFG (pars orbitalis) showed no effect of dominance or resolution, indicating that this region responds to ambiguity but is not influenced by the cognitive load required to resolve that ambiguity. A three-way ANOVA comparing responses in left and right anterior/ventral IFG demonstrated a significant region x resolution interaction: the increased response to resolved sentences (relative to unresolved sentences) was greater in the left IFG compared with the right. These results confirm the key role of left (but not right) IFG and posterior temporal cortex in the cognitively demanding process of reinterpreting ambiguous sentences.

A53 ERP responses to code-switching in cognate/non-cognate word recognition by Chinese-Japanese bilinguals *Yingyi Luo[1], Changhao Jiang[1], Shengyan Long[1], Hiromu Sakai[1]; [1]Hiroshima University*

The Bilingual Interactive Activation model (Grainger & Dijkstra, 1992; Dijkstra & van Heuven, 1998) assumes that cognate words are linked to more than one language nodes in bilingual mental lexicon. If this is the case, do cognate words lead to code-switching effects in the context of one language or the other? ERP studies on bilinguals observed responses unique to code-switching that can be regarded as indices for inhibitory control (Alvarez et al. 2003; Chauncey et al. 2008). We conducted a series of ERP experiments to examine whether Chinese-Japanese bilinguals show such response in cognate/non-cognate word recognition. In Experiment1&2, fourteen highly advanced Chinese learners of Japanese performed lexical decision task. The stimuli consisted of randomly mixed 200 non-cognate target words (100 Japanese, 100 Chinese) and 80 pseudowords. Target words (Chinese in Ex1, Japanese in Ex2) were visually presented on the computer screen one-by-one, in such a way that they are preceded by either a word from the same language (non-switch) or the other language (switch). Participants pressed a button whenever pseudowords appeared. The ERP data was recorded from 19 scalp locations (the international 10-20 system). The response to the target word was quantified by taking the mean amplitude in the temporal window 300-500ms. In Ex1, language-switch from Japanese to Chinese was more negative than non-switch ($F(1, 13) = 4.9$, p value less than 0.05). The comparable switch from Chinese to Japanese and no-switch in Ex2 produced no significant difference. These results suggest that L2(Japanese)-L1(Chinese) code-switching incurred stronger inhibitory control. In Experiment 3&4, fifteen highly advanced Chinese learners of Japanese performed the same task. The stimuli consisted of randomly mixed 200 non-cognate words (100 Japanese, 100 Chinese) and 100 cognate words.

In Experiment 3, a cognate target word was preceded by either Chinese or Japanese non-cognate words. In Experiment 4, a non-cognate (Chinese) target word was preceded by a cognate word that was further preceded by Chinese or Japanese non-cognate words. ERP recording and analysis procedure were identical to those in Ex1&2. No significant difference was observed between conditions in Ex3, whereas L2(Japanese)-cognate-L1(Chinese) trials were more negative than L1(Chinese)-cognate-L1(Chinese) trials (F (1,14) =10.0, p value less than 0.01) in Ex4. The overall results indicate that cognate words can escape from inhibitory control since they are linked to more than one language nodes. Nevertheless, they incur code-switching effects depending on the strength of association to each language.

A54 Oscillatory dynamics in semantic cognition: Neural processes underlying automatic and controlled semantic retrieval revealed by MEG *Beth Jefferies[1], Catarina Teige[1], Piers Cornelissen[2], Giovanna Mollo[1]; [1]University of York, UK, [2]Northumbria University, UK*

Semantic cognition involves the interaction of (i) semantic representations with (ii) executive control processes that allow us to focus on task-relevant aspects of knowledge. Here we used magnetoencephalography to explore how relatively automatic and more controlled forms of semantic retrieval emerge over time within the semantic network. We probed the neural response to semantic judgements involving pairs of words: these were either strongly associated, such that automatic semantic retrieval to the first word was likely to activate relevant semantic representations, or they were weakly associated, increasing the demands on controlled semantic retrieval. Virtual electrodes were seeded in key left hemisphere sites involved in semantic cognition: inferior frontal gyrus (LIFG), posterior middle temporal gyrus (pMTG) and anterior temporal lobe (ATL). There was a stronger response to weak than strong associates in ATL 100ms after presentation of the second word, suggesting that this region generates an error signal when semantically-driven predictions do not match an incoming stimulus. A similar response was seen in LIFG at 250ms, consistent with the role of this region in controlled semantic retrieval. Later, at 250ms, left ATL showed a greater response to strong than weak associates, potentially reflecting richer and more coherent semantic retrieval when the second word was primed semantically. In contrast, posterior middle temporal cortex showed a greater response to weak associations at all times throughout the analysis period. This pattern was seen from 150-200ms, building to a peak response at around 350ms. In conclusion, our findings suggest that ATL is a key semantic region, involved in both automatic and controlled aspects of semantic retrieval, while pMTG contributes to controlled retrieval processes that establish a semantic link that is appropriate to the context. These results are consistent with emerging evidence that LIFG and pMTG work together to support controlled aspects of semantic processing.

A55 A neural network model of a semantic space: correlation with priming and EEG data *Alvaro Cabana[1], Camila Zugarramurdi[2], Eduardo Mizraji[1], Juan C. Valle-Lisboa[1,2]; [1]Facultad de Ciencias, [2]Facultad de Psicología, Universidad de la República, Uruguay*

The relevance of the lexicon for present-day theories of language is sustained both on theoretical grounds and on psycholinguistic and neurobiological evidence. There is substantial discrepancies over what type of information is stored in the lexicon and how it is used in sentence production and comprehension. Neural network models of language processing have contributed to this and other related debates regarding the neurobiological substrates of language performance. In the present work, we use a particular neural model to explore the correlations between semantic space-derived word similarities and behavioral data obtained in priming and ERP experiments. Context-dependent memory modules are neural network models that have been used in many cognitive tasks and settings, such as goal-directed behavior, logic operations, and normal and pathological language processing (see: Mizraji, Pomi and Valle-Lisboa, Cog. Neurodynamics, 3, 401, 2009). These memory modules receive two input vectors and associate an output to the Kronecker product of the inputs; their performances are comparable to hidden-layer feedforward perceptrons, but they are successfully trained using simpler gradient descent methods. We present here a modular neural network that can be used to obtain a semantic space when trained on large corpora. The model consists of two main modules: a semantic module that implements the notion of topic context and retains mostly semantic relations between words, and a "word-order" module that captures sequential information of word occurrences. Both modules resemble a simple recurrent network in which the output vector is fed back as a context input for the next input in the sequence. The semantic context module is inspired in a topic selector module, previously built, that is capable of text categorization with supervised training (Cabana, Mizraji and Valle-Lisboa, in preparation). In contrast, the word-order module is concerned with the prediction of the next word in the sequence, or more specifically, the next type of word, in a POS-like sense. We trained such a modular network on the Spanish version of the Wikipedia online article collection. We analyze its performance in explaining variance in semantic priming and ERP experiments, evaluating the influence of pragmatic and event information in lexical representation. In addition, we evaluated the correlation between amount of priming and N-400 amplitudes in experiments with semantic similarity measures derived from the modular neural network obtained. The main result is that the inclusion POS module, even if too simple to be taken as a realistic implementation of part of speech

tagger, enhances recognition abilities of the modules and better matches the RT measurements. The semantic context module can be used as a semantic space, performing similarly as a LSA-based semantic space built from the same corpus. Finally, we analyze the idea that some of the discrepancies between the experiments and the model point toward the necessity of a richer model for the lexicon.

Syntax, Morphology

A56 Representational similarity analysis reveals the nature and sequence of syntactic computations in the fronto-temporal language network

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The core human capacity of syntactic analysis involves a left hemisphere network that includes inferior frontal gyrus (LIFG) and posterior middle temporal gyrus (LpMTG) and the anatomical connections between them (1–3). This system must accommodate and resolve the temporary syntactic ambiguities that are frequent in spoken language processing as a consequence of the temporal nature of the speech signal. However, little is known about the nature and timing of the functions performed by the LIFG and LpMTG during the processing of syntactic ambiguity. Here we use magnetoencephalography (MEG) to determine the spatio-temporal properties of the activation and integration of syntactic computations in this network as participants listened to spoken sentences. Listeners heard sentences containing syntactically ambiguous phrases (e.g. "landing planes"), where a verb participle could function either as an adjective (e.g. "… landing planes are …") or a gerund ("… landing planes is …"). At the offset of the phrase participants heard a disambiguating verb ("is"/"are") and decided whether it was an acceptable or unacceptable continuation of the sentence. We charted the time-course of the activation, selection and integration of these multiple candidate syntactic representations by measuring MEG responses in three time windows, measured from the onset of the two words in the ambiguous phrase and the disambiguating word. We used representational similarity analysis (RSA) to characterize syntactic information represented in the LIFG and left posterior middle temporal gyrus (LpMTG) over time and to investigate their relationship to each other as syntactic information is activated and integrated. We created several representational dissimilarity models coding for the presence of ambiguity in the sentences, the preferences associated with the possible interpretations of ambiguous phrases, and whether those preferences were satisfied by the disambiguating word. Another model encoded lexico-syntactic information associated with the verb participle (e.g. "landing"), derived from verb subcategorization frame distributions in the VALEX lexicon (4). Thus, different aspects of sentence processing were captured by different dissimilarity models, from the representation and access of lexico-syntactic information associated with the verb participle, to activation of multiple candidate representations associated with the ambiguous phrase and the subsequent resolution of the ambiguity in the context of the disambiguating word. Testing these models against the MEG data, we found early lexico-syntactic responses in the LpMTG, consistent with the hypothesis that LpMTG represents lexical-level information relevant to processing verbs in context. The LpMTG effects were followed by two later effects in LIFG: sensitivity to the presence of ambiguity in the sentences and then later the ambiguity's resolution, pointing to a clear differentiation in the functional roles of these two regions. Our results therefore suggest that the LpMTG represents and transmits lexical information to the LIFG, which responds to and resolves the ambiguity. References 1. M. Papoutsi, et al., NeuroImage 58, 656–664 (2011). 2. L. K. Tyler et al., Brain 134, 415 –431 (2011). 3. G. J. M. Parker et al., NeuroImage 24, 656–666 (2005). 4. A. Korhonen, Y. Krymolowski, T. Briscoe, in Proceedings of the 5th International Conference on Language Resources and Evaluation, (Genova, Italy, 2006).

A57 Irregular and regular verbs elicit identical ERP responses to violations of tense expectations: Evidence for single-route over dual-route models.

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Introduction. The Dual Route model of irregular vs. regular inflection (Pinker & Ullman, 2002; Ullman, 2001a, 2001b, 2004, 2006) predicts that violations of the expected tense on a regular verb should elicit a Left Anterior Negativity event-related potential (indicative of processing involving morphosyntactic combinatorial operations), whereas violations of irregular verbs should be akin to encountering an unexpected unanalyzable word form, eliciting an N400 response. Using visually presented stimuli, Newman, Ullman, Pancheva, Waligura, and Neville (2007) tested ERPs to present tense verbs when a past tense was expected. They observed a LAN to regular verbs but no ERP response to irregular in the same time window, and a subsequent P600 to both verbs. This was taken as evidence for distinct processing routes for regular and irregular verbs. The aims of the current study were to replicate this finding using auditory stimuli, to test both past and present tense verbs in the ungrammatical condition, and to compare past and present tense verbs without expectation generating time adverbials to control for a possible confound (ERPs caused by mere differences in morphology). Methods and Results. 28 subjects participated in Experiment 1, which compared "Yesterday, I eat/ate a banana" and "Yesterday, I kick/kicked a ball", as well as the same stimuli without adverbs; "I eat a banana" vs. "I ate a banana". ERPs time-locked to both verb onset and verb offset were recorded with a 65 channel EGI system. Experiment 1 resulted in a clear LAN for both regulars and irregulars in the ungrammatical

present tense condition, and no interaction with verb type (or with time-locking point). Bare past and present did not differ (except for a tendency towards a LAN for bare past irregulars). Thirty-three subjects participated in Experiment 2, where we compared "Now, I eat/ate a banana" and "Now, I kick/kicked a ball", as well as the same stimuli without adverbs, and recorded ERPs in the same way using a 128 channel EGI system (to increase spatial resolution). Again, a clear LAN was observed to ungrammatical past tense, with no interaction with verb type. Discussion. The findings are consistent with single-route models such as Distributed Morphology (Stockall & Marantz, 2006) and contradict the predictions of Dual-Route models. The time adverb sets up an expectation for a matching tense on the verb. The LAN is an error signal generated equally by an unexpected V+PAST as an unexpected V+PRESENT. The lack of interaction with verb type shows that irregulars and regulars are processed via the same route.

A58 Imaging speech comprehension in quiet with high density diffuse optical tomography *Mahlega Hassanpour[1], Adam T Eggebrecht[2], Jonathan E. Peelle[2], Joseph P. Culver[2]; [1]Washington University in St. Louis, [2]Washington University School of Medicine*

Although numerous studies have studied the neural basis of speech processing using fMRI, these studies all face challenges of acoustic contamination and/or relatively poor temporal resolution due to the constraints of echoplanar imaging. Here we measured brain activity in listeners using high-density diffuse optical tomography (HD-DOT), an optical imaging method that permits presenting speech in a well-controlled acoustic environment and with excellent temporal resolution relative to the hemodynamic response. We presented listeners with spoken sentences that contained either a subject-relative or object-relative center embedded clause in order to identify networks supporting increased processing demands for syntactically complex sentences (i. e. object-relative clause), along with a control condition consisting of speech-shaped noise. Both the noise and the sentences activated parts of the temporal cortex, bilaterally. In addition, the simple sentences activated the core language processing areas on the left hemisphere along left temporal and inferior frontal cortex. Finally, the increased processing demand for the syntactically complex sentences resulted in significantly increased activation in lateral temporal and frontal cortex. These results are in agreement with the previous fMRI studies and indicate the feasibility of imaging higher order cognitive processes with HD-DOT. The results indicate that HD-DOT is capable of detecting subtle changes in the networks recruited during processing of more demanding language tasks.

A59 Stripping off semantics from the syntax skeleton: the role of Broca's area *Tomás Goucha[1,2], Angela D. Friederici[1]; [1]Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany, [2]Berlin School of Mind and Brain, Humboldt University, Germany*

Broca's area is proposed as the core computational region for syntax. There is an ongoing debate whether only its posterior subregion Brodmann area (BA) 44 is responsible for the processing of sentence structure. Whereas German studies show the activation of BA 44 proper as a function of syntactic complexity, English studies have also shown an additional activation of the more anterior BA 45. We postulate that the activation of BA 45 is due to automatic parallel semantic processing. In order to disentangle both processes, we varied the amount of available semantic information across conditions with and without sentence structure in two consecutive experiments. Right-handed German native speakers were scanned (22 in Experiment 1, and 26 in Experiment 2) in an event-related functional magnetic resonance imaging (fMRI) design with a Gradient-echo EPI sequence (TR=2000ms, TE=30ms), and a total experiment duration of respectively 50 and 42 minutes. Subjects performed an auditory Word-Monitoring Task, where the target word was presented at the beginning of each trial and had to be detected within the following sentence. In Experiment 1, we compared complex sentences with word sequences without any coherent overall sentence structure. In this contrast we found the activation of BA 44, BA 45, the left anterior temporal lobe and the posterior superior temporal sulcus (pSTS). In the "Jabberwocky" conditions, the word stems of content words were replaced by pseudowords while keeping grammatical endings and function words as well as derivational endings unchanged. In this case, the syntactic contrast yielded the activation of BA 44, BA 45 and the pSTS. The activation in BA 45—usually dedicated to semantics—was interpreted to reflect the presence of semantic information in the derivational endings of the pseudowords. Therefore, in Experiment 2 the derivational morphology in pseudowords was also deleted, again maintaining the grammatical endings and function words intact. Now, in the absence of derivational morphology, only BA 44 was active. The two experiments show that Broca's area (BA 44 and BA 45) is activated as a whole during sentence processing, as long as semantic information is available. However, once all semantic information is deleted and only pure syntactic information is left—provided by function words, inflectional morphology and word order—only BA 44 is activated. These data indicate that BA 44 is therefore the core area in syntax processing.

A60 Are you talkin' to me? An fMRI study on syntactic priming effects in a communicative context *Lotte Schoot[1,3], Laura Menenti[1], Peter Hagoort[1,2], Katrien Segaert[1,2]; [1]Max Planck Institute for Psycholinguistics, [2]Donders Institute for Brain, Cognition and Behaviour, Centre for Cognitive Neuroimaging, [3]University of Groningen*

Although language is most naturally used to communicate, participants in psycholinguistic experiments often use language devoid of a goal to communicate. In this study, we investigated whether having a communicative goal

can influence syntactic processing in production and comprehension. We chose to look at syntactic priming effects: it is an established phenomenon that less processing is needed for sentences with the same syntax as the preceding sentence relative to sentences with a novel syntax. It has been proposed that syntactic priming effects are not merely facilitation effects but that their magnitude can be influenced by having a (shared) goal to communicate (Garrod & Pickering, 2009). This would mean that top-down processes such as audience design (Bell, 1984) can influence the automatic process of priming. To date, however, there is little conclusive evidence to support this hypothesis. We compared syntactic priming effects in a communicative (N=24) and in a non-communicative (N=24) context. To allow us to make a comparison between effects in production and comprehension, we did not only measure RT-priming effects (smaller speech onset latencies for repeated syntax) but we also looked at fMRI adaptation effects (less brain activation for repeated stimuli), which can be measured in the same brain areas for production as well as comprehension (Segaert et al., 2012). Participants in both contexts were presented photographs of two persons performing a transitive action (e.g. a man serving a woman). Participants in the non-communicative context were instructed to describe the green-red photographs starting with the green figure (agent or patient was green). This way, we manipulated their use of active and passive sentence structures. For gray-scaled photographs, participants needed to perform a sentence-picture matching task with pre-recorded sentences (active or passive). In the communicative context, the participants' tasks were identical, although in this case they were performing the experiment together with another participant, who they met before the experiment started. To increase the feeling of being in a communicative context, we included feedback moments that showed a percentage that reflected how well participants were performing as a pair. In both the communicative and the non-communicative context, participants showed significant RT-priming effects and fMRI adaptation effects in regions traditionally implicated in syntactic processing. However, we did not find a significant difference in the magnitude of syntactic priming effects between contexts. Additionally, no difference between contexts was found in pre-defined ROIs in the left IFG and left pMTG (coordinates based on Menenti et al., 2011). We did find a significant correlation between the magnitude of RT priming of two participants in a communicative pair ($r = 0.382$, $p = 0.033$): if participant A was strongly/weakly primed by participant B, participant B was also strongly/weakly primed by participant A. These findings indicate that participants in the communicative context were influenced by their conversational partner, but that their priming effects were not increased by having a communicative goal per se. In this study, thus, we did not find evidence that the magnitude of priming effects is influenced by having the goal to communicate.

A61 Processing of Negative Polarity Items in Turkish

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[INTRODUCTION] Negative polarity items (NPIs) include words like "any/ever" which must co-occur with a licensor (e.g., negation) in order to be well-formed (e.g., "John has *ever left" versus "John has NOT ever left"). Further, licensor/NPI-dependencies must realize a particular syntactic/hierarchical relationship (e.g., in "[A man who has NO beard] has *ever left" negation is a structurally ineligible licensor since it is nested inside a preceding relative clause). NPIs represent a type of logical-semantic/pragmatic deviance which has attracted increasing attention in the ERP literature. A common finding is that unlicensed NPIs elicit P600-type effects (Steinhauer et al. 2010), though other negative-going deflections have also sometimes been reported. NPI-licensing has typically been investigated in languages where licensor/NPI-dependencies are retrospective (where the licensor precedes the NPI; note that negation does not predict the occurrence of a downstream NPI). In these languages (e.g., English/German) "intrusion-effects" have been found where NPIs seem to be "attracted" by preceding but structurally ineligible licensors (as in the relative clause example above), resulting in attenuation of violation ERP effects. However, it is unknown whether such intrusion-effects are conditioned by the nature of the memory/retrieval mechanisms supporting these retrospective dependencies. [METHODS] We conducted an ERP reading study (N=14) in Turkish, where NPIs typically precede licensors (prospective/predictive dependency). We tested sentences with embedded clauses and NPI-subjects (e.g., [NPI […embedded-Verb] main-Verb]) and manipulated the presence/absence of negation on the embedded/main-verbs. Only main-verb negation licenses Turkish main clause subject-NPIs; embedded-verb negation could result in an intrusion-effect, but it is unclear whether this should show ERP reflexes similar to previous findings given the predictive nature of the dependency in Turkish. In addition, agreement and argument-structure violations were included (predicted to elicit LAN/P600 and N400/P600 effects respectively), so that such "standard" response patterns could be compared to the NPI cases. [RESULTS] Among other findings, our results showed that, like German, unlicensed NPIs in Turkish yield a biphasic N400/P600 pattern. Moreover, similar to behavioral findings from English/German, violation effects were attenuated by the presence of intrusive (embedded-negation) licensors in Turkish. However, ERP responses did not yield a reduced effect of N400 or P600 for intrusion cases as found in German/English (Drenhaus et al. 2005; Xiang et al. 2009). Instead, intrusion-effect in our data from Turkish yielded similar N400-like responses as the violation condition (no attenuation) while P600 effects were absent entirely. Agreement violations yielded a clear (monophasic) P600

effect, and argument structure violations yielded a biphasic N400/P600 response. [CONCLUSION] That the N400 was not suppressed in the intrusion condition in Turkish suggests that the intervening/(embedded) negation does not cause parsing mechanisms to abandon the prediction of negation-marking on the main verb. Moreover, the absence of the P600 for the intrusion case suggests that parsing mechanisms nonetheless consider embedded negation as a possible licensor. The combined picture further suggests that the locus of NPI-licensing processes should be understood as corresponding to those systems which underlie these late positive-going responses. Comparison of these NPI-licensing effects to N400/P600 responses elicited by our filler violations will also be discussed.

A62 Context influences word order predictions in Broca's region

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Introduction The exact function of left inferior frontal gyrus (L-IFG) in language processing is highly disputed. The region has e.g. been associated with the processing of syntactic movement. Previous studies, however, have often been confounded by the fact that syntactically complex sentences often are less frequent than less complex ones and only viable in certain contexts. Another interpretation of these results could therefore be that L-IFG activation reflects prediction error from processing sentences that are unexpected in the context in which they are presented, rather than reflecting a syntax manipulation. The present fMRI-study investigates the effect of a pragmatically appropriate context on the processing of subject-initial and object-initial clauses with the IFG as our region of interest (ROI). *Methods* 32 native speakers of Danish completed two separate auditory linguistic tasks (a main task and a control task) and responded to comprehension questions. Both neuroimaging data (fMRI) and behavioral data (response accuracy and response time) were obtained. The neuroimaging data was processed in SPM8 using standard preprocessing and an event-related design. In the main task, the participants listened to Danish subject-initial and object-initial target sentences which were either preceded by a pragmatically appropriate or inappropriate context sentence. In the control task, the participants listened to the same target sentences, but this time the preceding context sentence was played in reverse, i.e. the context did not constitute a linguistic input, and merely served as an acoustic input. *Results* -Neuroimaging Results- We find that Danish object-initial clauses yield a higher BOLD-response in L-IFG, but we also find an interaction between appropriateness of context and word order, overlapping with traditional syntax areas. For object-initial clauses, the effect of an appropriate context is bigger than for subject-initial clauses. -Behavioral results- The response accuracy data showed a main effect of word order as well as a significant interaction between context and word order, i.e. an appropriate context had a greater facilitating effect on response accuracy for object-initial target conditions than for subject-initial target conditions. The response time data showed a similar interaction, i.e. a greater difference in response times for the two object-initial conditions than the two subject-initial conditions. *Conclusions* We argue that extraclausal factors such as discourse context contribute to the recipients' predictions of upcoming language input, and that increased BOLD-responses in the L-IFG may reflect the recipients' failure to correctly predict word order. While the linguistic context is not the only source used by recipients to predict the speaker's next move, our study shows that context and word order interact. For object-initial clauses, an appropriate context has a more pronounced facilitating effect on response accuracy and response time, and on decreasing the BOLD-response in the L-IFG. The low odds for object-initial clauses out of context correlate with low frequency and specific contextual requirements. Increased BOLD-response for object-initial clauses out of a discourse context can be seen as reflecting a reanalysis of the predicted word order. L-IFG may thus be understood as processing linguistic prediction error in general, rather than mere syntactical manipulations.

A63 ERP Signatures of Intransitive Verbs' Argument Structure Violations

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Omaki et al (2012) reported reading time evidence for "hyper-active" gap-filling after both transitive and intransitive verbs. Hestvik, Stoehr & Kurban (2011) aimed to replicate this finding with ERPs. They predicted N400 as a result of semantic incongruity after transitive verbs (i); and LAN as a result of subcategorization violations after intransitive verbs (ii): (i) "The city that the author wrote *[t] regularly about was named for an explorer", (ii) "The city that the author chatted *[t] regularly about was named for an explorer." However, LAN was observed in both conditions. The current study aimed to support the interpretation of these LAN effects as indicating gap-filling by testing whether overt violations elicited the same ERP responses. 24 subjects participated in a self-paced reading task while EEG was recorded. Subjects read 24 declarative sentences (derived from Omaki et al. (2012)) and 48 control sentences in each of three conditions: (1) S-selection violations after transitive verbs ("The man killed the country that was proud of its military forces"; preposition control: "The man killed for the country..."; verb control: "The man loathed the country..."); (2) Subcategorization violations after unergative verbs ("The woman jogged the house that was inspected by the board"; preposition control: "The woman jogged around the house..."; verb control, "The woman visited the house..."); and (3) Theta-Criterion violations after unaccusative verbs ("The student fell the carpet that was small and ugly"; preposition control: "The student fell on the carpet..."; verb control, "The student washed the carpet..."). We found that both

S-selection violations and subcategorization violations elicited anterior negativities around 400msec after the onset of the critical noun. Theta-Criterion violations elicited an N400 response. The fact that overt s-selection violations elicited a LAN provides evidence that the LAN observed in at *[t] in (i) was triggered by gap-filling. This raises the question of why an N400 was observed at the gap in Garnsey, Tanehaus, & Chapman (1989), where verbs, not fillers, were manipulated. The LAN effect elicited by subcategorization violations could be explained by unergatives having already discharged their single theta-role by the time the postverbal NP is encountered; this NP thus violates both the subcategorization restriction of the verb and the theta-criterion because they receive no theta-role. Such double violations have previously been observed to elicit LAN, not N400 (Friederici, Steinhauer, &Frisch (1999)). These two findings, together with Hestvik, Stoehr & Kurban (2011), demonstrate that equal brain responses are triggered by filled gaps as by overt noun phrases (thus lending further support to Omaki's hyper-active gap-filling hypothesis). Third, overt objects after unaccusatives elicited an N400 response. Friederici and Frisch (2000) observed a similar ERP by adding direct objects to German intransitives. In both cases, overt NPs induce a semantic violation because they cannot be integrated with the argument structure of the verb. These findings lend ERP support to previous behavioral and fMRI evidence for object traces after unaccusatives in processing (Friedmann, Taranto & Shapiro, 2008; Shetreet, Friedmann & Hadar (2009)).

Language Disorders

A64 An fMRI-equivalent of Mismatch Negativity correlates with psychological speech tests in patients with sensory aphasia

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It is still unclear how the extent of fMRI-activation reflects language and speech perception, particularly in the damaged brain. This study aimed to find a correlation between severity of speech impairment in patients with post-stroke sensory aphasia using the neurophysiological testing of speech perception and an fMRI-equivalent of Mismatch Negativity (MMN), the component of evoked potentials, which is well known as an index of auditory discrimination. 23 patients (10 males, mean age 57) after left hemisphere stroke with sensory aphasia and 20 right-handed age-matched healthy volunteers (16 males) participated in the study. A degree of aphasia was evaluated by a 5-point scale from an absent (0) to very rough (4) (mean score 2.8 [2.5; 3]). Patients' language abilities were estimated by 300-point scale (mean score 122 [78; 182.5]). A passive oddball paradigm with a random block presentation was adapted to obtain an fMRI-equivalent of MMN. One third of blocks contained 10 syllables (/ba/ – standard, /pa/ – deviant with 10% frequency, duration 330 ms, volume 85 dB, intersitmulus interval 850 ms), another third of blocks contained only standards and the last third of blocks was silent and used as a baseline. 90 T2*weighted images were acquired at 1.5 T scanner with BOLD contrast (TR 12500 ms, delay 9500 ms) after T1*weighted anatomical image for all subjects. The fMRI-data analysis was performed by SPM8 including co-registration, motion correction and normalization to MNI space. General linear model was used to determine differences in activations between all stimuli versus baseline and in the MMN contrast. Correlation between volume/intensity of fMRI activations and scores of language abilities was tested by Spearman' coefficient. The contrast to all stimuli has shown bilateral activation (5640 and 4970 voxels on the right and left sides) in the primary and secondary auditory cortex (41, 42, 52, 22 Brodmann's areas) in the control group. The same contrast in the patient's group has shown significant activations (4830 voxels; 41, 42, 52, 22 BA) only in the right temporal lobe. MMN activations were observed in the superior temporal and angular gyri in the right and left hemispheres (3145 and 4820 voxels) in the control group. In patients there was a significant activation only in the right auditory cortex (1335 voxels). The patients' fMRI maps also demonstrated a deactivation in the frontal areas, which was absent in the control group. For MMN contrast a negative correlation (r=-0.46) was obtained between the degree of aphasia and the extent of fMRI activation in the right supratemporal gyrus (RSTG) while the verbal scores correlated positively with the extent of activation (r=0.70) and the volume of activation in RSTG (r=0.59). The patients' fMRI data demonstrated a significant BOLD activation corresponding to MMN-contrast only in the intact right temporal lobe. The significant correlation of speech abilities of post-stroke patients with a size of MMN-fMRI activation in RSTG suggests a possible impact of the right hemisphere in the compensation of impaired speech perception. This research was supported by the grant of Russian Foundation of Humanities (12-06-00711).

A65 Termination processes and jargon aphasia: My mind will not stop!

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Different theoretical interpretations have been proposed to account for jargon aphasia, a disorder characterised by fluent, well-articulated, logorrhoeaic, almost incomprehensible propositional speech. We investigated the jargon speech produced by a patient (JC) who suffered a post-surgical infarct following the clipping of a middle cerebral artery aneurysm. Speech output was characterised by predominantly semantic jargon with occasional neologisms and phonological paraphasias. We

contrasted the patient's word and sentence generation with those of previously reported dynamic aphasic patients. We noted that JC had difficulty stopping propositional speech generation, and often had to be prompted to cease talking. In contrast with dynamic aphasic patients, JC had no difficulty in generating sentences; however, these were largely meaningless, while the few sentences produce by the dynamic aphasic patients were meaningful. In tasks requiring generation of single words, JC mostly produced sentences. By contrast, the dynamic aphasic patients produced single words although their performance was affected by the level of sentence constraint. We suggest that JC's jargon aphasia provides a mirror contrast to the severely reduced, but otherwise relatively normal, propositional language characteristic of dynamic aphasia. Previous research on dynamic aphasia has identified two crucial mechanisms involved in conceptual preparation for speech, namely the generation of novel thoughts and selection from amongst competitors. Previous research on normal and atypical speech generation suggests a third mechanism, namely a termination process. We suggest that JC's jargon aphasia is due to, at least in part, a propositional language impairment characterised by a failure of this termination mechanism.

A66 Neural activations during nonlinguistic category learning in individuals with aphasia

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Probabilistic category learning has been extensively researched in cognitive neuroscience in order to better understand the processes and mechanisms engaged in learning (Ashby & Maddox, 2005). Despite major advances in our understanding of category learning, however, little remains known about probabilistic category learning in post-stroke aphasia, and its consequence on language relearning in these individuals. Only recently has research explored category learning in patients with aphasia, demonstrating that some patients show intact category learning while others do not (Vallila-Rohter & Kiran, 2013a). Furthermore, measures of nonlinguistic learning ability have been found to depend on stimulus characteristics (Vallila & Kiran, 2013b), and correlate with progress with therapy (Vallila-Rohter & Kiran, under review). In the current study, we used functional magnetic resonance imaging (fMRI) to better understand the neural mechanisms engaged in category-learning in patients with aphasia. Methods: Four patients with aphasia (PWA, 1 female) and three age-matched right-handed control participants (all male) completed our study. PWA were premorbidly right handed, had a single left hemisphere stroke and were at least six months post onset of stroke. Participants completed nonlinguistic tasks in which they learned to categorize novel animals as belonging to one of two categories (Vallila-Rohter & Kiran, 2013a). Stimuli were fictional animals that varied on ten binary dimensions. Two maximally different animals were selected as prototypes. Categories were established along a continuum based on the number of features shared with each of the two prototypes. Animals appeared one at a time in training and participants were instructed to guess each animal's category affiliation via button press, receiving feedback related to accuracy after each trial. The perceptual-motor baseline required participants to determine whether animals appeared alone or in a pair. Functional and structural images were acquired using a 3T 6-channel scanner. Training was organized in a block design, alternating between four learning and five baseline trials. Functional and behavioral data were collected as participants completed 100 learning and 96 baseline trials. We examined the contrasts learning>baseline and testing>baseline. Results: Behavioral analyses revealed that two patients with aphasia successfully learned category tasks, while two did not. Functional imaging analyses produced small clusters of activation during training relative to baseline for patient learners. Of particular interest were activations in the right middle frontal gyrus (MFG) and right inferior frontal gyrus (IFG). In contrast, the two patients who did not show successful category learning produced patterns of diffuse activation bilaterally in frontal, temporal and visual regions. Similarly, control learners had small clusters of activation bilaterally, while non-learners had diffuse bilateral activation. Summary: Results demonstrated that behavioral differences in success with category learning were reflected in differential neural engagement during learning. Patients who learned categories efficiently recruited right hemisphere areas (MFG and IFG), consistent with previous studies involving similar feedback-based category learning in which significant activations were observed bilaterally in the IFG and MFG (Poldrack et al, 1999). In contrast, participants who exhibited poor learning across trials had diffuse activations suggestive of increased effort, monitoring, and executive functioning throughout learning.

A67 Functional MRI confirms subjective experience of internal naming success in aphasia

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Introduction: Stroke frequently causes language impairment, called aphasia, which may present with impaired comprehension and/or production, but always involves difficulties with naming and word finding. Many people with aphasia report naming words correctly internally (i.e. "it sounds right in my head") even when they say a word aloud incorrectly. This difference between internal and overt speech may represent a disruption after a phonological word form is retrieved. We examined this effect with fMRI to compare brain activity for correct vs. incorrect naming, judged either by actual spoken output or by self-report in two patients. Method: Two men with post-stroke aphasia were examined. One is a 65 year-old right-hander with moderate Broca's aphasia from an ischemic left middle cerebral artery (MCA) stroke 2 years

ago; the second is a 52 year-old left-hander with moderate mixed aphasia after an ischemic right MCA stroke 3 years ago. Over 3 days, a corpus of line drawings was used to identify words that were consistently named correctly or incorrectly out loud. BOLD fMRI data were then obtained while the subjects named these pictures "in their heads" and pressed a button to indicate whether they internally named each item correctly. Results: Both participants reported correctly naming multiple items "in their heads" that they were never able to name correctly aloud. In one subject, the activity related to these items was nearly identical to that associated with items he could reliably name aloud, whereas the items that he reported failing to name "in his head" activated largely non-overlapping areas. For the second subject, the overall pattern of activity appeared similar regardless of his ability to produce correct responses aloud or name items only "in his head." However, interaction analyses uncovered different activation patterns attributable to internal correctness, but not to overt naming accuracy. Conclusions: People with aphasia frequently report being able to internally produce words that they are not able to say aloud. Here, we have provided neurophysiological evidence confirming their subjective experience of internal word retrieval. The same neural substrates are recruited for items perceived as internally named correctly regardless of whether the verbal output is correct. Further, different brain areas are recruited when internal naming fails. Additional research on self-reported internal word retrieval may elucidate the neural and psychological stages of processing at which anomic events occur, and have direct therapeutic implications.

A68 Beta band oscillations during basic sentence comprehension in patients with schizophrenia *Kirsten Weber[1,2,3], Ellen Lau[1,2,3,4], Nathaniel Delaney-Busch[3], Matti Hämäläinen[1,2], David Henderson[1,2], Gina Kuperberg[1,2,3]; [1]Harvard Medical School, [2]Massachusetts General Hospital, [3]Tufts University, [4]University of Maryland*

Comprehending a sentence requires us to bind individual words together to form a coherent message-level representation. There is evidence that, during incremental processing, we are able to use this message-level representation to predict which words are likely to come up next. In patients with schizophrenia, there is evidence that top-down language processing mechanisms like prediction are impaired (Kuperberg, 2010, Boudewyn et al., 2012). Most of this evidence comes from event-related analyses of electrophysiological measures, which index the consequences of top-down prediction for processing an incoming individual word. Here, we took a complementary approach, carrying out a frequency analyses of MEG data, focusing on power in the beta band. In healthy individuals, beta activity is increased during sentence reading compared to random word lists (Bastiaansen et al. 2010). This increase is thought to more directly reflect the build-up of the message-level representation that is used to predict upcoming words (Weiss & Mueller, 2012). If predictive impairments in schizophrenia stem from impairments in building a message-level representation of context, beta band modulation should be abnormal. To test this hypothesis, we conducted an MEG experiment in which 20 patients with schizophrenia and 20 demographically-matched controls read sentences and random word lists, presented word by word. Epochs of 500 ms around each word, from the 3rd word onwards (resulting in 140 segments per condition), were computed as well as a pre-sentence baseline of 500 ms. Frequency analyses on these entire segments were performed using multitapers. A one-sided t-test was run using non-parametric cluster statistics (Maris & Oostenveld, 2007) over a frequency range from 4 to 30 Hz using an alpha level of 0.05. As expected, the frequency analysis showed significant increases in beta band power (15 to 25 Hz) in sentences compared to word lists in healthy controls. This effect was not seen in the schizophrenia patients. Moreover, a group comparison showed significant differences in the beta frequency range between the two groups. Even at this basic level of sentence comprehension, oscillatory signatures are impacted in patients with schizophrenia. We tentatively suggest that this might reflect impairments in the build-up of a coherent sentence context to predict upcoming words during language comprehension.

A69 Silences in speech in primary progressive aphasia *Sharon Ash[1], Danielle Weinberg[1], Jenna Haley[1], Ashley Boller[1], John Powers[1], Corey McMillan[1], Murray Grossman[1]; [1]Perelman School of Medicine, University of Pennsylvania*

Efforts to characterize variants of primary progressive aphasia (PPA) on the basis of language-based clinical characteristics have met with difficulty. Nonfluent/agrammatic PPA (naPPA) has been described as "effortful," although the nature of effortfulness has not been well defined. These patients also have grammatical difficulty. Semantic variant PPA (svPPA) is distinguished by impairments of semantic memory and object knowledge, and these patients have difficulty with confrontation naming. The present study quantifies the pattern of pauses in the speech of patients with PPA to determine how these pauses contribute to the apparent effortfulness of speech and how they relate to grammatical impairments and word-finding difficulty. We studied 34 patients, including 19 with naPPA and 15 with svPPA, and 19 healthy seniors. A semi-structured sample of spontaneous connected speech was elicited by the narration of the story of a wordless children's picture book. The digitized speech samples were analyzed for pauses longer than 2.0 sec within utterances. We assessed the occurrence of these pauses in environments preceding or within a noun phrase (NP) and preceding or within a verb phrase (VP). Voxel-based morphometry was used to relate gray matter atrophy to measures of performance. naPPA patients produced long pauses more than other subject groups and paused in

all environments indiscriminately, which contributed to the slowing of their speech. Only naPPA had significant pauses associated with verb phrases. svPPA patients paused more frequently in NPs compared to VPs. Pausing in the patient groups was related to differing cortical regions of the left hemisphere: to prefrontal and inferior temporal regions in naPPA and to temporal regions in svPPA. The frequent occurrence of long pauses within utterances contributes to the impression of effortfulness in the speech of naPPA patients. Unlike the other groups, naPPA patients pause in the production of verb phrases as much as in the production of noun phrases, and this is linked to their grammatical difficulty. svPPA patients pause more in noun phrases than in verb phrases, which may be related to their semantic impairments. svPPA is relatively spared in verb phrase production with respect to long pauses.

A70 Reduced hemispheric asymmetry in the use of weak sentential context in schizotypy *Edward W. Wlotko[1,2]; [1]University of Illinois, [2]Tufts University*

Schizotypy is associated with the reduced tendency to use context to activate appropriate related information and/or inhibit inappropriate information during language comprehension, mirroring language-related symptoms often seen in schizophrenia. Evidence suggests that one potential factor leading to these language disturbances is disrupted structural and functional lateralization of the cerebral hemispheres. To assess electrophysiological patterns of hemispheric asymmetry during message-level sentence processing in schizotypy, healthy college student volunteers were asked to read entirely plausible sentences varying in contextual strength, while the electroencephalogram was recorded. Strongly constraining and weakly constraining sentence frames were completed with expected words, unexpected words related to (synonymous with) expected words, or unexpected and unrelated words [e.g., Strongly Constraining: The ship disappeared into the thick FOG/MIST/SMOKE. Weakly constraining: Larry chose not to join the ARMY/MILITARY/PARTY]. Sentence-final critical words were presented in the left or right half of the visual field (LVF/RVF), biasing processing to the contralateral hemisphere. Inferences about hemispheric asymmetry are based on patterns of event-related brain potentials (ERPs) elicited by these words, as a function of visual field. Analyses focused on the N400 component of the ERP, a functionally specific index of semantic processing. The amplitude of the N400 is reduced whenever demands on semantic processing are eased. Semantic 'facilitation' due to sentence context was assessed by subtracting ERPs for expected and related endings from ERPs to unrelated endings, for strong and weak constraint. N400 effects were measured on the resulting difference waves as mean amplitudes from 300-500 ms over all electrodes. Each participant completed the Schizotypal Personality Questionnaire (SPQ), a non-diagnostic self-report measure of the expression of schizotypal personality traits. The Pearson correlation coefficient was calculated between scores on each sub-scale of the SPQ and the degree of asymmetry of N400 effects (raw difference in facilitation scores for LVF and RVF). The sub-scale of Odd Speech significantly correlated with asymmetry of facilitation for related endings in weak contexts. Whereas the overall group average showed larger RVF (vs. LVF) facilitation for related endings in weak context, increased Odd Speech scores were associated with reduced asymmetry (r=.52). This relationship was driven by a reduction in facilitation for RVF items rather than an increase for LVF items, consistent with literature suggesting that measures of abnormal language production and disorganized thought are associated with decreased activation of weakly related information in sentences. No significant correlations were observed for facilitation of strongly related words, nor for expected words, implying that the reduced activation for weakly related items is not explained by an overall inability to gain information from sentential context. These results, obtained within a non-clinical sample of undergraduates from the general university population, demonstrate that individual differences in self-report measures of schizotypal personality traits can identify neurobiological differences related to sentence comprehension that are similar to those observed in schizophrenia. Future work investigating changes in hemispheric asymmetries across non-clinical manifestations of schizotypal traits, schizotypal personality disorder, and schizophrenia may reveal fundamental features underlying schizotypal traits as well as features specific to pathological disordered thought and psychosis in schizophrenia.

A71 Language and communication abilities in depression and Mild Cognitive Impairment: a comparative study *Lilian C. Scherer[1], Fernanda S. Loureiro[2], Eduardo L. Nogueira[2], Michele Beckert[2], Gislaine M. Jerônimo[1], Bruna Tessaro[1], Irênio G. da Silva Filho[2]; [1]Pontifical Catholic University of Rio Grande do Sul (PUCRS), Linguistics Department, Brazil, [2]Pontifical Catholic University of Rio Grande do Sul (PUCRS), Biomedical Gerontology, Institute of Geriatrics and Gerontology Brazil*

Introduction: In a worldwide increasing aging population, there is a growing necessity of investigating cognitive features that may signal the onset of cognitive decline, as well as depressive symptoms. This is relevant since it is not an easy task distinguishing depressive symptoms from those generated by neurodegenerative diseases, such as Mild Cognitive Impairment (MCI). Very few studies have concentrated on analyzing the relationship between linguistic and communication performance and depression and MCI. Aim: The aim of this study was to analyze the performance of two aged adult groups, diagnosed with depression and MCI, compared to a healthy group, while performing language tasks. More specifically, we analyzed their performance while orally producing discourse in free and controlled narratives, in narrative comprehension and retelling, as well as in performing linguistics tasks at

the word and sentence levels, including verbal learning of word lists, naming, categorizing and interpreting proverbs. Method: Participated in the study 124 aged adults (aged 58-89 years, mean 68.72), classified according their schooling level as illiterate (25,7%), low education level (71.5%) and higher education level (11 years of schooling, 2.8%), assisted at the Brain Aging Ambulatory (Ambulatório de Envelhecimento Cerebral-AMBEC), at São Lucas Hospital, at the Pontifical Catholic University of Rio Grande do Sul (PUCRS), Brazil. The following procedures were adopted for data collection: cognitive assessment (Adenbrook), psychiatric evaluation (GDS), and language assessment: controlled narrative production (Cookie Theft Picture), free narrative production (narrating a recent event), comprehension and retelling of oral narrative, verbal learning of word lists; naming and semantic knowledge tasks (categorization and proverb interpretation). Results: Average values and standard deviation were calculated comparing the three groups. An ANOVA was conducted, indicating that there were significant differences between the performance in all linguistics tasks in the comparison between healthy participants and those diagnosed with MCI. No significant linguistic deficits were observed in the performance of the group diagnosed with depression in comparison to the other groups. A second statistical analysis was conducted in order to correlate linguistic data with the GDS scores. Again, no correlation was found between language performance and depressive symptoms. Conclusion: Our results seem to corroborate previous studies indicating the preservation of linguistic abilities in depression. Also, data have shown that MCI patients do not benefit from cues in verbal learning tasks, corroborating evidence brought by previous research with this population. Thus, an understanding of linguistic features associated to cognitive impairment may aid its diagnosis and treatment in order to postpone its emergence. Moreover, language and communication abilities assessment may represent an important tool to aid a differential diagnosis between patients with depression from those with MCI.

A72 Right brain, wrong verb: functional neuroanatomy of action naming in aphasia *Olga Dragoy[1], Maria Ivanova[1], Svetlana Malyutina[2], Elena Kozintseva[1,3], Yulia Akinina[1], Daniil Sevan[3], Svetlana Kuptsova[1,3], Aleksey Petrushevsky[3], Oksana Fedina[3], Evgeny Gutyrchik[4]; [1]National Research University Higher School of Economics, Russia, [2]University of South Carolina, [3]Center for Speech Pathology and Neurorehabilitation, Russia, [4]Ludwig Maximilian University of Munich, Germany*

In previous research on object naming in aphasia perilesional activation in the left hemisphere, sometimes along with recruitment of right inferior frontal regions, has been associated with correct naming responses (Fridriksson et al., 2009; Postman-Caucheteaux et al., 2010). At the same time semantic paraphasias produced in a naming task were related to additional activation of right temporal-occipital areas (Fridriksson et al., 2009). The current fMRI study aimed to further extend these findings by examining action naming and attempting to link verb production efficiency to specific cortical regions. Nineteen healthy individuals and 6 chronic patients with aphasia (half with non-fluent and half with fluent) due to left hemisphere damage were tested using an overt picture naming task in a block-design fMRI paradigm. In the experimental condition, participants were presented with drawings of actions and had to name an action with a single verb. In the baseline condition, they uttered a constant pseudo-verb in response to abstract pictures constructed by digital distortion of real drawings. Behavioral profiles of patients were assessed in a separate action naming test out of the scanner using the same stimuli. Action naming contrasted to the baseline condition elicited specific activation in the left inferior frontal cortex in healthy participants, providing support for the critical role of the latter in verb production. Two patients with relatively spared action naming (91% and 90% correct, 5% and 1% semantic paraphasias) showed a similar activation pattern, although extended to the right homologue in one of them. Additional activation in two patients with decreased naming performance (81% and 79% correct, 18% and 12% semantic paraphasias) was found in the left temporal lobe. Yet another two patients with the poorest behavioral profiles (53% and 47% correct, 43% and 52% semantic paraphasias) showed increased temporal activation bilaterally. The data suggest that left temporal activation is associated with a relatively productive attempt to overcome increased action naming difficulty and moderate lexical-semantic search deficit, which results in an increased but not excessive number of semantic paraphasias. In contrast, in poor performers, the left hemisphere resources are insufficient and broader semantic maps of the right temporal regions are recruited providing inadequate semantic specification, thus leading to high percentage of semantic errors. These findings are in line with research demonstrating that effective language processing relies primarily on the language network of the left hemisphere (Fridriksson et al., 2010; Price & Crinion, 2005; Saur et al., 2006) and that recruitment of right hemisphere regions (particularly posterior ones) is associated with more pronounced naming errors (Fridriksson et al., 2009; Postman-Caucheteaux et al., 2010).
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Poster Session B

Thursday, November 7, 9:50 – 11:50 am, Emerald Ballroom

Auditory Perception, Speech Perception, Audiovisual Integration

B1 The neural basis of speech perception is task-dependent: a lesion study *Corianne Rogalsky[1], Kristin Raphel[2], Vivian Tomkovicz[2], Tasha Poppa[1], Steve Anderson[3], Hanna Damasio[2], Tracy Love[4], Gregory Hickok[1]; [1]University*

of California, Irvine, [2]University of Southern California, [3]University of Iowa, [4]San Diego State University and University of California, San Diego

The neural basis of speech perception is hotly debated, particularly regarding the role of the motor system, with several conflicting findings attested. A major roadblock in resolving this debate is the confusion that task-specific effects may cause. For example, much of the evidence for motor involvement comes from syllable discrimination type tasks, which have been found to doubly dissociate from auditory comprehension tasks. The present study is the first, to our knowledge, to directly compare within subjects the neuroanatomy crucially involved in syllable discrimination compared to auditory comprehension tasks using voxel-based lesion symptom mapping (VLSM). Patients with left hemisphere focal chronic lesions (n= 58) and right hemisphere controls completed an extensive psycholinguistic battery including syllable discrimination and auditory comprehension tasks. For the syllable discrimination task, VLSM analyses identified a temporal-parietal voxel cluster, including area Spt and extending into primary auditory and somatosensory cortex. Conversely, the auditory comprehension task was not associated with damage to this same network, but rather implicated left mid-temporal regions. To further address frontal motor involvement in the discrimination task, a series of additional VLSMs were conducted using damage in Spt, Broca's area, premotor, and precentral regions as covariates, respectively. These analyses of covariance indicate that the temporal-parietal involvement in the discrimination task is independent of damage to the frontal lobe regions. Also, once Spt damage is factored out, there is no apparent contribution of individual frontal regions to the discrimination task. Overall, these results indicate that speech discrimination tasks engage dorsal temporal-parietal regions, whereas auditory comprehension tasks engage more ventral temporal regions. Our findings are evidence that speech discrimination tasks do not engage the speech networks involved in typical speech comprehension processes, and that frontal regions are not implicated in auditory comprehension.

B2 Temporal dynamics of selective auditory attention, discrimination and sequencing: anatomically constrained aMEG studies. *Paula Tallal[1], Matt Erhart[2], Terry Jernigan[2], Timothy T. Brown[2]; [1]Rutgers University, Newark, [2]UCSD*

Auditory attention, discrimination, and sequencing are fundamental to language development in humans and have been linked to a variety of developmental disorders including Autism, ADHD, SLI, CAPD and Dyslexia. We completed anatomically constrained MEG (aMEG) in 20 healthy adults with tasks that probed these auditory processes. The motor demands and sensory stimuli were identical across tasks. Subjects were presented with two 70 ms tones with a constant 75 ms inter-stimulus-interval, which varied by ear of presentation and by frequency, then pressed one of two buttons according to task instructions. The same subjects and series of stimuli were used in each task. In the selective attention task subjects were trained to report ear (right or left) stimulated last. In the discrimination task, the same subjects were trained to report whether the tones were the same or different in frequency. In the sequencing task, subjects were trained to report the temporal order of tones (was the high or low tone presented second?). Behavioral data showed that, across all tasks, response times were slower when tones were incongruent for ear of presentation and tone frequency (i.e., when the first tone was heard in a different ear or with a different frequency than the second tone). Also, consistent with a left ear, right hemisphere (RH) advantage for processing non-speech stimuli, in combination with the congruency effect, response times in all tasks were fastest when both tones were presented to the left ear. Neurophysiologically, the highest amplitude cortical responses occurred between 90 and 150 ms across subjects and were localized to the posterior aspect of superior temporal gyrus, including Heschl's gyrus. This is consistent with lesion-behavior mapping studies of primary auditory cortex as well as with fMRI and intracranial recording studies. As expected for non-verbal auditory stimuli, the RH showed greater sensitivity [amplitude] to and faster processing [peak latency] of tone stimuli than the left hemisphere (LH). Consistent with dichotic listening and other behavioral studies, for both tones, the largest amplitudes were found in the hemisphere contralateral to ear of presentation, particularly when tones were delivered to the left ear. This same pattern was found for peak latency, but only for tone one. For the second tone, the RH latency was faster, regardless of ear of presentation. That is, the contralateral effect was significantly diminished. It has been inferred from behavioral and lesion studies that each ear has a stronger connection to the contralateral hemisphere. A LH [right ear] advantage has been shown for fast- changing stimuli, such as speech, while a RH [left ear] advantage has been shown for processing slower, non-speech auditory stimuli. Using aMEG, which has good spatial resolution, coupled with millisecond temporal resolution, we show the neurophysiological dynamics of this ear-hemisphere relationship including a rightward preference for tone processing within this time window, regardless of whether tasks require selective attention, discrimination or sequencing of acoustic stimuli. Current studies are investigating ear-hemisphere relationships for speech and non-speech stimuli differing in temporal dynamics.

B3 Audio-visual integration deficits in Alzheimer's Disease (AD): clinical and theoretical implications *George Stothart[1], Nina Kazanina[1]; [1]University of Bristol*

The aims of our ERP investigation of audio-visual integration of speech in AD patients were two-fold: to further understanding of multi-sensory processing in AD, and to further inform theories of multisensory information processing. Fourteen patients with probable AD (aged 64-91, mean age 79.5 (±7.2), mean MMSE 22.2 (±2.8), 4 males) and 26 healthy age-matched controls (aged 62-88, mean age 76.0 (±7.0), mean MMSE 29.1 (±1.0), 14 males) watched a speaker repeatedly pronouncing a syllable. The audio played was always a /ba/ syllable, and in 89% of presentations the articulation in the corresponding video represented /ba/ movements (congruent standard). Occasionally in 11% of presentations(an 8:1 ratio of standards to deviants) the video presented a /ga/ articulation (incongruent deviant); the incongruent audio /ba/ + visual /ga/ stimulus predominantly elicited the McGurk illusion, i.e., a fused percept /da/. An auditory-only condition in which a standard stimulus /ba/ was interspersed with a deviant /da/ (8:1 ratio) was used as a control. Participants' EEG was recorded and averaged relative to the onset of the audio in each condition. In the audio-only paradigm, AD patients' early ERP responses (in particular, P50 and N100) did not differ from healthy older adults'. In the audio-visual paradigm healthy older participants showed an effect of visual information congruency, i.e., N100 amplitude was larger in the congruent than incongruent condition; however, this effect was absent in the AD group. The lacking effect of visual congruency in AD patients stood in contrast to the fact that the same participants registered the presence of visual information similarly to healthy older adults (as suggested by both groups demonstrating an increased N1 compared to the auditory-alone condition). Cumulatively, our findings clearly pointing to deficiency in multisensory processing in AD and receive a natural explanation by bringing the superior-temporal sulcus (STS) into focus, a critical structure in audiovisual binding (Campanella & Belin, 2007) and known to be a site of significant AD pathology (Killiany et al., 2000). This supports the disconnection syndrome hypothesis of AD (Delbeuck et al., 2003) which accounts for deficits in audiovisual binding as a consequence of impaired superior-temporal sulcus (STS) function in AD, in the absence of unimodal deficits. On the theoretical side, our findings on healthy and pathological ageing provide support to the dual route model of speech processing proposed by Arnal and colleagues (Arnal et al., 2009). The model proposes firstly that the visual articulatory information has a general priming effect on the auditory cortex, and secondly that congruency is monitored via a feedback loop between the STS and primary auditory cortex. In our study AD patients showed an unimpaired first phase (i.e., a priming effect of articulatory information which was represented by an increased N1 in the presence of visual information). However the second phase – congruency monitoring – was impaired, as demonstrated by the equivalent N1 amplitudes to congruent and incongruent visual information in AD patients. Further evidence from healthy-aged controls for the dual-route model of speech processing will also be discussed.

B4 Auditory Deficits Correlate to Atrophy in the Logopenic Variant of Primary Progressive Aphasia

A. Lisette Isenberg[1], Jamie Reilly[2], Murray Grossman[1]; [1]University of Pennsylvania, [2]University of Florida

The logopenic variant of primary progressive aphasia (lvPPA) is characterized by progressive impairments in single word retrieval and repetition. Additional deficits include phonological errors in spontaneous speech and naming as well as mixed reports of receptive language ability at the level of a sentence or phrase. Single word comprehension is typically spared. One hypothesis attributes this set of behavioral deficits to degradation of the phonological short-term memory network (Gorno-Tempini et al 2008). Consistent with this view, structural imaging in lvPPA has shown gray matter (GM) atrophy predominantly in left hemisphere posterior peri-Sylvian regions (Gorno-Tempini et al 2008), often extending anteriorly into neighboring auditory and language association cortex. Functional neuroimaging evidence in healthy adults has implicated these regions in tasks supporting phonological short-term memory and speech perception (Hickok, 2009), although integrity of phonological processing following auditory association cortex disease has been difficult to demonstrate. Previous reports investigating speech perception and phonological processing have used syllable discrimination and auditory comprehension tasks. In aphasic patients, data suggests a dissociation between the regions that correspond to deficits in these two tasks (Schwartz, et al, 2012, Dronkers et al, 2004, Rogalsky et al, submitted). Here we examine the contribution of GM atrophy in lvPPA to speech and language perceptual processing using performance on an auditory perception task involving syllable discrimination. To investigate the integrity of perceptual processes supporting auditory comprehension in a more ecologically valid context, additional data were collected in a subset of patients using an auditory speech comprehension task. We recruited lvPPA patients who were diagnosed using published criteria (Gorno-Tempini et al, 2011). Healthy senior controls were comparable for demographic variables. Participants heard pairs of consonant-vowel syllables and made same-different judgments for the discrimination task. The onset consonant in half of these pairs differed phonologically by voicing and manner of articulation. In the auditory comprehension task, participants were asked to point to the picture matching the word they heard. We performed volumetric MRI analyses in lvPPA relative to seniors, and regression analyses to relate lvPPA performance on the syllable discrimination task to GM atrophy. Patients were impaired in their judgments relative to controls for the auditory discrimination task. Auditory comprehension however was unimpaired. lvPPA had left lateralized GM atrophy

in posterior peri-Sylvian, temporal and parietal regions FDR corrected ($p<.05$), similar to previous findings (Gorno-Tempini et al 2008). Regressions related deficits on the discrimination task to observed atrophy in posterior portions of parietal GM associated with the dorsal stream language network as well as auditory/language association regions in the posterior superior temporal lobe associated with early ventral stream processes. A large-scale neural network involving posterior peri-Sylvian cortical regions as well as canonical auditory and language association cortex contributes to the unique pattern of task sensitive impairments involving the phonological short-term memory network observed in lvPPA. These findings suggest a neuroanatomic basis for the deficits in task related phonological discrimination processes in patients with a focal neurodegenerative condition.

B5 Top-down effects from sentence context on speech processing in aphasia *Neal Fox[1], Sheila E. Blumstein[1,2]; [1]Brown University, [2]Brown Institute for Brain Science*

Understanding speech requires the online integration of information from multiple levels of the grammar. Evidence from past research has shown that perceiving ambiguous sounds and words is influenced by higher-level information sources including semantic (Borsky et al, 1998) and syntactic (Fox & Blumstein, submitted) sentence context. The neural basis of this online integration of information, however, remains unclear. In particular, it is unclear whether patients with Broca's aphasia (BAs), who display deficits in syntactic processing (Swinney et al, 1996), or patients with Wernicke's aphasia (WAs), who show deficits in semantic processing (Zurif et al, 1974), are able to make use of top-down information from sentential context in the identification of ambiguous words. In two experiments examining the influence of semantic (Experiment 1) and syntactic (Experiment 2) sentential context on spoken word recognition, 3 BAs, 3 WAs, and 8 age-matched control subjects (Cs) identified both good exemplars and acoustically ambiguous target word stimuli preceded by auditorily presented sentence fragments. In Experiment 1, subjects heard target tokens from a goat-coat continuum in goat-biasing (e.g., He milked the…) or coat-biasing (e.g., He hemmed the…) sentence contexts. They indicated whether the target was goat or coat on each trial by pressing the appropriate response key. In Experiment 2, subjects heard target tokens from a bay-pay continuum in noun-biasing (e.g., Tom liked the…) or verb-biasing (e.g., Dennis liked to…) sentence contexts. They indicated whether the target was bay or pay by pressing the appropriate response key. In both experiments, the voice-onset time of the initial consonant of natural speech tokens was manipulated to create a continuum containing both exemplar and boundary value (ambiguous) stimuli. To determine whether there were changes in the perception of the ambiguous stimuli as a function of the context, the mean difference in voiceless responses to the ambiguous stimuli was computed. Results for Experiment 1 showed that, Cs were more likely to label an ambiguous g/coat token as coat in coat-biasing compared to goat-biasing contexts (difference = 11%), as were BAs (difference = 5%). WAs, however, did not show this pattern (difference = -3%). These results indicate that WAs displayed an impairment relative to Cs and BAs in the integration of semantic context during speech processing. In Experiment 2, Cs were more likely to label an ambiguous b/pay token as pay in verb-biasing compared to noun-biasing contexts (difference = 21%). WAs showed a similarly large effect (difference = 33%). BAs showed a reduced effect size compared to Cs and WAs (difference = 17%). These results indicate that BAs displayed an impairment relative to Cs and WAs in the integration of syntactic context during speech processing. Taken together, these findings indicate that separate neural mechanisms are engaged in semantic and syntactic computations that lead to top-down effects on speech perception. They also suggest that semantic processing deficits shown by Wernicke's aphasics and syntactic processing deficits displayed by Broca's aphasics may affect their ability to efficiently use these information sources in context to help compensate for the variability in the sensory speech input.

B6 Music Perception in Aphasia: Relationship to Aphasia Subtype and Lesion Site *Juliana Baldo[1], Barbara Tillmann[2], Timothy Justus[3]; [1]VA Northern California Health Care System, [2]Lyon Neuroscience Research Center, [3]Pitzer College*

An unresolved question in cognitive neuroscience is the degree of neural association between music and language. Does the perception of language make use of cognitive and neural resources that are also used for the perception of music, and vice versa? Previous studies of both healthy individuals and brain-injured patients have produced conflicting results, with some data suggesting that music and language are subserved by overlapping neural regions, and other data suggesting that the underlying brain regions are distinct. Our goal is to address this question by testing a group of left hemisphere patients with varying degrees of speech and language deficits on a series of music perception tasks. We have tested six right-handed individuals (1 female, 5 male) with a history of left hemisphere stroke whose aphasic symptoms range from mild to severe. At the time of testing, two of the individuals had Wernicke's aphasia, and the others presented with anomia. Participants were administered the Montreal Battery for the Evaluation of Amusia (MBEA; Peretz, Champod, & Hyde, 2003). Here, we report data from the first four tests of the MBEA: detecting melodic changes with respect to scale, contour, and interval (tests 1-3), and detecting rhythmic changes (test 4). For each condition, participants were presented with 30 experimental trials that consisted of a brief melody, followed by an inter-stimulus interval of 2000 ms, and then another brief melody. The participants' task was to determine whether the two melodies were the same or

different. Half of the melodies were the same, and half of the melodies differed by a single pitch or rhythmic change. As a group, left hemisphere patients with aphasia performed in the impaired range on the melodic conditions of the MBEA, but they performed in the low average range on the rhythmic condition. However, there was a great deal of variability in performance that was not predicted by linguistic variables such as overall aphasia severity, aphasia subtype, and auditory/speech comprehension, or by other factors such as lesion volume and prior musical background. Interestingly, the two patients who performed worst across all blocks (2.5-6.0 SDs below controls) had lesions that overlapped in left posterior superior temporal cortex, a region that has been previously implicated in speech perception. These findings support the notion that left hemisphere regions critical to speech perception also play a role in the perception of musical structure. Future work with larger numbers of aphasic individuals will evaluate the robustness of these findings and allow for more detailed analyses of the left peri-Sylvian regions most essential to the melodic and rhythmic components of the MBEA.

B7 Alpha phase as a marker of biased speech-in-noise perception *Antje Strauss[1], Molly Henry[1], Mathias Scharinger[1], Jonas Obleser[1]; [1]Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany*

Noise detrimentally affects speech perception, since it degrades the available sensory evidence. Degradation, however, increases the impact that other external variations (e.g., the speech context, the listener's task, etc.), as well as internal brain states, might have on the listener' interpretation of the sensory evidence. As for the role of brain states, neural changes in cortical excitability, measured in terms of the phase of neural oscillations, are associated with variations in perceptual sensitivity, at least for low-level stimuli. Pre-stimulus phase modulations in the alpha band (8–12 Hz) can partly explain differences in detection or discrimination accuracy of visual stimuli (e.g., Busch & VanRullen 2009). A similar impact of (slower, 1–4 Hz) pre-stimulus oscillatory phase on auditory detection has also been shown (Ng et al., 2012; Henry & Obleser, 2012). This latter finding is particularly relevant in light of recent models emphasizing the role of slow neural oscillations for speech comprehension (e.g., Ghitza et al., 2011; Giraud & Poeppel, 2012). However, it is unclear whether brain-state-dependent performance similarly permeates to higher, more cognitive levels. Here, we asked whether neural phase could also impact lexical decisions in an experimental lexical-decision-in-noise setup where perceptual errors occur frequently. Participants (N=11) performed a lexical decision task on real words, ambiguous pseudowords (differing only in one vowel from real words), and opaque pseudowords (derived by scrambling syllables across items). They were presented in individually-thresholded noise, while the electroencephalogram (EEG) was recorded. Listeners made more lexical decision errors for ambiguous pseudowords than for real words or opaque pseudowords. This was due to decreased perceptual sensitivity (d') as well as a significant bias (c) to respond "word" to ambiguous pseudowords. Importantly, neural phase differences in the EEG alpha band were able to predict accuracy of lexical decisions. Specifically, correct versus incorrect trials were characterized by opposite phase angles in the 8–12-Hz band in two time windows. One cluster with a right anterior distribution was found ~75 ms prestimulus-onset, likely reflecting differential excitatory states, and thus preparedness for processing upcoming input. A second cluster was found during stimulus presentation (~500 ms post-onset) with a left-central distribution. Alpha phase differences in this late processing stage might mark already the outcome of lexical processing and impact the ensuing decision more directly. Critically, both phase effects were observed in the absence of ERP or alpha power differences. In sum, speech perception in adverse listening situations can become substantially biased by the speech context (here, the 'wordness' of an ambiguous pseudoword). However, such external influences are met by the internal state of the listener (here, the instantaneous phase in alpha frequency band at two separate time points and topographical locations). The results demonstrate that neural alpha oscillations possess explanatory power with respect to cognitive functions such as lexical decision-making; they also underscore how speech and language studies can profit from embracing experimental protocols from low-level perceptual science.

B8 How the Brain Processes Talker Variability: The Role of Expectation *Emily Myers[1,2,3], Laura Mesite[2,3], Alexis Johns[1,3], James Magnuson[1,3]; [1]University of Connecticut, [2]Brown University, [3]Haskins Laboratories*

Different talkers produce speech that differs substantially in its acoustic properties. Many models of language comprehension assume that when listening to spoken words, listeners somehow accommodate this acoustic variability by mapping stimulus properties to perceptual categories, a hypothesized process referred to as "talker normalization" (in contrast, episodic theories claim that exemplar aggregation could provide phonetic constancy without normalization, e.g., Goldinger, 1998). One crucial phenomenon that motivates normalization theories is that listeners are slower to recognize speech when the talker changes from stimulus to stimulus than when the talker is constant. One study suggests that this multi-talker processing penalty is at least partially subject to effects of expectation (Magnuson & Nusbaum, 2007), suggesting that normalization is not an automatic process. In that study, a framing manipulation led two groups of listeners to believe that they were about to hear words spoken by either one talker (1T group) or two talkers (2T). Both groups heard the same stimuli, half of which were synthesized with a slight (~10hz) increase in fundamental frequency (F0). Both groups performed a word monitoring

task. In 'blocked' trials, F0 was constant. In 'mixed' trials, F0 varied randomly from word to word. 1T subjects were instructed that pitch variation was an attempt to make the stimuli more natural sounding, but that all words were produced by the same talker. 2T subjects were instructed that the pitch difference was due to a talker change. The 1T group showed no multi-talker penalty, whereas the 2T group showed the usual multi-talker penalty. This result indicates that, at least when acoustic differences between talkers are small, the talker normalization process may be modulated by expectation. However, it is unclear whether this expectation effect arises from decision-level processes, or whether it percolates to lower levels of processing. In our study, we adapted this paradigm to fMRI in order to examine brain bases of talker normalization. Thirty participants were divided into two groups (1T, 2T). Before scanning, each group heard a framing manipulation which led them to expect to hear one or two talkers, respectively. Next, all participants performed an identical word monitoring task, in which they listened to trials of 16 word stimuli, and pressed a button whenever they detected the visually presented word that remained on screen throughout the trial. Within a block, all stimuli were either from the same "voice" (blocked) or alternated randomly between two "voices" (mixed). Analyses examined main effects of expectation and blocking (blocked vs. mixed), and their interaction. Greater activation for mixed vs. blocked trials was observed in a large right superior temporal gyrus (STG) cluster, consistent with other data showing that talker normalization may recruit right temporal regions. A cluster in the right posterior STG and extending into the supramarginal gyrus showed a significant interaction, with greater activation in each group for the unexpected listening condition, suggesting that greater neural resources are expended in listening conditions that do not conform to expectations. Results are discussed in the context of current theories of speech perception and word recognition.

B9 Human superior temporal gyrus encoding of speech sequence probabilities *Matthew Leonard[1], Kristofer Bouchard[1], Edward Chang[1]; [1]University of California, San Francisco*

Spoken word representations are hypothesized to be built from smaller segments of the speech signal, including phonemes and acoustic features. This process involves integrating acoustic and higher-level linguistic knowledge, however the specific operations involved in transforming an acoustic neural code into a lexical code are largely unknown. One feature of speech that is speculated to play a role in linking sub-lexical representations is the language-level statistics of sound sequences, also known as phonotactics. Lifelong exposure to phonetic sequences likely shapes the organization and synaptic weights of neural networks that process sounds in a given language. We hypothesized that speech auditory cortex encodes phonotactics in real-time, and that this encoding plays an important role in the acoustic-lexical transformation. To address this hypothesis, we recorded and analyzed electrocorticographic (ECoG) neural activity in the high-gamma (HG) frequency range (70-150Hz) in four neurosurgical patients while they listened to spoken real words and pseudowords with varying transition probabilities (TPs) between the consonants and vowels (Cs and Vs) in a set of C-V-C stimuli. We found that individual electrodes over left superior temporal gyrus (STG) that were sensitive to the acoustic content of speech were also modulated by TPs. Specifically, cortical activity was correlated with TPs in 3 distinct ways: (1) an inverse correlation with the C-to-V forward TP during the first CV transition, (2) a positive correlation with the C-to-V forward TP, and (3) a positive correlation with the V-from-C backward TP around the end of the word. These correlations between neural activity and TPs exist independently from activity explained by acoustic variability as measured by each electrode's spectro-temporal receptive field (STRF). Furthermore, we found that relative to the neural response explained by the linear STRF model (i.e., its acoustic sensitivity), TP effects on some but not all electrodes lagged behind acoustics by ~120ms. Population-level analyses found TP effects on the neural responses across electrodes that were dynamic and closely tracked speech inputs in real time. This analysis further demonstrated that the magnitudes of TP effects were different for real versus pseudowords, providing support for our hypothesis that lexical access is a distributed process that relies on language-level probabilistic information. Overall, these results support the hypothesis that speech auditory cortex not only encodes the spectro-temporal acoustic-phonetic properties of spoken words, but also the higher-order, language-specific statistical structure of phoneme sequences. The acoustic-lexical transformation along the speech hierarchy may involve the integration of prior knowledge at both sub-lexical and lexical levels in a way that dynamically tracks speech input in real time.

B10 Interplay between auditory and motor areas during phoneme and word processing investigated on a millisecond time basis *Annelies Aerts[1,2], Gregor Strobbe[3], Pieter van Mierlo[3], Robert J. Hartsuiker[4], Patrick Santens[1,2], Miet De Letter[2,5]; [1]Department of Internal Medicine, Ghent University, Belgium, [2]Department of Neurology, Ghent University Hospital, Belgium, [3]Department of Electronics and Information Systems (IMinds), Ghent University, Belgium, [4]Department of Experimental Psychology, Ghent University, Belgium, [5]Department of Speech, Language and Hearing Sciences, Ghent University, Belgium*

Phoneme perception/discrimination and word recognition is subserved by dorsal and ventral language circuitries, in a widespread fronto-temporo-parietal cortical network (Binder et al., 1997; Friederici, 2012; Hickok and Poeppel, 2004, 2007). Demographic factors, such as age and

gender, and attention-related effects seem to influence (electrophysiological) activation of cortical language areas (Shaywitz et al., 1995; Shtyrov et al., 2009; Tremblay et al., 2013). The present study aimed to explore the specific interaction between auditory and motor dorsal and ventral language areas on a millisecond time basis, with respect to (1) auditory phoneme discrimination (APD) and (2) auditory word recognition (AWR). Additionally, potential effects of age and/or gender were examined. For this, 47 subjects were included with an equal distribution of men (n=23) and women (n=24) and younger (≤50 years; n=23) and older (>50 years; n=24) subjects. APD was investigated using six oddball paradigms with a differentiation between three phonemic contrasts (voicing, place and manner of articulation) and an automatic, pre-attentive and controlled, attentive condition. AWR was investigated by contrasting real words with pseudowords in an oddball paradigm as well, though only in an automatic setting. An electroencephalogram (EEG) was recorded through 24 Ag/AgCl-electrodes placed on the scalp according to the international 10-20 system. Data was analyzed using BrainVision Analyzer (Brain Products, Munich, Germany) to elicit the cognitive ERPs of interest (Mismatch Negativity, P300 during APD; N100, P200 and N400 during AWR). Source imaging was performed using the "multiple sparse priors" algorithm (SPM8) (Friston et al., 2008). A sensor space analysis was first performed to determine time frames of interest during which statistical comparisons were made between different conditions (phonemic contrasts and attention; wordness; gender and age) in a subsequent analysis at source level. During APD several time windows demonstrated significant differences in activation of auditory and motor dorsal regions, influenced by the phonemic contrasts. The automatic and controlled condition showed differences in an early time window (50-110 msec) whereas only the controlled condition revealed other, later time windows (130-175 msec; 200-225 msec) holding distinct neuroanatomical activation patterns determined by the phonemic contrasts. Furthermore, controlled APD showed attention-related influences in frontal regions, early in time (50-110 msec) for MoA and voicing, but later in time (130-175 msec) for PoA. Moreover, automatic attention-allocation during APD based on MoA and voicing required more auditory processing, PoA mainly required more motor processing. AWR revealed early (150-300 msec) higher sensorimotor activation for real words followed by a switch to higher inferior frontal and parietal activation for pseudowords (300-550 msec). Remarkably, right hemisphere was involved during both language tasks and, unexpectedly, no differences between men and women or younger and older subjects were found for either language process. In sum, the present study evidenced significant interactions between auditory and motor language areas in distinct millisecond time frames with a differentiation in phonemic contrasts and attention during APD and wordness during AWR, though without a differentiation in age or gender. In future research, the above-mentioned methodological procedure can be "field-tested" in the clinical evaluation of aphasia patients.

B11 Neural basis of multistability in auditory cortex and perceptual decision making *Amrita Basu[1]; [1]School of Cognitive Science, Jadavpur University, Kolkata, India*

A single physical stimulus producing alternations between two or more subjective percepts leads to multistability in auditory domain. For example, a sequence of two fast repeating syllables (/ka/ and /ta/) produces two alternate subjective percepts (/kata/ and /taka/). These percepts have a deeper anchor in distinct lexical - semantic categories in Bangla (i.e., /kata/, B. v {to cut}; /taka/, B. n {money}. As a result the switch between two categories and its relation between simultaneous syllable, lexical and semantic access becomes an interesting node to study how dynamic speech is encoded and decoded in human brain. Intuitively, these multistable states backed by multi-level (syllabic, lexical, and semantic) category binding to form subjective percepts provide a new insight into the neural mechanisms of information processing during multistability in auditory language perception and perceptual (or linguistic?) decision making. Apart from lexical category-switch, usual multiple sensory streaming (/ka / /ka/ /ka/… etc.) and hearing illusory percepts (/pata/ etc.) have also been reported by participants during behavioural tasks. Investigation of such multistable forms in lexico-semantic access is challenging due to the subjective nature of percepts formed. Although the time-course for lexical-semantic category switch may appear similar, the exact time-point of category switch varies across trials and participants. Single trial electrical activity was investigated in the spatio-temporal domain to look for components common in the space, time and frequency domains that can discriminate between category switch condition, illusory percept condition and streaming condition. For the present study, scalp 64 channel EEG data (n = 40) was recorded in normal Bengali speaking natives, who listened to the fast repeating syllables and indicated whether they heard any change in lexical-semantic category, streaming of syllables, or illusory words. A multiway tensor decomposition approach was adopted as it provides a more natural representation of the data structure and fairly good discrimination of frequency bands and temporal windows for individual participants. To determine the most discriminative band for multistable perception, NTF components were clustered using K-means clustering algorithm. The results show distinct activity in gamma, beta and delta clusters in lexical category change condition. Regular ICA based approaches were also used to look at the time-course of activity in participants. The ERP components show differential activity in first 200 ms for the lexical-semantic category switch condition. The present results suggest

possibility of a top-down/bottom-up rhythmic alternation between syllabic/lexical-semantic levels affecting hearing of category-specific subjective percepts.

B12 Temporal dynamics of speech processing: an EEG decoding study of individual spoken words within and across two languages in bilingual adults *Joao Correia[1], Elia Formisano[1], Lars Hausfeld[1], Bernadette Jansma[1], Milene Bonte[1]; [1]Department of Cognitive Neuroscience, Faculty of Psychology and Neuroscience, Maastricht University and Maastricht Brain Imaging Center (M-BIC), The Netherlands*

Spoken word comprehension involves the processing of complex auditory input and the access to semantic-conceptual information underlying the meaning of words. Spoken language is dependent on the temporal dynamics of the auditory input, as it becomes available to the listener. Nevertheless, speech processing is a surprisingly fast, effortless and accurate cognitive ability. In this EEG study we investigate the temporal dynamics of spoken word comprehension at the individual word level, by exploiting the semantic commonalities between equivalent words across first and second language of Dutch-English bilinguals. Using machine-learning methods, multivariate classifiers and temporal clusters of EEG features we find within-language and across-language neural representations of spoken words over time, as listeners process auditory words. The stimuli were four monosyllabic words in both languages, belonging to the same category – animal nouns - spoken by three different speakers. All words were acoustically-phonetically distinct within and across languages. Firstly, to identify temporal intervals encoding the identity of the spoken words, we let classifiers discriminate between word pairs within the same language (e.g. horse vs. duck) independently of the speaker. Secondly, to isolate language-independent representations of the words, we assessed the ability of classifiers trained within one language (e.g. horse vs. duck) to generalize to the other language (e.g. the Dutch equivalents 'paard' vs. 'eend'). Our findings suggest that the neural representations underlying the identity of individual spoken words (within-languages) becomes available to the listener as early as 100 to 300 ms after word onset, but their language-invariant representations underlying the semantic representations of the words (across-languages) only becomes available around 400 ms after word onset. These results corroborate previous findings in the literature in respect to the importance of specific ERP components in spoken word comprehension. Specifically, of N100 and P200 in the acoustic-phonological processing of speech input and of N400 in the semantic access of conceptual information. Moreover, our results describe in fine temporal detail, the temporal dynamics of spoken word comprehension.

Motor Control, Speech Production, Sensorimotor Integration

B13 Distinct networks are engaged in speech versus non-speech monitoring *Stephanie Ries[1], Kira Xie[1], Kathleen Y. Haaland[2], Nina F. Dronkers[3], Robert T. Knight[1]; [1]Helen Wills Neuroscience Institute and Department of Psychology, University of California, Berkeley, California, USA., [2]New Mexico Veterans Affairs Healthcare System and Departments of Psychiatry and Neurology, University of New Mexico, Albuquerque, NM, USA., [3]Veterans Affairs Northern California Health Care System and University of California, Davis, California, USA.*

Recent studies suggest a general-purpose mechanism, most likely supported by anterior cingulate and/or pre-supplementary motor areas, is involved in overt-speech monitoring and is initiated before auditory feedback can be perceived. This mechanism is reflected in an event-related electroencephalographic potential peaking shortly after vocal-onset called the "error-related negativity" (Ne). This component was initially reported only in errors, hence its name. However, similar but reduced activity was recently reported in correct trials in speech and non-speech action production, suggesting a general action monitoring underlying system rather than error-detection per se. Investigating patients with lateral pre-frontal (PFC) damage due to stroke and using a non-verbal task, Gehring and Knight (2000) suggested this monitoring mechanism is dependent on the integrity of the lateral PFC and not solely on medial frontal regions. Indeed, the patients tested did not show an amplitude difference between the Ne measured in correct versus incorrect trials, suggesting interactions between the lateral PFC and the medial frontal region are necessary for normal action monitoring. Here we investigated whether this was also true in overt speech production using a simple picture-naming task. We compared the performance and EEG activity recorded in a lateral PFC patient cohort (6 left, 6 right) to aged-matched controls. The aged-matched controls did not produce enough errors to allow the comparison of the Ne or other ERPs in errors vs. correct trials. However, PFC patients showed a clear Ne which was larger in errors than in correct trials ($p=.008$). This suggests the monitoring mechanism reflected by the Ne in overt speech production is not impaired by damage to the lateral PFC to the same extent as in non-speech actions. In addition, activities recorded in electrodes over bilateral temporal cortices and peaking around vocal-onset were observed in PFC patients and in controls. In patients, these temporal ERPs were larger in errors than in correct trials ($p<.001$), suggesting temporal cortices were also associated to speech monitoring starting before vocal onset. We propose that a different network of brain regions is involved in speech versus non-speech on-line monitoring engaging temporal cortices and a common node in the medial frontal cortex.

B14 Domain-specific and domain-general monitoring in speech production and non-linguistic choice reaction tasks *Jolien ten Velden[1], Dan Acheson[1,2], Peter Hagoort[1,2]; [1]Max Planck Institute for Psycholinguistics, Nijmegen, the Netherlands, [2]Donders Institute for Brain, Cognition and Behaviour, Radboud University, Nijmegen, The Netherlands*

Recent theories about self-monitoring in speech production have hypothesized that conflict signals within the production system might serve as cues to increase monitoring and control (Nozari, Dell & Schwartz, 2011; Cognitive Psychology). Such conflict naturally arises when multiple responses are simultaneously active, such as when multiple phonemes are activated in the generation of speech errors. A region of the medial prefrontal cortex, the dorsal anterior cingulate cortex (dACC), has consistently been observed in high conflict situations ouside of language (Yeung, Botvinick, & Cohen 2004; Psychological Review), and recent EEG studies in speech production have observed a electrophysiological signatures of such conflict not only for errors, but also on trials where high conflict occurred (Acheson, Ganushchak & Hagoort, 2012; Brain & Language). The present study was designed to test whether common regions of the brain are sensitive to conflict in speech production and non-linguistic, choice reaction tasks. 24 native Dutch subjects performed both a tongue twister task and a factorial combination of the Simon and Flanker task. In the tongue twister task, people overtly produced a string of 4 nonwords 3 times. In tongue twister trials, onset phonemes followed a pattern of A-B-B-A, whereas rhymes followed an A-B-A-B pattern (e.g. wep ruust rep wuust). In non-tongue twister trials, the nonwords contained minimal phonological overlap (e.g. jots brauk woelp zieg). These two conditions correspond to a high conflict and a low conflict condition respectively. In an arrow version of the the Simon-Flanker task, subjects responded to the direction of a middle arrow while flanking arrows faced in the same (i.e., congruent; >>>>>) or different (i.e., incongruent; >><>>) directions. These stimuli were presented on either on the right side or the left sde of the screen, potentially creating a spatial incongruency with their response as well. Due to this, a single trial could be congruent in both the Flanker and the Simon condition, congruent in one but incongruent in the other, or incongruent in both. Behavioral results demonstrated sensitivity to conflict in both tasks, as subjects generated more speech errors in tongue twister trials than non-tongue twister trials, and were slower to incongruent relative to congruent flanker trials. Preliminary fMRI results show that common regions of the dACC and the right cerebellum were sensitive to high relative to low conflict across both the tongue twister and the Simon-Flanker tasks. Different regions of the dACC, the cerebellum and the dorsomedial prefrontal cortex were found to be more active for conflict related to language than for conflict in the Simon-Flanker task. The present results thus suggest that within the dACC there may be both domain-specific as well as domain-general monitoring regions. More generally, the present study provides evidence in favor of a common mechanism underlying monitoring in linguistic and non-linguistic action.

B15 Behavioural and neural network components of sensorimotor integration for speech. *Benjamin Elgie[1], Mamie Shum[2], Lucas Dangler[2], Thomas Gisiger[2], Douglas M Shiller[2,3,4], Shari R Baum[2,5], Vincent L Gracco[2,5,6]; [1]Integrated Program in Neuroscience, McGill University, Montreal, Canada., [2]Centre for Research on Brain, Language and Music, Montreal, Canada., [3]School of Speech-Language Pathology and Audiology, Université de Montréal, Canada., [4]CHU Sainte-Justine Research Centre, Montreal, Canada., [5]School of Communication Sciences and Disorders, McGill University, Montreal, Canada., [6]Haskins Laboratories, New Haven, CT*

Sensorimotor integration for speech underlies two mechanisms, one for acquisition of speech motor representations and another for sensorimotor control. While the neural substrate for speech production has been the focus of both past and recent publications, there has been little focus on attempting to separate the neural framework for these two mechanisms. Here we focus on identifying the brain regions associated with sensorimotor integration for speech motor learning and speech motor control using repetitive transcranial magnetic stimulation (rTMS). Multiple studies were conducted using offline inhibitory (1 Hz) rTMS and an auditory feedback adaptation paradigm. Producing speech under constant and predictable feedback alteration results in sensorimotor adaptation, reflecting a recalibration of the relationship between sensory signals and motor output. In the present studies, we examined the effects of stimulation on both normal (unaltered) and altered auditory feedback. Subjects were first recorded under unaltered feedback and then subjected to rTMS stimulation. Following the rTMS subjects repeatedly produced the target word under the following auditory feedback conditions: 1) unaltered feedback (30 trials, baseline phase), 2) ramp up to a maximum 1st formant shift (40 trials, ramp phase), 3) maintained at maximum shift (100 trials, hold phase), and 4) return to unaltered feedback (30 trials, after-effect phase). The four brain regions targeted for stimulation included: left pSTG, left IPL, right IPL, and left MFG. A sham group was included. Speech output changes were obtained by identifying a 30ms segment from each vowel midpoint and extracting the first and second formant (F1 and F2) resonances. Changes in vowel production were calculated for the baseline trials before and after TMS stimulation and for changes during the adaptation relative to the baseline trials. In addition to the TMS effects we also compared the resting state functional connectivity of the different stimulation sites to identify the networks being affected by the stimulation. In general, subjects undergoing the sham stimulation exhibited a robust adaptive response to the auditory feedback alteration whereas subjects undergoing

rTMS exhibited a diminished adaptive response. However, the different stimulation sites yielded different patterns dependent on the phase of the adaptation. For example, left IPL yielded the most significant reduction overall while right IPL resulted in an increase in the adaptive response during the ramp phase only. Inhibiting left pSTG reduced the adaptive response to a lesser extent that the left IPL. No effect was noted on the baseline trials immediately following the stimulation. Significant differences in the networks associated with all stimulation sites were observed. The present study assessed the contribution of multiple brain areas to sensorimotor integration for both speech adaptation (error-based learning) and speech motor control. In order to better understand the networks underlying these brain regions we also examined their resting state functional connectivity. The behavioral results and the networks identified from the stimulation sites suggest that sensorimotor learning and control for speech rely on similar but not identical networks.

B16 Left frontal-temporal-parietal network supporting speech and its cognitive control. *Fatemeh Geranmayeh[1], Robert Leech[1], Richard J.S. Wise[1]; [1]Imperial College London*

Introduction: We have previously shown that a left lateralised frontal-temporal-parietal (FTP) system is involved in spoken discourse production.1 This system is reliably present in resting state networks suggesting it is a robust system in healthy brains.2, 3 In this fMRI study we re-examined the neural networks that support speech production in a different cohort of healthy subjects. Methods: 24 right-handed subjects without neurological disease were scanned (7 male, age; 37-78 years). Subjects underwent a "sparse" fMRI paradigm with 10 s TR consisting of 3 runs, each containing 20 Speech, 16 Count, 16 Visual Decision (non verbal task), 16 Rest. 20 subjects had repeat scans (average interval = 97 days), and all 3 runs for the two scans for these subjects were used in the analyses. Univariate analysis, group temporal concatenation independent component analysis (ICA), and dual regression were carried out.4, 5 The associated subject-specific and run-specific time courses for the components of biological interest were regressed against the design matrix and tested for significance. This identified components in which activity was greater during Speech than Count or Decision. Results: 1) Univarate analysis of Count (high-level baseline) against Rest (low-level baseline) revealed bilateral somatosensory, auditory, supplementary motor (SMA), right inferior frontal (IFG) and parietal opercular activity. The contrast of Speech with Rest revealed activity in left dorsolateral prefrontal cortex (including Broca's area), SMA, anterior cingulate cortex, left inferior temporal gyrus (ITG), and bilateral visual cortices activation, but no left parietal activity. 2) In keeping with the univariate analysis, ICA with 55 components revealed a sensorimotor system associated with Speech and Count, and a Speech-related visual and eye movement network (the stimuli for this condition were pictures of objects). Unlike the univariate analysis, ICA revealed a left lateralized FPT network that was unique to the Speech condition. A right FPT network that mirrored the spatial distribution of the left FTP network, was active in Count and Decision but deactivated in Speech. These two mirroring FTP systems overlapped in the left parietal lobe, indicating overlapping neurons within this region that support separate functional neural networks. 3) Using the speech related left FTP network that we published previously, as a "seed region" in a dual regression analysis, revealed that the activity in this network in the current study was significantly correlated with Speech (P = 0.0001 , t (137) = 3.97), and significantly anticorrelated with Count (P = 0.001 , t (137) = -3.19). Conclusion: This study supports the notion of overlapping but functionally separate neuronal networks within the left parietal lobe, some of which support language and its cognitive control. The right fronto-parietal network that was more active for counting and the decision task is likely to represent domain-general sustained vigilance for the performance of these two tasks, whereas the linguistic, attentional and cognitive control of speech production is largely confined to the left cerebral hemisphere. 1. Brain Lang. 2012;12:47–57. 2. PNAS. 2009;106:13040–13045. 3. Phil. Trans. R. Soc. B. 2005;360:1001–1013. 4. IEEE Trans Med Imaging. 2004;23(2):137-52 5. PNAS. 2009;106(17):7209-14.

B17 Cortical Activity Following Natural and Simulated Saccadic Eye Movements during a One-Back Word Recognition Task *Yu-Cherng Chang[1], Sheraz Khan[1], Samu Taulu[3], Emery N. Brown[1,2,4], Matti S Hämäläinen[1,2], Simona Temereanca[1,2]; [1]MGH/MIT/HMS Athinoula A. Martinos Center for Biomedical Imaging, Massachusetts General Hospital, [2]Harvard Medical School, [3]Elekta Neuromag Oy, [4]Massachusetts Institute of Technology*

Saccadic eye movements frequently shift the gaze in text during reading, yet their contribution to the brain response at fixation remains elusive. Here we investigated the cortical activity related to saccades and saccade-like external image motion in healthy human subjects engaged in a one-back word recognition task (Temereanca et al., 2012) using anatomically-constrained magnetoencephalography. Ocular artifacts were removed using spatial and temporal signal-space projection methods. Natural and simulated saccades produced short-latency responses with a time-course of ~400 ms, beginning in visual cortex ~80 ms after onset and spreading to downstream regions of the ventral and dorsal visual pathways within 120 ms. Subsequent response components engaged simultaneously cortical regions of the sensory-motor pathways, as well as regions implicated in language and memory. Significant differences in responses to natural and simulated saccades, corresponding to differences between self-induced and external image motion on the retina, occurred in several cortical regions. These regions overlapped with parietooccipital cortex and posterior Sylvian fissure implicated in visual stability; posterior

cingulate cortex implicated in semantic memory; and left lateral occipitotemporal and adjacent inferior temporal cortex implicated in orthographic-lexical processing. This is the first evidence suggesting that central saccadic mechanisms selectively impact the visual word recognition system likely via interactions with working memory, possibly contributing to efficient reading.

B18 Oscillating speech acts: dynamic processing of naming and requesting in the brain as reflected in early and parallel beta and gamma band oscillatory dynamics

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Neural bases of comprehension of communicative goals and intentions conveyed through language remain largely unknown. Our previous EEG study indicated several specific neural networks involved in comprehension of communicative functions of utterances, the so-called speech acts. Specifically, the processing of a speech act of Naming seems to engage primarily the referential lexico-semantic network, while that of Requests involves activation in the action and theory-of-mind networks (Egorova et al., Front Hum Neurosci 2013). The results also suggested a rapid and dynamic timeline of this process, with the Naming speech acts eliciting greater activation between 100-200 ms after the word onset and Requests showing increased activation first around 100 ms, and later at 260-335 ms. These previous results focused on the contrast between the speech act types, revealing the temporal stages of processing of Naming and Requesting, rather than the within speech-act dynamics. To address the latter, we set out to investigate dynamics of neural oscillations underlying Naming and Request comprehension in the brain. Using MEG, we recorded neuromagnetic brain activity while participants read single words used, depending on the stimulation contexts, for Naming or Requesting an object in visually presented scenes in a tightly controlled stimulus set. Activity in beta and gamma frequency bands, previously implicated in language, action and social processing has been studied: in low-beta 12-15 Hz (Weiss & Mueller, Front Psych 2012); higher-beta 15-25 Hz (Hari et al., PNAS 1998), lower-gamma 25-35 Hz (Pulvermüller et al., Progr Neurobiol 1997) and medium-gamma in 40-50 Hz (Hagoort et al., Science 2004; Pavlova et al. Cer Cor 2010) bands. Time-frequency representations were calculated using 7-cycle Morlet wavelets at individual MEG channels. For statistical analysis, a spatio-temporal cluster-based random permutation test (Maris & Oostenveld, J Neurosci Meth 2007) at the sensor level was applied for magnetometers and gradiometers separately. The analysis of power revealed an increase in the 25-35 Hz gamma frequency over the left magnetometer sensors between 100 and 240 ms when single words were used to name objects present in the visual display. In the higher-beta band there was an increase of power over the right fronto-central areas (50-260 ms) for Naming and a decrease in power when the same critical words were used to Request an object. Additionally for Requests, there was an increase in the lower-beta band over the parietal areas in 170-500 ms window, while in the medium-gamma band, an increase in the medial anterior frontal gradiometers between 280 and 340 ms was observed. These results show that, although the same words were used in different conditions, the communicative functions of these stimuli were reflected immediately (starting ~50ms after stimulus onset) by a complex, speech-act specific spectral dynamics in different frequency bands. Understanding of Naming rapidly engages lexico-semantic fronto-temporal circuits, and comprehension of Requests involves parallel processing in the fronto-central and parietal networks known to be relevant for both action and theory of mind related information. These dynamics are reflected in the patterns of suppression and enhancement of oscillatory activity in beta and gamma bands.

Orthographic Processing, Writing, Spelling

B19 Impaired Exception Word Reading in Aphasia: Lesion Localization

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Alphabetic writing systems are designed to capture regular correspondences between visual characters and phonemes, yet many written languages contain spelling-sound inconsistencies. Literate English readers can easily work out the pronunciation of a novel word like "kint" based on known words like "lint" and "mint", but also have no trouble violating these so-called rules for words like "pint". One account of this ability proposes that readers access word-specific (lexical or semantic) information in the case of inconsistent words. Impairment of this ability, called "surface dyslexia", is associated with other semantic impairments, particularly in patients with semantic dementia, however the full lesion correlates of exception word reading impairment are not yet clear, particularly in patients with stroke. We examined this issue in 30 chronic left hemisphere stroke patients (15 women, 15 men; all native English speakers; all right-handed pre-stroke; all at least 180 days post-stroke) using voxel-based lesion-symptom mapping (VLSM). Patients read aloud a list of 224 items that included 108 regular words, 80 exception words (e.g., wool, sweat, pint, gross, plaid, glove, warp, brooch), and 36 pseudowords. Each spoken response was digitally recorded for off-line scoring and error typing. Regularization errors were defined as incorrect application of spelling-sound correspondence

rules to exception words, such as pronouncing "soot" to rhyme with "boot". Lexicalization errors were defined as production of a similar-looking word in response to a pseudoword, such as pronouncing "churse" as "church". Lexicalization errors are of interest because they reflect an impairment opposite to surface dyslexia: deficient spelling-sound mapping leading to over-use of lexical-semantic knowledge. All scoring and error-typing was done blind to the MRI data. Lesions were labeled on high-resolution T1 MRI volumes using a semi-automated image segmentation method, followed by diffeomorphic registration to a common template. VLSM used a logistic regression model incorporating the number of regularization errors, the number of lexicalization errors, age of the patient, and days since stroke onset as explanatory variables. T-maps were thresholded at a corrected $p < .05$. The rate of regularization errors ranged from 1.3% to 13.8% of exception words, and the rate of lexicalization errors ranged from 0% to 55.6% of pseudowords. Regularization errors were correlated with damage in an extensive region of the middle temporal gyrus, extending from the posterior ventral MTG near the inferior temporal sulcus (ITS) through the mid-portion of the MTG and mid-STS. In contrast, lexicalization errors were associated with more dorsal damage in the supramarginal gyrus and posterior STG. The results are consistent with recent functional imaging studies of reading aloud in healthy participants (Graves et al., Cerebral Cortex, 20: 1799-1815), which suggest a ventral reading pathway involving the MTG/ITS that is modulated by spelling-sound consistency (stronger activation for inconsistent words) and a dorsally-directed pathway involving posterior STG and SMG that mediates direct orthography-phonology mapping.

B20 Pure agraphia: Implications for Cognitive Models of Reading and Writing/Spelling

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The conceptualization of pure motor agraphia (Pitres, 1884) and the localization of its lesion in the foot of the second frontal convolution of the left hemisphere had drawn much criticism from Dejerine (1914) and Wernicke (1903) based on their theoretical view point of the dependency of written language on spoken. This notion of spoken language (or phonological) mediation of writing/spelling is still an issue in contemporary cognitive neuropsychology. Currently cognitive models of reading and writing/spelling offer alternative perspectives on the common cognitive processes (Hillis & Rapp, 2005): 1) the independent component account and 2) the shared component account. The independent component account will argue for, for instance, the autonomy of orthographic lexicon (Piras & Marangola, 2004; Hanley & McDonnell, 1997; Shelton & Weinreich, 1997; Rapp, Benzing, & Caramazza, 1997) on the basis of the observation of preserved writing and impaired oral reading, verbal naming, and repetition in brain damaged cases. The shared component account, for instance, will argue that the common orthographic lexicon will be used for both reading and spelling (Rapcsak, Henry, Teague, Carnahan, & Beeson, 2007). The current study offers support to the autonomous status of orthographic lexicon on the basis of the data obtained from a case of pure agraphia (PA). PP, a 65-year-old female with a stroke-induced lesion of the left temporo-parietal region served as the subject of this study. Two major test batteries, Boston Naming Test (BNT) and the Johns Hopkins University Dysgraphia Battery (JHUDB), were used to gain an understanding of verbal naming and written word production to dictation, respectively. In addition, word lists were used to elicit oral reading and spelling responses to the same set of words. PP performed at 80% accuracy level in naming a total of 60 pictures of BNT. Her error patterns included both semantic and phonemic paraphasias. PP's scores on the five subtests of JHUDB were as follows: 10 Written naming : 3.9% (2/51), 2) Word length: 0% (0/70), 3) concreteness: 0% (0/42), 4) parts of speech: 0% (0/138), and 5) copy transcoding: 100% (62/62). PP's error patterns included a large number of partial responses that included the correct first grapheme/letter of the target word as well as graphemes in non-initial positions that were not part of the target words. PP also produced several phonologically implausible non-words. These error patterns seem to suggest that PP's 'functional lesion' must be in the graphemic buffer (Caramazza, Miceli, Villa, & Romani, 1987). The upshot of these findings for the cognitive models of writing and reading is that the orthographic lexicon can be selectively implicated in writing in the context of near intact word reading and naming. Although the autonomy of orthographic lexicon was supported, in the past, by case studies that identified selective impairment of naming and oral production of words in the context of intact spelling to deny the obligatory phonological mediation of writing, it can be argued that data from pure agraphias may also do the same.

B21 Language orthography and task demands modulate the engagement of regions within the reading networks

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Neuroimaging and neuropsychological evidence suggests that left-lateralized ventral and dorsal neural routes are implicated in reading (Dejerine, 1891; Turkeltaub et al., 2002). Whereas the ventral reading network seems to be recruited more for orthographic processing, the dorsal pathway seems to be more engaged during phonological processing (Schlaggar & McCandliss, 2007). However, it is still under debate how the two pathways are modulated by the type of information processed and the role of key areas such as the visual word form area (VWFA) and the inferior frontal gyrus (IFG). Some theoretical accounts suggest that the VWFA is mostly involved in prelexical

computation of visual word forms (Dehaene et al., 2001), while others consider that its activation depends on top-down predictions mediated by feedback connections interacting with bottom-up sensory inputs (Price & Devlin, 2001). Regarding the IFG, it has been argued that the pars opercularis and pars triangularis subregions contribute differently to phonological and semantic processes (Binder et al., 2009), with the former being more involved in phonological operations and the latter in semantic processes (Katzev et al., 2013). The present fMRI study sought to examine the involvement of these regions two regions in reading processes as a function of language orthography (deep versus shallow) and the nature of the reading task (perceptual versus semantic). Participants included a total of 40 right-handed native Spanish-speaking late bilinguals who either have an opaque (English; n=20) or transparent (Euskera; n=20) L2. Participants' proficiency levels between their L1 and L2 were similar, and they had minimal exposure to other languages. At the scanner, participants performed two separated Go/No-Go tasks, where they were asked to press a button when they saw a colored letter within a given string (perceptual task) or when they saw an animal word (semantic task). During these tasks participants were presented with words, pseudowords, consonant strings, and false fonts. Region-of-interest analyses revealed that the VWFA was more strongly recruited for L2 versus L1 words, especially for the opaque orthography during the semantic task. This result qualifies prior theoretical accounts indicating that the engagement of the VWFA not only depends on prelexical features of visual word forms, but also on language orthography and the type of reading operations. Within the IFG, pars opercularis and triangularis showed a similar overall pattern of activation, being more strongly recruited for readable (words/pseudowords) than for non-readable stimuli (consonant strings/false fonts). Nevertheless, pars opercularis was more engaged for pseudoword processing in the group with a transparent versus opaque L2, reflecting stronger sensitivity to sublexical orthography to phonology conversions. In contrast, pars triangularis activation profile exhibited a fine-grained differentiation between stimuli (words>pseudowords>consonant strings) only for the opaque orthography in the semantic task, suggesting a greater reliance on semantic demands and graphemic analysis. In sum, our results suggest that orthographic as well as semantic processes modulate VWFA activation and that, although there appears to be a functional alignment of pars triangularis and opercularis, there is also an important division of labor among them.

B22 ERP Effects of Frequency and Regularity Are Modulated By Task Demands: Evidence from Categorization and Delayed Reading Aloud *Danielle S. Dickson[1], Simon Fischer-Baum[2], Kara D. Federmeier[1]; [1]University of Illinois at Urbana-Champaign, [2]Rice University*

Most theories of visual word processing assume that both phonological and semantic information are always extracted from word forms by readers. However, when a person is reading words to later be produced out loud, the nature of processing necessarily differs from when that person is reading for comprehension. For example, reading aloud requires readers to resolve conflicts between alternative phonological realizations and choose a single pronunciation for a word form, which is not necessary for silent reading. In this study, participants were presented with written words in the context of two tasks designed to expose potential differences in processing mechanisms: delayed reading aloud and category membership identification (proper name detection). In order to determine how and when the impact of task plays a role during reading, we manipulated word frequency, a lexical variable thought to influence the ease of word knowledge access, and regularity, a lexical variable reflecting the predictability of orthographic to phonological translation, while controlling for orthographic neighborhood size (N) and bigram frequency. We recorded event-related potentials (ERPs) and examined how functionally relevant, well-studied waveform components, such as the N400, responded to these manipulations. Word frequency has sometimes, but not always, been linked to modulations in N400 amplitude, which reflects the ease with which semantic information is accessed. By using the same critical stimuli across tasks, we were able to assess if part of the N400 frequency effect replication difficulty was specifically due to differences in task demands. Regularity (other than orthographic) has not been associated with any particular ERP effect and has not been previously studied with ERPs to our knowledge, but the conflict generated by words that break the typical rules of spelling-to-sound mappings (e.g., "PINT") was predicted to have later effects in the waveform. We found that the effects of frequency (on N400 amplitude) and regularity (on LPC size) were modulated by task. For frequency, differences in N400 amplitude were observed only in the reading aloud task, such that low frequency words elicited a higher amplitude N400. The absence of a frequency effect in the detection task suggests that reading context swamped the influence of experience with a particular word on semantic access; it was no longer easier to access high frequency words because the flexibility of semantic memory allowed for proper names to dominate activity in the reader's semantic network. For regularity, low frequency, irregular words showed a large LPC that was absent in the other three conditions, but only in the context of the delayed reading aloud task (where words were followed by a prompt to verbalize them). Intention to later name an item increased the influence of regularity, thus suggesting that top-down control plays a role in the phonological processing of written words as well. Taken together, these results demonstrate that the nature of semantic and phonological processing that

is engaged when reading visually presented words is dependent on the context under which that reading takes place.

B23 Eye-tracking measures in reading homophones and heterophones in Hebrew *Zohar Eviatar[1], Hamutal Kreiner[2], Tamar Degani[1], Orna Peleg[3]; [1]University of Haifa, [2]Ruppin Academic Center, [3]Tel Aviv University*

Models of reading debate the relationship between orthography, phonology, and semantics. Recently Peleg and Eviatar (2012) suggested that specific hemispheric differences in the relations between orthography and phonology underlie the complexity of access to meaning from print. Here, we use homographs to explore differences in these relations. Hebrew orthography is an abjad (Peters, 1990) where vowel information is mostly absent, therefore homophonic (e.g., bank) and heterophonic (e.g., tear) homographs are very frequent (roughly 40% of all words). Critically, in homophones a single orthographic and phonological form is associated with multiple meanings whereas in heterophones the shared orthographic form is associated with two phonological forms each associated with a different meaning. If meanings can be accessed directly from orthographic input, no difference should be found between homophones and heterophones, but differences should emerge if phonology mediates access to meaning. We assume that if two meanings are activated readers would experience reading difficulty due to the conflict, and we used Eye-Tracking to explore the time-course of such difficulties. Thirty-seven participants read sentences that included homophones, heterophones or unambiguous words. All sentences were neutral up to the target word. In half the sentences the context following the target word disambiguated towards the subordinate meaning, and in half the context remained neutral. We show two main differences between homophones and heterophones. First, there were longer go-past durations for homophones compared to the other targets. Slightly later, the gaze duration on the spillover region, was longer for heterophones compared to the other targets. This indicates that both subordinate and dominant meanings are activated on the first encounter with a homograph, but the subordinate meaning is activated slightly earlier for homophones than for heterophones. Second, regression rates into the target region as well as regression rate out of the disambiguation region were higher in heterophone sentences than in homophone sentences, and in the latter they were higher than in sentences containing unambiguous words. This reflects a lesser need to revisit the orthography for reanalysis in the case of homophones, possibly due to the shared phonology still represented in working memory. By contrast readers are more likely to revisit the orthography for reanalysis in heterophones where different phonological representations are activated. Taken together the findings suggest that both homophones and heterophones activate multiple meanings, but with slightly different time courses. These findings are inconsistent with previous studies (e.g., Duffy, Morris & Rayner 1988) that argued that only the dominant meaning is activated initially, and that without bias towards the subordinate meaning, it may not be activated at all. However, most of these studies examined English readers. It is possible that Hebrew readers adopt a different reading strategy more adapted to the high rate of homographs. These results emphasize the dynamic aspects of brain functions for reading in different languages, and the danger inherent in generalizing from one writing system to others, even within the alphabetic orthographies.

B24 The centro-parietal N200: A neural marker specific to visual Chinese character recognition *John Xuexin Zhang[1], Bao Zhang[2], Xiaofei Jia[3]; [1]Chinese University of Hong Kong, [2]Guangzhou University, [3]Zhejing University*

Almost all written languages currently used in the world are alphabetic or phonologically-based except Chinese that is usually characterized as a logography. Whether reading of the two types of scripts is associated with different neural processes is a fundamental question in psycholinguistic research intensively debated in the past three decades. We have recently reported the finding of a new ERR component possibly specific to visual Chinese word recognition. When Chinese readers perform visual lexical decision tasks, two-character Chinese words elicit a widespread negative deflection with centro-parietal focus in scalp topography around 200 ms post-stimulus onset. This component, referred to as the centro-parietal N200, shows a clear and large amplitude enhancement upon immediate word repetition. The N200 is unrelated to auditory processing as it is absent for spoken Chinese two-syllabic word recognition. It could not be attributed to non-linguistic sensori-perceptual processes, nor phonological or semantic processes, but likely reflects early orthographical processing. With a series of experiments, here we show that the N200 is also present at the character level fundamental to written Chinese. For single characters, N200 also shows a clear enhancement for repetition priming. More importantly, the enhancement effect is greater for real characters than for pseudo-characters (combinations of real radicals in legitimate positions) matched in perceptual properties. The N200 clearly distinguishes itself from the well-studied N170 and N400. N170 is not sensitive to repetition priming and does not differentiate between real and pseudo-characters. N400 shows repetition suppression (amplitude reduction) but not enhancement for repetition priming in the visual modality as well as in the auditory modality. Contrasting the characteristics of N200 with the other two components reveals for the first time a clear view of the time course of visual Chinese word recognition. In this view, the centro-parietal N200, N170 and N400 correspond to three distinctive major stages of recognition: while N170 reflects basic visual feature processing and N400 reflects phonological and semantic processing, the intermediate N200 reflects a process to integrate visual parts into single characters and to access stored

orthographic representations. Furthermore, reflections on the absence of centro-parietal N200 in alphabetic word recognition lead to a new theory conceptualizing written Chinese as a meaning-spelling script at the vocabulary level, in contrast to alphabetic scripts that are sound-spelling or pinyin systems. This theory deduces that the alphabetic and the Chinese scripts represent two and the only two destinations of written language evolution, with one deeply rooted in human audition and the other in human vision. Constituting a dichotomy, the two types of writing systems have complementary strengths and weaknesses so that one cannot be converted to the other without significant reduction in communication efficiency. This theory possibly resolves a big controversy that has baffled the Chinese over the past hundred years, i.e., whether written Chinese can be or should be Romanized (replaced with a writing system using the Roman alphabet)? Briefly, the discovery of the centro-parietal N200 and the meaning-spelling theory it sparked possibly signify a breakthrough in the study of Chinese language processing.

Language Development, Plasticity, Multilingualism

B25 ERPs Recorded During Early Second Language Exposure Predict Subsequent Proficiency in Adult Learners

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Millions of adults worldwide are faced with the task of learning a second language (L2). Understanding the neural mechanisms that support this learning process is an important area of scientific inquiry. However, most previous studies on the neural mechanisms underlying L2 acquisition have focused on characterizing the results of learning, relying upon end-state outcome measures in which learning is assessed after it has occurred, rather than on the learning process itself. In the present study, we adopted a novel and more direct approach to investigate neural mechanisms engaged during L2 learning, in which we recorded ERPs from beginning adult learners as they were exposed to an unfamiliar L2 for the first time. Learners' proficiency in the L2 was then assessed behaviorally using a grammaticality judgment task, and ERP data acquired during initial L2 exposure were sorted as a function of performance on this task. High proficiency learners showed a larger N100 effect to less predictable, open-class words compared to more predictable, closed-class words, while low proficiency learners did not show a significant N100 difference between open- and closed-class words. Further, the magnitude of the N100 word category effect during early L2 exposure predicted learners' subsequent proficiency on the grammaticality judgment task. Native speakers run on this paradigm also showed a larger N100 effect to open-class words compared to closed-class words, similar to the effect observed in high proficiency learners. These results indicate that high proficiency L2 learners may have better selective attention, allowing them to more easily focus on the least predictable or most difficult units of language and ultimately leading to higher levels of L2 attainment. These findings have implications for L2 training, suggesting that methods that explicitly target selective attention may represent a promising new avenue for L2 training in adults.

B26 No trespassing? Papiamento-Dutch conflict sites

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Introduction In Papiamento-Dutch bilingual speech, the nominal construction is a potential 'conflict site' if there is an adjective from one language and a noun from the other. Do we expect e.g. rode biña or biña rode, and còrá wijn or wijn còrá? Cantone and MacSwan (2009) argue that the language of the adjective determines word order, so that wijn còrá and rode biña would be possible, but not biña rode or còrá wijn. Myers-Scotton (2002), on the other hand, expect the word order to follow that of the morphosyntax in the rest of the sentence, so that wijn còrá and biña rode would be expected where the rest of the sentence is in Papiamento, but rode biña and còrá wijn might be expected where the morphosyntax is Dutch. So far, these theoretical differences have not been reconciled, but ERP work on Welsh-English bilinguals combining converging evidence from different methodologies (corpus data, judgment data, reaction times, and ERP data) seem to point to the fact that the language of the verb is important (Parafita, Boutonnet, Davies, Deuchar & Thierry, 2013). Method To see whether Parafita et al.'s findings are generalizable, we tested the acceptability of code-switched nominal constructions using event-related brain potentials in 20 fluent Papiamento-Dutch bilinguals performing a sentence verification task. We manipulated (1) the matrix language which was that of the sentence verb, (2) the language of the adjective, (3) the language of the noun, and (4) word order. Results Whereas the Matrix Language Framework predicted that a Papiamento adjective in prenominal position within a Dutch matrix sentence would be acceptable, it predicted the occurrence of a violation for Dutch adjectives in prenominal position within a Papiamento matrix sentence. Crucially, the predictions from Cantone and MacSwan's account were exactly the opposite. A negativity in the frontal region (delayed anterior negativity, 450-600 ms window) as well as a slightly delayed P600 were elicited when the position of the adjective was in conflict with the morphosyntax of the sentence (Myers-Scotton 2002), but no significant difference was found when conditions were grouped based on word order according to the language of the adjective (Cantone & MacSwan, 2009), hence supporting what was found in the Welsh-English study. Conclusion & Summary Electrophysiological data using the event-related brain potential (ERP) technique were collected to provide objective measures of the neurocognitive processes underlying code-switching

in Dutch-Papiamento bilinguals. The results supported previous findings with Welsh-English bilinguals, namely, that the relative order of the noun and the adjective is determined by verb inflection (Parafita et al., 2013). Implications of these results include the importance of the clause in the grammaticality of determiner phrases. In addition to understanding the mechanisms involved in processing languages with conflicting grammars, the use of ERPs generates interesting insights into the validity of theories of code-switching.

B27 A computational model of distinct hippocampal and cortical contributions to word learning under referential ambiguity *David Warren[1], Melissa Duff[1], Bob McMurray[1]; [1]University of Iowa*

The hippocampus and the neocortex play distinct roles in learning, yet these are rarely examined in complex developmental domains like language acquisition. For example, to learn the words of their language, children must learn to map tens of thousands of word-forms on to their meanings, yet they typically do this under conditions of high referential ambiguity where the intended meaning of a word is not always obvious at any time. Learning under such conditions requires the ability to extract associations between a word and its referent across many learning episodes even as any one may be ambiguous. The result is a complex developmental learning trajectory that has been usefully characterized using dynamic associative computational models (e.g., McMurray et al., 2012). However, the distinct contributions of hippocampal and cortical learning systems have not been explored in this context. Building on an existing computational model (McMurray et al., 2012), we developed a model with separate, parallel learning pathways representing hippocampal and cortical learning systems. This allowed us to evaluate word-learning performance (recognition, response time, and complex behaviors like inference) of the two pathways separately and in combination. Mirroring expectations derived from the neuropsychological literature, the cortical model learned incrementally and better reflected the statistical history of learned associations, while the hippocampal model learned quickly and (initially) tended to reflect the influence of individual learning episodes irrespective of accuracy. In combination, these two model systems produced rapid, accurate learning that was very robust to referential ambiguity. Using this combined model, we make predictions about the consequences of adult-onset hippocampal lesions for familiar word selection under ambiguity, fast mapping, and associative word-learning.

B28 Neural patterns of mathematical processing in monolingual and bilingual speakers *Shin-Yi Fang[1], Ping Li[1], Yue Wang[2]; [1]Pennsylvania State University, [2]Simon Fraser University*

Language and mathematics are two important skills in modern society. In spite of typological differences in phonology, syntax, and lexical semantics across languages, basic mathematical operations of numbers, such as addition, subtraction, division, and multiplication, have similar meanings in different languages. However, numbers are represented in different languages by different words or syllables and the operations of numbers are acquired and learned with different methods in different cultures. Previous research has indicated significant cross-language differences in neural response patterns during mathematical processing (Tang & Liu, 2006 & 2009), and for bilingual speakers, significant differences in neural responses to arithmetic questions depending on which language is used (Lin, et al., 2011; Wang et al., 2007). In this study we investigated the neural correlates of mathematic processing in Chinese-English bilinguals and English monolinguals. Our study examined the Chinese-English bilingual speakers in order to understand the cognitive and neural mechanisms involved in the mental operation and representation of mathematical functions in multiple languages. In particular, we investigated that how late bilinguals process a familiar task (addition task) in an unfamiliar language input. We also examined the role of working memory capacity, strategies to solve mathematic questions, and level of proficiency in modulating neural response patterns during mathematical processing. Twenty-four Chinese-English bilingual and twelve English monolingual speakers participated in the study. Participants were asked to perform an arithmetic verification task during MRI scans. In the arithmetic verification task, participants were asked to determine whether the third digit was equal to the sum of the first two (e.g., 2 + 5 = 7, correct; 2 + 5 = 8, incorrect). Our results showed that during arithmetic verification processing, there was no main effect of Language: regardless of whether English or Chinese was used in the task, both bilinguals and monolinguals recruited intraparietal sulcus and posterior superior parietal lobe which were considered key arithmetic processing areas regardless of input language (Dehaene et al., 2003). However, there was a main effect of Group: bilinguals showed decreased activity than monolinguals in anterior cingulate (ACC), inferior frontal (IFG), inferior parietal (IPL), caudate, cuneus, and middle frontal gyrus. Decreased activation in ACC, IFG, IPL and caudate in bilinguals as compared with monolinguals could be associated with more efficient executive control ability in bilinguals (e.g., Abutalebi & Green, 2007). Furthermore, individual differences in working memory capacity correlated with accuracy of arithmetic task in unfamiliar language input ($p < .001$) in the behavioral results. Consistent with Wang et al. (2007) and Lin et al. (2011), we found higher activation during arithmetic processing in inferior frontal and inferior parietal regions. However, we did not find significant activation differences between language inputs in bilinguals. Our findings suggest that instead of recruiting new brain regions,

bilinguals use the brain regions that are involved in L1 input to conduct mathematical processing in L2, suggesting that L2 is assimilated into the L1 network by the Chinese-English bilinguals (cf. Perfetti et al., 2007), although there may be differences in processing efficiency between L1 and L2.

B29 Working hard really does pay off: An fMRI investigation of lexical access in L2 learners *Angela Chouinard[1], Ping Li[1], Shin-Yi Fang[1]; [1]The Pennsylvania State University*

This study uses functional magnetic resonance imaging (fMRI) to investigate how the development of lexical access in second language (L2) learners may be influenced by individual differences in working memory (WM) and inhibitory control (IC). Models of bilingual processing suggest that (a) bilinguals must consistently use IC in comprehension and production and (b) highly proficient learners access concepts directly while less proficient learners access concepts only through the L1 (Green, 1998; Kroll & Stewart, 1994). The neural implication of these models is that less proficient bilinguals, compared with highly proficient bilinguals, will require more effort to inhibit their L1 in order to successfully retrieve words in the L2. Our hypothesis, based on the current neuroimaging literature, is that lower proficiency learners will more strongly activate inhibitory control areas, such as the left inferior frontal gyrus (LIFG) and anterior cingulate cortex (ACC), in addition to areas associated with semantic retrieval, such as the left middle temporal gyrus (LMTG). Higher proficiency learners, by contrast, should utilize more efficient networks where the LMTG acts as a hub of semantic retrieval rather than in the LIPFC or ACC for cognitive control (Abutalebi, 2008; Yokoyama, 2009). Participants in our study completed measures of proficiency (TVIP; Dunn et al. 1986) WM (phonological letter number sequencing; Wechsler, 1997) and IC (flanker task; Emmorey et al. 2008) before an fMRI experiment in which participants were asked to make a language-specific lexical decision on L1 words, L2 words, and homographs (e.g.. pie, the Spanish translation of foot). Homographs by nature cause high levels of activation of both languages, and consequently require high levels of inhibitory control to negotiate this activation when choosing which meaning to utilize (Van Heuven et al., 2008). Behavioral results did not show any significant correlations between proficiency, WM, or IC. Although these measures did not correlate significantly with each other, when included as covariates in the fMRI data analysis, we observe a positive correlation between greater activation in our pre-specified regions of interest, working memory, and proficiency. This suggests that, contrary to our predictions, L2 learners with higher WM and proficiency are calling on the LIFG, ACC, and LMTG more when accessing L2 words, rather than less. Specifically, learners are utilizing the LIFG under high conflict conditions (when identifying homographs), and the ACC under normal conflict conditions (when identifying unambiguous Spanish words). Participants also utilized the LMTG and left precuneus more when accessing Spanish words compared with English words, areas associated with semantic and episodic retrieval, respectively. Results are discussed in the context of current neuroimaging models of second language acquisition and bilingualism.

B30 Alteration of functional connectivity between brain regions for executive control and those for language processing in bimodal bilinguals *Le Li[1], Guosheng Ding[1], Lijuan Zou[1], Xin Yan[1]; [1]Beijing Normal University*

Previous studies revealed that the dorsal anterior cingulate cortex (dACC) and the left caudate nucleus (LCN) play critical roles in bilingual language control. The dACC was proposed to monitor and solve the conflict between languages, while the LCN to control the language in use. Both regions are also engaged in general executive control. Structural and functional changes of both regions have been identified in bilinguals. However, it is unknown whether and how the functional interaction of these two regions with other brain regions alters in bilinguals as a consequence of long-term experience of using two languages. We aimed to address this issue with both resting-state fMRI and task-related fMRI. The participants included 14 bimodal bilinguals and 15 monolinguals. The functional imaging data during the resting state were collected for both groups. Two seed regions, the dACC and the LCN, were selected and the whole brain FC with either region (dACC or LCN) were compared between bimodal bilinguals and monolinguals. The bilinguals were further scanned when they carried out a picture naming task with either the spoken language or the sign language. Several regions of interest (ROIs) were selected based on the results of resting-state fMRI and the activation and the FC among these ROIs were further calculated. The results of resting-state fMRI showed that, the FC of dACC with both the left putamen and the left rolandic operculum (RolOp) was decreased in bilinguals compared to monolinguals. For the LCN, the FC with the left inferior temporal gyrus (ITG) and the right superior parietal lobule (SPL) was increased in bilinguals. The task-related fMRI showed that, the putamen and RolOp positively activated in spoken language and negatively activated in sign language, while the ITG activated more in sign language. For the LCN, its FC with the putamen, RolOp and SPL was stronger in spoken language, while its FC with the ITG was not different. For the dACC, its FC with the putamen and RolOp was stronger in spoken language, while its FC with the ITG was stronger in sign language. This pattern of FC difference was repeated when seeding in other language specific regions for production. We concluded that, the dACC and the LCN interacted with language regions with different patterns in language control during bilingual language production, which may induced an alteration of intrinsic brain functional connectivity during resting state.

The results shed light on how the dACC and the LCN work with other brain regions during bilingual language processing.

B31 The use of cognitive control in the comprehension of Spanish-English code-switching *Jorge Valdes Kroff[1], Sharon Thomspon-Schill[1], John Trueswell[1]; [1]University of Pennsylvania*

The experimental evidence on language switching in bilinguals suggests increased processing costs (e.g. higher naming latencies on switch trials v. non-switch trials, Meuter & Allport, 1999) and increased recruitment of brain regions associated with cognitive control (e.g. left inferior frontal gyrus, anterior cingulate cortex, Abutalebi & Green, 2007, 2008). Generally, language switching paradigms present items in isolation and signal via external cue (e.g. color of background screen) the target language. However, bilinguals in the presence of other known bilinguals engage in code-switching, defined as the fluid alternation between languages during conversation (Poplack, 1980). In contrast to language switching paradigms, code-switches are embedded within sentential contexts and are integrated into the morpho-syntactic frames of both languages, e.g. pero no tenían el flag out there? "but didn't they have the flag out there?" (Deuchar et al., 2012). Sentential code-switching raises the question as to whether bilinguals rely upon similar neural and cognitive processes (i.e. cognitive control) to successfully comprehend code-switches. To investigate this question, Spanish-English bilinguals were recruited to participate in an fMRI study in which participants heard 164 Spanish sentences, half of which ended in code-switches. Additionally, the sentences were normed to be highly semantically constraining, generating an expectation for the final noun phrase of the sentence, e.g. tras aquel terrible accidente mi tío estuvo a punto de perder la vida "After that horrible accident, my uncle almost lost his life." This constraint allowed us to further manipulate the expectancy of the final noun phrase, resulting in a 2 x 2 design (Language x Expectancy) with the following 4 conditions: 1) Spanish Expected (vida, "life") 2) Spanish Unexpected (pierna, "leg") 3) English Expected (life) 4) English Unexpected (leg). The expectancy manipulation provides a second point of comparison for the comprehension of sentential code-switches due to previous findings that unexpected semantic completions also show increased activation in the left inferior frontal gyrus (e.g. Baumgaertner et al., 2002). Consequently, a comparison between the code-switched conditions to the Spanish Unexpected condition should indicate whether the comprehension of code-switches are always costly compared to same language sentences or if under different processing demands (i.e. unexpectancy), code-switches require less cognitive control than same language comprehension. To identify each individual's region of highest engagement of cognitive control in the prefrontal cortex, participants completed a modified color Stroop task (Millham et al., 2001) as a functional co-localizer (January et al, 2008; Hindy et al., 2012). Mean beta weights were calculated for each condition within the top 50 voxels exhibiting the Stroop effect within the left inferior gyrus for each subject. Group mean beta weights trend towards showing higher engagement of cognitive control for the code-switched conditions as well as for the Spanish unexpected condition, when compared to the Spanish expected condition. These trends offer tentative support that the experimental manipulation can be used to investigate the recruitment of cognitive control in the comprehension of sentential code-switching.

B32 Development of Number Representations and Mappings in Bilingual 5- to 7-Year-Olds *Shirlene Wade[1], Irene Chavez[1], Jessica Valdivia[1], Jessica Sullivan[1], David Barner[1]; [1]University of California, San Diego*

Previous research has looked at mechanisms used in refining estimation skill in monolingual children as well as the effect of language in approximate and exact arithmetic in bilingual adults. However, no study has looked at how bilingual children learn how to estimate in their dominant and less preferred languages. The present study asks whether estimation involved language-specific or language non-specific input to develop number word-magnitude mappings in L1 and L2. If estimation recruits processes that are language non-specific, it is expected that a bilingual child's accuracy at estimation to remain similar in both languages. However, if estimation recruits processes or mechanisms that are specific to language, estimation accuracies should differ based on language experience. A total of 23 Spanish-English bilingual children between the ages of 5 and 7 participated in the study. Nine participants were excluded from final analyses because they failed to complete half of the estimation trials in one or both language conditions. Fourteen English-dominant Spanish-English bilingual adults and 14 balanced Spanish-English bilingual adults also participated in the study. Participants were presented with dot arrays and asked to provide verbal estimates. Each participant provided oral responses in English and Spanish, depending on the language condition. For all groups, A Standard Least Squares (REML) regression model was used to predict response from Numerosity, Language Dominance (Dominant, Less Preferred), their interaction, and Participant was considered a random variable. Of interest, dominant bilingual children and dominant bilingual adults showed an interaction of Numerosity and Language Dominance (β = .066; SE = .01; t = 4.64; p < .0001 and β = .04; SE= .01; t = 3.5; p <.0005, respectively), indicating that these groups estimated more accurately in the Dominant language over the Less Preferred language. Balanced bilingual adults, on the other hand, did not show a significant interaction (β = -.02; SE = .01; t = -1.94; p = .0524). This shows that Balanced Bilingual Adults do not reliably provide different estimates for the same magnitudes in English and Spanish. Specific language experience in children and adults appears to contribute to the accuracy of estimates in each respective

language. We conclude that number word-magnitude mappings are strengthened by language specific experience and as such can be affected by bilingual proficiency or frequency effects.

B33 Inhibitory control during sentential code-switching: Evidence from fMRI *Eleonora Rossi[1,2], Sharlene Newman[3], Michele Diaz[4], Paola E. Dussias[1,2,5], Caitlin Ting[1,2], Janet G. van Hell[1,2,6]; [1]Department of Psychology, Pennsylvania State University, [2]Center for Language Science, Pennsylvania State University, [3]Department of Psychological and Brain Sciences, Indiana University, [4]Psychiatry and Behavioral Sciences, Duke University, [5]Department of Spanish, Italian, & Portuguese, Pennsylvania State University, [6]Radboud University Nijmegen*

Code-switching (defined as the fluent and natural alternation between a bilingual's two languages during discourse) is ubiquitous in many bilingual communities around the world. Despite its prevalence in actual bilingual conversation, and despite the voluminous literature on the syntactic and social constraints that regulate code-switching, very little is known about the psycholinguistic mechanisms that regulate this phenomenon. Even less is known about which brain areas are engaged while bilinguals code-switch between their two languages. On the one hand, language switching has been suggested to be a costly mechanism especially during language production (Altarriba et al., 1996; Meuter & Allport, 1999). However, recent evidence shows that for some speakers (i.e. habitual code-switchers) the processing of a code-switch might be less problematic than expected (Moreno, Federmeier & Kutas, 2002; Dussias, 2003). Also, recent neuroimaging studies show that language switching engages brain areas involved in domain-general cognitive control (e.g., left inferior frontal gyrus, anterior cingulate cortex, Abutalebi & Green, 2008). However, the majority of previous neurocognitive studies have predominantly examined code-switching in bilinguals who were not habitual code-switchers, and mainly investigated single-word switches in isolation which are less representative of natural code-switching behavior (but see Abultalebi et al., 2007 for switches in sentence-context). To investigate whether habitual code switchers rely on similar domain-general cognitive control mechanisms while processing code-switches, we recruited Spanish-English habitual code-switchers (n=21) who read sentences with embedded code-switches during an event-related fMRI paradigm. Participants read sentences in Spanish or English only (without code-switches) or sentences that began in Spanish and switched into English mid-stream (40 sentences per condition) mirroring code-switching patterns found in naturalistic corpora (e.g. Deuchar et al., 2012). We also investigated the role of linguistic complexity in code-switching, by including two types of switches that occur in natural language switching environments: switches that occur at the noun phrase (e.g. El crítico pensó que the novel would take several days to read.) or at the verb phrase (e.g. El crítico pensó que la novela would take several days to read). Preliminary results show that areas involved in general cognitive control (e.g., pre-SMA) are recruited when processing sentences without code-switches, relative to sentences containing code-switches. Ongoing correlation analyses will determine whether language dominance and aptitude in language switching modulates activation. Additionally, significant activation in the cerebellum when processing sentences containing code-switches suggests that habitual code-switchers might engage a wider control network to adapt inhibitory control processes according to task demands, as proposed by the bilingual adaptive cognitive control model (e.g., Green & Abutalebi, 2013). Further analyses will determine whether different levels of code-switching behavior (as measured by a questionnaire of daily language use) will modulate the strength of the observed neural activity.

B34 The bilingual advantage and conflict adaptation: An fMRI investigation *Susan Teubner-Rhodes[1,2], Donald J. Bolger[1], Jared Novick[1,2]; [1]University of Maryland, College Park, [2]Center for Advanced Study of Language*

Compared to monolinguals, bilinguals often adjust behavior more efficiently on tasks involving information-conflict [1]. But this "bilingual advantage" in cognitive control emerges only when subjects must frequently switch between conflict and non-conflict trials [2], perhaps reflecting superior conflict monitoring—the ability to detect competing information signals and reactively recruit cognitive control [3]. Conflict adaptation, wherein individuals resolve conflict better after encountering conflict on a previous trial [4], reflects moment-to-moment cognitive control engagement and is considered the hallmark of the conflict-monitoring system [3]. Underlying this phenomenon is greater anterior cingulate (ACC) activation during initial conflict detection, triggering subsequent conflict resolution by the dorsolateral prefrontal cortex (dlPFC) [5]. However, these effects have not been examined in bilinguals. Using fMRI, we compared adaptation effects in bilinguals and monolinguals to test if the bilingual advantage involves the conflict-monitoring system (e.g., ACC/dlPFC activity following conflict detection). Early Spanish-English bilinguals (n=6) and English monolinguals (n=9) completed a color-word Stroop task in a 3T Siemens MRI scanner. Subjects viewed words in different font colors, indicating the font color as quickly as possible via button press. Subjects encountered 168 congruent (C) trials, where word meaning matched the font color; 168 incongruent (I) trials, where word meaning and font color mismatched; and 48 neutral trials, where word meaning was unrelated to color. Evaluating conflict adaptation depends on trial history: preceding trial type determines cognitive control engagement on current incongruent trials. We therefore presented 72 CC, CI, IC, and II sequences (the first letter indicates preceding and the second letter current trial type). Bilinguals were nominally

more accurate (but slower) than monolinguals on CI (Mdiff=3.5%, Mdiff=42ms) and II trials (Mdifference=3.2%, Mdifference=37ms), but showed equivalent behavioral conflict adaptation (MAccuracydifference=-0.3%, MRTdifference=5ms). Interestingly however, preliminary analyses show greater activation in bilinguals than monolinguals ($p<.001$) when detecting conflict (CI>II) in the left caudate head [-6 14 16] and the left rostral mid-cingulate gyrus [-8 -10 30], including ACC. Our findings suggest that bilinguals exhibit more "adaptation" in the conflict-monitoring system: the ACC is more active during initial than subsequent conflict trials particularly in bilinguals, suggesting increased sensitivity to preceding trial context when processing conflict. Although the left caudate is not typically implicated in conflict adaptation, it is involved in language-switching, as is ACC. Specifically, bilinguals show increased left caudate and ACC activation when switching to their subordinate language [6], which may be akin to conflict detection, as the subordinate language is unlikely to compete with the dominant language prior to switching, but should compete after switching. Thus, via language-switching, bilingualism may enhance the role of the left caudate and ACC in conflict monitoring. Such increased neurobiological efficiency in conflict detection may explain the bilingual advantage.
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B35 A framework for the automated analysis of speech production data. *Frédéric Roux[1], Wouter De Baene[4], Manuel Carreiras[1,2,3]; [1]Basque Center on Cognition, Brain and Language (BCBL), San Sebastian, Spain, [2]Ikerbasque, Basque Foundation for Science, Bilbao, Spain, [3]UPV/EHU, Universidad del Pais Basco, Spain, [4]Department of Experimental Psychology, Ghent University, Belgium*

The assessment of behavioral performances in speech production tasks requires a reliable way of measuring speech onset times and response accuracy. However, the assessment of response accuracy is usually done manually and can be very time consuming. Speech onset detection, on the other hand, can be influenced by subjective bias. Here, we present a framework for the automatic analyis of accuracy and onset latencies in speech production data. We tested its performance on n = 10 participants and quantified its reliability by comparing automatic scores with manually assessed response accuracies and reaction times. Our approach is inspired by similar procedures developed to quantify song bird development (Tchernichovski, 2000) and employs multitaper spectral analysis to extract a set of acoustic features from human speech. Based on these features, response accuracy is measured automatically by quantifying the similarity between speech responses. We demonstrate that the present procedure is suitable to automatically measure (1) response accuracies and (2) response latencies by presenting data collected on a bilingual naming task in balanced bilingual participants. To this end we will present data from a bilingual naming task where the present framework was used to automatically assess switch cost effects and to quantify the intra-individual stability of bilingual switch costs across different measurements.

Lexical Semantics

B36 An electrophysiological investigation of task effects in visual word recognition *Ian Hargreaves[1], Penny Pexman[1]; [1]University of Calgary*

Researchers interested in the neural correlates of semantic processing typically manipulate meaning through the presentation of different types of words and pictures. A growing literature suggests that semantic processing is also sensitive to top-down effects, and can be shaped by the demands created by different tasks (e.g., detecting a letter vs. generating mental imagery; West & Holcomb, 2000). We examined a very fine-grained manipulation of task context by contrasting the event-related potentials (ERPs) associated with two semantic categorization tasks: is it an animal? vs. is it a concrete thing?. Converging evidence suggests that when participants place a relative emphasis on concrete information during lexical processing, they elicit N400 effects, with more negative ERPs for high-imagery words (concrete) compared to low-imagery words (abstract; West & Holcomb, 2000). If task context alone is capable of changing participants' reliance on concrete information, we should be able to elicit larger N400 effects for a set of animal words under a concrete SCT, than under an animal SCT. This, despite the fact that the animal items used in this, and in our previous study (Hargreaves et al., 2012) were all judged to be clear examples of both the animal and the concrete categories. Twenty-five right-handed monolingual English speaking students at the University of Calgary participated for course-credit. Animal items (N = 108) were divided into two lists of 54, balanced across numerous lexical and semantic dimensions. Individual items were presented on a computer monitor in an acoustically, and electromagnetically shielded environment. We counterbalanced the presentation of these two lists under the animal and concrete SCTs. Participants completed two blocks of the SCT (one animal block and one concrete block), the order of which was counterbalanced across participants. Simultaneous EEG data was collected across 64 active Ag/AgCl electrodes. Using time windows corresponding to the N400 (300-500 ms), we conducted repeated measures analyses of variance (ANOVA) on mean EEG amplitude during this window. Despite null differences in reaction time, under the concreteness decision we observed greater negativities in an N400 window (300-500) than when the same items were presented under the animal decision. This task-

driven N400 concreteness effect suggests that top down modulation of semantic processing can be elicited by minor shifts in decision criteria. Clearly, despite being semantic, the choice of SCT category has significant consequences for the results. As a consequence of this the current findings bear upon conflicting results in the N400 literature for any two studies that used different tasks. One interpretation is that task context shifted participants' relative emphasis on item-specific properties such as tangibility and imageability, leading to a corresponding N400 effect. That task-context was able to influence semantic processing in the same temporal window as a direct comparison of concrete and abstract words suggest that semantic processing is flexible. Our usage of word meaning is not solely driven by the properties of words themselves. Rather, semantic categorization is a dynamic process that constructs meaning in a context-dependent manner (Kiefer, 2012; Kutas & Federmeier, 2011).

B38 Category Specific Temporal and Spatial Dissociations as Revealed by Grouped Human Electro-Corticography *Cihan Kadipasaoglu[1], Christopher Conner[1], Vatche Baboyan[1], Nitin Tandon[1]; [1]Vivian Smith Dept. Neurosurgery, UT Houston*

The spatio-temporal characteristics of electro-corticography (ECoG) data yield novel insights into cognitive operations such as category-specificity activity during visual naming tasks. However, the broader application of ECoG has been confounded by difficulties in accurately representing individual data, as well as performing statistically valid population-level analyses. To overcome these limitations, we developed methods for accurately registering ECoG data to individual cortical topology. We integrated this technique with surface-based co-registration and a mixed-effects multilevel analysis (MEMA) to perform grouped analysis, controlling for cortical variability, sparse coverage across patients, and intra- and inter-subject variability. We applied this Surface-Based MEMA (SB-MEMA) technique to visual naming tasks (tools, animals, famous faces and places) performed in patients implanted with subdural electrodes for the treatment of pharmacologically resistant epilepsy (n=25, left hemisphere). Percent power change was computed in the mid-gamma range (60-120 Hz) following stimulus onset (50 to 700 ms), compared to baseline (-850 to -200 ms). To investigate temporal activation profiles, the loci of peak activity from the grouped results were used to identify corresponding electrodes across individuals and compute a grouped time series. SB-MEMA yielded significant power changes in the ventral and lateral occipito-temporal cortices, consistent with results from individual data and meta-analyses of these four categories. The only region to express pure category selectivity was the superior parietal gyrus (tools). Ventrally, regions of overlapping activity were identified in the fusiform, parahippocampal, and lingual gyri, as well as the retro-splenial cortex. Laterally, regions of overlapping activity were identified in the middle and inferior occipital gyri. Significant differences were noted in locations of peak activity amplitude in these regions (p=.05, corrected), forming antero-posterior and medio-lateral category-specific gradients. Time series analysis revealed prominent early activity (<150 ms) in all tasks. Of note, the inferior occipital gyrus revealed a bimodal activation profile, most prominent for faces and then tools, which likely represents signatures of bottom up and top down modulation of local processing. This profile is not a result of group averaging, as identical temporal profiles were seen in individual subjects. Across categories, significant differences were revealed in the onset of activity within a given region. Interestingly, categories with the strongest percent power change did not always have earliest onset of activity. Our results demonstrate that neural substrates in the ventral and lateral occipito-temporal cortices exhibit similar and over-lapping category specific activity. Specificity is demonstrated not only through the location and peak strength of activity, but also in its temporal profile. ECoG is uniquely suited to uncover these details, given its unmatched temporal and spatial resolution. However, the lack of fundamental techniques to compare and analyze grouped datasets has constrained ECoG analyses largely to the individual level. Using novel methods of ECoG data representation and statistically valid grouped analyses (SB-MEMA), we have demonstrated these results at the population level.

B39 ERP Evidence for Language Effects on Visual Processing of Motion Events in Bilinguals *Monique Flecken[1], Vicky T. Lai[1,2]; [1]Donders Institute for Brain, Cognition and Behaviour, Radboud University Nijmegen, [2]Max Planck Institute for Psycholinguistics*

Do the languages bilinguals speak affect the way they attend to reality? Studies in monolinguals using behavioural measures show mixed results (for overviews, see Gentner & Goldin-Meadow, 2003). Event-Related Potential (ERP) studies in monolinguals showed how language influences the earliest stages of, e.g., colour perception (Thierry et al., 2009) using nonverbal visual oddball paradigms, comparing native speakers of languages with different categorical distinctions in the lexicon. In bilinguals, Athanasopoulos et al. (2010) showed that bilinguals who had learned a second language late (i.e., after puberty) displayed a lower degree of perceptual discriminability of native language colour distinctions. We examined in how far language drives attention to motion events in Turkish-Dutch early bilinguals (born in the Netherlands, highly proficient in both languages, onset of acquisition before 4 years). Turkish and Dutch differ in how they encode motion. In Dutch, the manner of motion is typically encoded in the main verb in a sentence (A man 'runs' into a tunnel). In Turkish, manner of motion is optional, and the path or direction/endpoint of motion is encoded in the main verb (A man enters a tunnel ('running')). Does this cross-linguistic difference prompt manner to be more salient to Dutch eyes than to

Turkish eyes (Slobin, 2004)? Does this affect speakers' attention to motion events, and if so, to what extent do both language systems co-determine what Turkish-Dutch bilinguals attend to? 24 Turkish-Dutch early bilinguals and 24 Dutch monolinguals performed a motion matching task with an ERP oddball paradigm. On each trial, a target picture depicting a motion event (a person cycling to a tunnel) (200ms) was preceded by one of four kinds of dynamic videoclips (1500ms), representing four conditions: Full-mismatch (skating to a gate), manner-match (skating to a tunnel), endpoint-match (cycling to a gate), and full-match. The percentages of the conditions were 70%, 10% (48 trials), 10%, and 10%, making the last three infrequent for eliciting P300 components, indicative of attentional processing. In both groups, P300s were more positive for the full-match relative to the full-mismatch control (P300 effect), confirming the oddball manipulation. In Dutch monolinguals, P300 amplitudes for manner-matches were larger than for endpoint-matches, suggesting that Dutch monolinguals allocated more attention to manner. In Turkish-Dutch bilinguals, P300s for manner-match and endpoint-match were similar in amplitude, suggesting that Turkish-Dutch bilinguals attended to manner and endpoint equally. Overall, both languages in bilinguals contribute to the interaction between language and attention patterns, resulting in a lower degree of manner of motion-salience in the Turkish-Dutch early bilinguals, compared to monolingual Dutch speakers, for whom manner is more salient. The acquisition of two typologically different languages from birth thus affects visual processing and attentional biases towards linguistically salient elements in complex scene processing.

B40 A longitudinal fMRI study of semantic association and categorical relatedness on children's semantic processing *Ciao-Han Wong[1], Shiou-Yuan Chen[2], Tai-Li Chou[1,3,4]; [1]Department of Psychology, National Taiwan University, Taiwan, [2]Department of Early Childhood Education, Taipei Municipal University of Education, Taiwan, [3]Neurobiology and Cognitive Science Center, National Taiwan University, [4]Graduate Institute of Brain and Mind Sciences, National Taiwan University*

Previous developmental studies with regard to semantic processing used cross-sectional approaches to examine developmental changes and did not make distinctions between semantic association and categorical relatedness. Semantic association was defined as character pairs produced by free association tasks; categorical relatedness was referred to character pairs within the same semantic category. The present study used a longitudinal approach to further investigate the roles of semantic association and categorical relatedness in the developmental changes of semantic processing. We orthogonally manipulated the semantic association (strong, weak) and categorical relatedness (high, low) to examine developmental changes of 12-year-old children in a two-year interval. Sixteen children who underwent functional magnetic resonance (fMRI) scans were asked to decide whether two visually-presented Chinese characters were semantically related and tested again two years later. The behavioral results showed children performed better on the second visit versus the first visit, on the strong versus the weak semantic association, and on the high versus the low categorical relatedness. As to fMRI results, there were two main results. First, the contrast of the weak versus the strong semantic association produced greater activation in left inferior frontal gyrus (IFG) for the second visit as compared with the first visit. Second, the contrast of the high versus the low categorical relatedness produced greater activation in left precuneus for the second visit as compared with the first visit. The developmental increase in the IFG may be related to increased demands on selecting semantic features in weaker association pairs, suggesting that older children may have learned to engage more thoroughly in selection of semantic knowledge. Moreover, the developmental increase in left precuneus could be associated with abstract relationship for low categorical pairs, suggesting that older children may devote resources to the less saliently conceptual and perceptual features to find out the semantic relations in categorical relatedness.

B41 Semantic processing in schizophrenia with motivational withdrawal *Fang-Chia Hsu[1], Tai-Li Chou[1,2,3], Tzung-Jeng Hwang[2,3,4]; [1]Department of Psychology, National Taiwan University, Taiwan, [2]Neurobiology and Cognitive Science Center, National Taiwan University, [3]Graduate Institute of Brain and Mind Sciences, National Taiwan University, [4]Department of Psychiatry, National Taiwan University Hospital and College of Medicine*

Schizophrenia is usually accompanied by motivational impairments and semantic deficits. However, the neural mechanism involved in the interaction between motivational impairments and semantic processing in schizophrenia is understudied. Functional magnetic resonance imaging was used to investigate the neural mechanism of motivational withdrawal in 26 healthy controls and 26 patients with schizophrenia. The two groups were age-, gender, IQ-matched, and right-handed. All of the patients had motivational withdrawal as evaluated by emotional withdrawal (N2) and passive-apathetic social withdrawal (N4) on the Positive and Negative Syndrome Scale. The participants were asked to judge whether two Chinese words were related in meaning. Brain activations for semantically related pairs were compared between groups. Compared to the controls, the patient group with motivational withdrawal showed greater activation in the right inferior frontal gyrus (IFG) and left insula. The right IFG may play a compensatory role in selecting relevant semantic features. Moreover, greater insula activation may be associated with an increased demand on integrating meaning and motivation, possibly due to deficits on meaning and motivational processes. In contrast, compared to the controls, the patient group had reduced activation in the left middle temporal gyrus,

implying an aberrant organization of semantic networks. This work was supported by the National Science Council of Taiwan (NSC 101-2410-H-002-093-MY2) to Tai-Li Chou.

B42 Developmental changes of structural connectivity and effective connectivity in semantic judgments of Chinese characters *Li-Ying Fan[1], Wen-Yih Isaac Tseng[2,3,4,5], Tai-Li Chou[1,2,3]; [1]Department of Psychology, National Taiwan University, [2]Neurobiology and Cognitive Science Center, National Taiwan University, [3]Graduate Institute of Brain and Mind Sciences, National Taiwan University, [4]Center for Optoelectronic Medicine, National Taiwan University College of Medicine, Taipei, Taiwan, [5]Department of Medical Imaging, National Taiwan University Hospital*

Previous studies have investigated the developmental changes of semantic processing regarding neural correlates between adults and children. However, it is little known whether the patterns of structural connectivity and effective connectivity differ between adults and children during semantic processing. Functional magnetic resonance imaging (fMRI), diffusion spectrum imaging (DSI), and dynamic causal modelling (DCM) were used to study the developmental changes of neural correlates, structural connectivity, and effective connectivity during semantic judgments. Twenty-six children (8- to 12-year-olds) and twenty-six adults were asked to indicate if character pairs were related in meaning. Compared to children, adults showed greater activation in the left ventral inferior frontal gyrus (BA 47) and left middle temporal gyrus (MTG). In addition, adults had significantly greater structural connectivity in the left ventral pathway (inferior frontal occipital fasciculus, IFOF) than children. Moreover, adults showed significantly stronger bottom-up effect from left fusiform gyrus to ventral IFG than children in the related condition. In conclusion, our findings suggest that age-related maturation in brain activation (ventral IFG and MTG) and structural connectivity (IFOF) might be associated with the bottom-up influence of orthographic representations on retrieving semantic representations for processing Chinese characters.

B43 Longitudinal relation between lexical performance and regional gray matter volume *JungMoon Hyun[1], James S. Babb[2], Susan M. De Santi[3], Loraine K. Obler[1]; [1]The Graduate Center of the City University of New York, [2]New York University Medical Center, [3]GE Healthcare*

Goals: Studies have reported aging-related lexical performance decline and morphological brain changes in cognitively healthy older adults. Despite the co-occurrence of language and brain changes, there is a paucity of longitudinal research on the relationship between these two components. The goals of this study were to examine performance changes on four lexical tasks with aging, and to determine which specific regional brain volumes were linked to the longitudinal lexical performance changes in cognitively healthy older adults. Methods: One hundred four cognitively healthy older adults (average age 71.87 (±4.89) years, and range 65-88 years) were selected from the longitudinal aging study at the Center for Brain Health, New York University Langone Medical Center. The participants were included in this study if they were cognitively healthy participants over 64 years of age at their baseline visit, right-handed, native speaker of English, completed at least two diagnostic evaluations which included lexical tasks and MRI scans, and retained the clinical diagnosis of normal at each evaluation. The average number of visits was 2.21 times (range: 2-5 times) and the average period from the first visit to the last visit was 4.18 years (range: 1.5 – 11.67 years). Four lexical tasks were administered: the modified Boston Naming Test (BNT), Two Verbal Fluency tests (Semantic and Phonemic Fluency), and the WAIS Vocabulary Test. Regional brain volumes were extracted via FreeSurfer selecting predefined brain regions. Mixed effect models were employed to examine the longitudinal relationship between 1) age and lexical performance and 2) lexical performance and brain volume. In the second model, age, education, gender, total intracranial volume and interval between visits were covaried. Results: 1) The analyses of this longitudinal data revealed that age significantly and negatively predicted modified BNT performance (df = 141, F = 9.71, p value was less than.01) from baseline to last visit (for Semantic Fluency, the p value approached significance (p =.054)). However, age did not predict the changes in Phonemic Fluency or WAIS Vocabulary. 2) the brain regions whose volumes significantly correlated to the lexical performance over time were as follows: BNT– R. entorhinal cortex, L. superior temporal gyrus, bilateral medial lingual gyri, and bilateral frontal poles; Semantic Fluency – L. superior planum polare, L. medial parahippocampus, and L. pars orbitalis; Phonemic Fluency – R. medial parahippocampus and R. frontal pole; WAIS Vocabulary – bilateral entorhinal cortices, R. temporal pole, and L. medial parahippocampus. Conclusion: The lexical tasks showed differential trajectories in cognitively healthy older adults. The modified BNT was the most sensitive predictor of decline with aging. Regarding the relationship between brain regions and language performance, all lexical tasks involved primarily frontal and temporal lobes that traditionally linked to memory and executive functions. These results imply the importance of memory and executive functions on longitudinal sparing of lexical performance in older adults.

B44 Individual differences in the neurofunctional reorganization for semantic categorization in normal aging *Ikram Methqal[1,2], Jean Sebastien Provot[1,2], Oury Monchi[1,2], Yves Joanette[1,2]; [1]Centre de Recherche, Institut Universitaire de Gériatrie de Montréal, Canada, [2]Faculty of Medecine, Université de Montréal, Canada*

Introduction: Aging is characterized by a preservation of semantic processes of language accompanied by an enrichment of lexicon. This preservation contrasts with

the existence of decline in most other cognitive domains, as well as important changes in the integrity of the brain. The semantic advantage conferred in normal aging is thought to be associated with improved efficiency and/or successful compensation of the neurofunctional reorganization of the brain. The goal of the present study was to describe the age-related changes in the brain and the behavioural pattern in individuals engaged in semantic categorization task. Methods: Under fMRI, 31 healthy participants performed a semantic categorization task in which target word needed to be paired with one of three reference words according to three possible semantic relations: two semantic-category (co-hyponyms) related words, half of high level of typicality 'HT' and half of low level of typicality 'LT'; as well as words having only a functional relationship 'F'. The sorting period was followed by feedback indicating to maintain the same semantic rule as in the previous trial or to select another one. Estimation of lexical executive profiles on older group was conducted by cluster analysis based on a battery of five neuropsychological tests which allowed to distinguish between nine « Regular » Normal Aged (RNA) and 11 « Optimal » Normal Aged (ONA). Results: No difference was found in terms of accuracy and response time between two older groups. Although, fMRI results revealed a distinctive pattern of brain activation according to the nature of the semantic relationship, as well as according to the lexical executive profile. During maintaining period, RNA as well as younger showed bilateral activation of frontal regions. ONA also showed bilateral activation of parietal regions as well. During the switching, ONA showed strong bilateral frontal and parietal activations, while RNA activated the same regions, though to a lesser degree. Furthermore, only younger showed activations of the striatal regions. With regard to 'HT' pairing, ONA and younger showed bilateral frontal and parietal activations while only unilateral activation was observed for the RNA. For 'LT', ONA showed enhanced activation in frontal and parietal regions while younger also recruited bilateral striatal regions. On the other hand, RNA showed only bilateral frontal activations. For the functional condition, younger and ONA recruited bilateral frontal and unilateral temporal while RNA had only unilateral activation for the same regions. Contribution of larger brain activation was observed for LT more than HT and functional. Conclusion: Our results show substantive difference of the neurofunctional reorganization for the semantic processing of words within normal aging. This result could indicate that some older adults could have access to a pool of resources more efficiently than others in order to maintain effective functioning word-semantic abilities. By contrast, in some cases, the recruitment of a neurofunctional network similar to the younger seems to be associated with diminished performance. The semantic processing of words appears to be allowed by the deployment of distinct neurofunctional network, according to the general cognitive abilities in aging.

B45 Meta-analytic and intrinsic functional connectivity mapping of lateral temporal cortex

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We used the task-based Meta-analytic Connectivity Modeling (MACM) and resting-state functional connectivity analysis techniques to investigate the brain networks associated with different subregions of the lateral temporal cortex (LTC) in the two hemispheres. We were particularly interested in how whole-brain network connectivity patterns vary across the lateral surfaces of the superior temporal, middle temporal and inferior temporal gyri (STG, MTG, ITG), along the longitudinal (anterior-posterior) axis of the LTC, and how this information can provide new insights into the neural networks supporting language. Further, we aimed to investigate interhemispheric differences in whole-brain connectivity patterns of LTC subregions, with particular emphasis on hemispherically asymmetric functional connections that are consistent with the well-established left hemisphere dominance for language. In order to implement the MACM analysis (Robinson et al., Hum. Brain Mapp., 2010), we utilized the BrainMap database (www.brainmap.org, Fox et al., Nat. Rev. Neuro., 2002). Activation maps from 1932 fMRI and PET neuroimaging experiments published prior to March 2013 and involving functional mapping in healthy participants were used for this purpose. We used the LONI LPBA40 Probabilistic Brain Atlas (Shattuck et al., NeuroImage 2007) to partition the STG, MTG and ITG in the left and right hemispheres into a series of regions of interest (ROIs) along the longitudinal axis of the LTC. For each ROI, all activation peaks from studies reporting activations within the ROI were submitted to Activation Likelihood Estimation (ALE) analysis with the GingerALE software package in order to derive co-activation maps for each ROI (Eickhoff et al., NeuroImage 2011, 2012). Resting-state functional MRI (RS-fMRI) data from 20 healthy participants were also used to map the intrinsic functional connectivity patterns associated with each LTC ROI (Biswal et al., PNAS, 2010). Behavioral domain meta-data from the BrainMap database were used for the functional interpretation of the meta-analysis-defined networks (Laird et al., J. Cogn. Neurosci., 2011; Herron et al., SfN 2013). These analyses provided a macroscopic delineation of several zones within the LTC with distinct functional connectivity patterns, segregated across gyri with rostro-caudal gradients. Analysis of hemispheric asymmetries in MACM and rs-fMRI revealed that the posterior MTG and underlying parts of lateral ITG (BA 37) exhibit prominent left-lateralized intrinsic functional connectivity and meta-analytic co-activation patterns extending to the left inferior frontal gyrus (IFG) and other frontal and parietal regions implicated in language functions. Consistent with the notion that the left posterior MTG serves as a core components of the language network (Turken

and Dronkers, Front. Sys. Neuro., 2011), the BrainMap behavioral domain analyses indicated a specific association between activations in the left posterior MTG and its network of functionally connected regions, and task-related activations in neuroimaging studies of language functions, in particular in the semantic domain.

B46 fNIRS investigation of the impact of age related physiological changes on the preservation of semantic word processing *Mahnoush Amiri[1,2], Philippe Pouliot[1,3], Paul-Olivier Leclerc[4], Michèle Desjardins[1] & F. Lesage[1,3], Y. Joanette[3,4,5]; [1]Ecole Polytechnique of Montreal, [2]Geriatric Institut of Montreal, [3]Montreal Heart Institut, [4]University of Montreal, [5]CIHR Institute of Aging*

Normal aging is characterized by modifications of brain's anatomy and physiology depending on region and brain component accompanying with changes in baseline physiology. Age also affects sensory and cognitive abilities in a heterogeneous fashion depending on the type of cognitive domain. Amongst brain functions preserved with aging, older adults have shown a good preservation of semantic words processing. Considering these deteriorated underpinnings essential for language abilities, investigating the mechanism underlying this relative preservation seems essential to the understanding how the aging brain confronts structural and physiological decline. To investigate cognitive aging, functional near-infrared spectroscopy (fNIRS) has been used because of its moderate costs, portability and examinations in a natural setting, and mostly the unique information it offers regarding the aging hemodynamics. With aging, changes in measured activation response are not merely related to neuronal activity but also to modifications of the underlying physiology. In this study 46 healthy Quebecois French-speaking individuals of two groups from age 65 to 75 and from 20 to 35 were recruited. For the activation task we chose a lexical-semantic task. Participants were presented with words and non-words in an event-related paradigm. Relative changes in optical intensity were measured with a 32- channel continuous wave NIRS instrument. We used time-resolved spectroscopy (TRS) systems to measure optical properties of cerebral tissues suspected to change with age. We acquired anatomical MR images followed by an Arterial Spin-Labeled (ASL) MR at rest to measure blood perfusion. A stereotaxic system was used to align anatomical images and the patch holding the optical fibers. Results from a mixed ANOVA analysis on lexical-semantic task revealed an age x lexicality x concreteness interaction. Group mean comparisons on the absolute oxy- and deoxyhemoglobin concentrations ([HbO2] and [HbR] respectively) as well as oxygen saturation (SatO2) measured by our 4-chanel TRS in both prefrontal hemispheres revealed decreased resting [HbO2] and SatO2 in the left prefrontal lobe in old adults. Analysis of ASL showed a different group average over the whole brain and gray matter blood perfusion. In response to semantic words processing task, a [HbR] decrease was observed in the elderly adults in their left frontal regions, right inferior frontal (IF) lobe and right superior temporal (ST). In contrast to elderly, activated areas were remained in the temporal sulci for words processing stimuli but in an inverse fashion. The presence of a right fronto-temporal activity in elderly in response to non-words processing with greater reaction times is consistent with findings claiming for compensatory neurofunctional reorganisation in aging. An inverse response amongst young participants could be due to a local coarse regulation of oxidative metabolism, provoked by increase neuronal activity, which is overwhelmed by increase in CBF. Controlling for the baseline physiology has proved differences in mere neural activity associated with the task and not in the absolute hemoglobin concentration differences for [HbR]. A remaining question is then whether bilateral frontal activity in older adults is driven by task difficulty per se or whether baseline physiological differences comparing to their younger counterparts has led to such difference.

Discourse, Combinatorial Semantics

B47 Towards a neurophysiological characterization of the human comprehension system: Time-Frequency analysis of sentence and visual scene processing *Anne-Lise Jouen[1,2], Sullivan Hidot[1,2], Carol Madden-Lombardi[1,2,3], Jocelyne Ventre-Dominey[1,2], Peter Ford Dominey[1,2,3]; [1]INSERM Stem Cell and Brain Research Institute, Bron, France, [2]University of Lyon, France, [3]CNRS France*

Introduction: We previously identified a fronto-temporo-parietal network involved in the representation of meaning during sentence and scene comprehension (Jouen et al. 2012). The current research investigates the real-time neurophysiology of this system. We tested 18 naïve subjects in a protocol where they saw a visual scene (or read a sentence) depicting a human event, and after a pause saw a second scene (or sentence) that was either semantically a coherent follow-up, or not, of the first scene (or sentence). Our objective was to test the hypothesis that comprehension of the second stimulus would vary for coherent vs. incoherent stimuli, and that this variance would be the same for sentence and scene processing, that is, it would reflect the operation of the common meaning system. Methods: Stimuli were presented for 2 seconds, separated by a delay of 1-1.5 seconds. Trails were blocked by modality (scene or sentence), two blocks per modality, for 4 blocks. Each block had 30 coherent, and 30 incoherent trials. Two thirds of the trials were followed by probe questions in order to maintain vigilance. We acquired neural activity with 64 channel EEG (Biosemi, ActiveTwo, version 5.36) while subjects performed the task. EEG data was processed using EEGLAB. We employed a time frequency spectral approach, extracting significant changes of oscillatory brain activity. We systematically explored 200ms time windows from 300ms post stimulus onset up to 400 post-stimulus offset, and frequency bands from 9 to 75 Hz. Analysis and Results: We performed a

repeated measures ANOVA with three factors: Modality (image or sentence), Condition (coherent or incoherent) and Stimulus (first or second), on subjects' average ERSP values. We used the following criteria to identify channels of interest: For both the sentence and scene modalities, no significant INCOH-COH difference for the first stimulus (p>5%), and significant INCOH-COH difference in second stimulus. Four left frontal channels (C1, FC1, FC3, FC5) survived these criteria, in a low gamma frequency window (35 - 45 Hz), and relatively late in the processing (1200-1400ms for FC5, and 2200-2400 for C1, FC1, FC3). For all four of these left frontal electrodes, there was a reduction in the ERSP value for the INCOH vs. COH stimuli in these late windows, independent of the stimulus modality. We also examine late ERPs, with the same inclusion criteria. In the same electrodes, this revealed a late positivity that was significantly greater for the INCOH vs. COH stimuli, independent of presentation modality. Discussion: Our time frequency and ERP results suggest that for sentences and images, integration of a coherent succession of stimuli engages common comprehension processes that have previously been revealed in the analysis of multisensory integration. Early modality specific processing appears to converge to a common mechanism within the first 700 ms. of processing. Implications for theories of comprehension will be discussed.

B48 Early magnetic brain responses to context-related presuppositions during speech perception *Ingo Hertrich[1], Anja Wuehle[1], Mareike Kirsten[1], Sonja Tiemann[1], Sigrid Beck[1], Bettina Rolke[1]; [1]University of Tuebingen, Germany*

The natural speech signal is highly redundant and restrained by its context. When listening to speech in realtime, we can use this redundancy by performing top-down processing, integrating various aspects of predictive information into the perceived data stream. This aspect has been largely underestimated in traditional models of speech perception considering just the hierarchical bottom-up procedure from auditory/phonetic processing toward higher-order linguistic representations. However, with the possibility of monitoring brain activity during speech perception, e.g, in auditory and frontal cortex, the need to integrate various aspects of top-down processing into models of speech perception becomes more and more obvious. Anticipatory activity may comprise lexical information, e.g. by the priming effects of a preceding sentence or by syntactic or semantic constraints, but predictive information might also encroach into sensory-specific domains, up to an auditory imagery of the expected word. The present magnetoencephalography (MEG) study considers the perception of test sentences in which discourse coherence was manipulated in some semantic/pragmatic aspects comprising the uniqueness and the existence presuppositions of the definite determiner and the non-uniqueness and novelty suggestions of the indefinite determiner. MEG recordings of 20 subjects were made while they had to rate the pragmatic adequacy of test sentences with regard to preceding context sentences. Example a: "Tina was in the zoo and saw an icebear. She observed that [THE ICEBEAR (good) / AN ICEBEAR (bad)] was quite aggressive". Example b: "Tina was in the zoo and saw some icebears. She observed that [THE ICEBEAR (bad) / AN ICEBEAR (good)] was quite aggressive". To obtain an index of early phase-locked auditory responses, the MEG data were cross-correlated with a prosodic syllable onset signal derived from the speech envelope of the critical passages. Furthermore, discouse coherence-induced variations in cortical alpha activity were analyzed in order to assess attentional responses to the various subconditions. Cross-correlation responses comprised M50, M100, and M200-like (M50c, ...) deflections. The latency of the M50c response was slightly longer in case of discourse-incoherent as compared to coherent items. Furthermore, the amplitude of the M200c was larger in case of incoherent items, but this increase in amplitude additionally interacted with further aspects of the test materials. It should be emphasized that the definite versus indefinite determiner, in spite of acoustic and lexical differences, did not yield any significant main effects on these measures, indicating that the observed cross-correlation effects are due to context-induced expectedness rather than local bottom-up effects. As a further, more global measure of brain responses to discours incoherence, alpha suppression was considered. Within a ca. 1.5-second time window following the presupposition triggers in the test sentences, global field power at about 8 Hz was larger in response to discourse-coherent as compared to incoherent items. These data show that early brain responses are sensitive to discourse coherence, which can only be explained by the assumption of top-down components even at the level of auditory and phonological processing.

B49 Top-down modulation of brain networks during discourse comprehension *Jie Yang[1], Michael Andric[2], Susan Duncan[1], Anna Holt[1], Uri Hasson[2], Emily Cooper[3], Steven Small[1]; [1]Brain Circuits Laboratory, Department of Neurology, University of California, Irvine, [2]Center for Mind/Brain Sciences, The University of Trento, Italy, [3]Helen Wills Neuroscience Institute, University of California, Berkeley*

Abstract Language comprehension incorporates not only pre-existing conceptual knowledge, but also recent or concurrent sensory and motor experience1. This suggests that comprehension can be shaped in real time by interactions between brain, body and environment. However, it is hard to generalize non-ecological experimental findings to the real-life processes that occur in more naturalistic settings, and the extent to which natural language comprehension behaves flexibly, depending on extralinguistic context, remains unclear. To address this issue, we investigated how intrinsic cues (e.g., attention) modulate the neural circuitry for discourse comprehension. Specifically, we examined whether

network connectivity patterns in the brain demonstrated differences when participants attended to different features encoded in a narrative. Twelve participants listening to identical stories were asked to focus on action- (e.g., run, eat), space- (e.g., in the zoo), or time-related information (e.g., yesterday)2. Graph theoretical approaches were used to characterize brain networks under these conditions. We analyzed functional brain connectivity by using voxelwise whole brain correlation to quantify the degree (i.e. number of connections) for each network node (voxel). This yielded a degree distribution for each condition3. In order to compute the degree distribution, we first generated connectivity graphs for the 3 task conditions and a concatenated rest run for each participant, thresholding the resulting graphs ($r > 0.25$) to indicate whether a pair of nodes was functionally connected. Second, we calculated the total number of connections of each node for each thresholded graph. Finally, we conducted non-parametric comparisons between each task condition and the rest run and across task conditions to determine how selective attention to a certain feature modulated the degree distribution of the network. All comparisons were corrected for family-wise error-rate ($p < 0.05$). Results showed that compared with the rest run, attention to spatial features increased connectivity of left fronto-temporal regions, attention to time increased connectivity of the left middle frontal gyrus as well as the right insula, and focusing on action features increased the number of connections of premotor cortex (bilateral). Direct comparisons between task conditions showed increased connectivity of the left superior frontal sulcus for attention to space compared with action. The results indicate that the neural circuitry for discourse processing is influenced by information-seeking goals and that this is reflected in shifting functional connectivity patterns. Further investigation will focus on the influence of intrinsic cues on the modular structure of the brain network. References Fischer, M. H., & Zwaan, R. A. (2008). Embodied language: a review of the role of the motor system in language comprehension. The Quarterly Journal of Experimental Psychology, 61(6), 825-850. Cooper, E. A., Hasson, U., & Small, S. L. (2011). Interpretation-mediated changes in neural activity during language comprehension. Neuroimage, 55(3), 1314-1323. Rubinov, M., & Sporns, O. (2010). Complex network measures of brain connectivity: uses and interpretations. Neuroimage, 52(3), 1059-1069.

B51 Two Divided Visual Field ERP Investigations of Global Contextual Influence on Word Processing

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An extensive literature in cognitive neuroscience has suggested that the right hemisphere (RH) plays a special role in the inferential processes necessary to incorporate global context into online comprehension processes. We report results from two divided visual field ERP studies, both of which investigated hemispheric asymmetry in the influence of global context on word processing. In both experiments, participants listened to short stories designed to provoke causal bridging inferences, such as, "A stack of papers was sitting next to an open window. A moment later, the pages were fluttering into the yard." In Experiment 1, after each story participants saw a probe word that was either causally related to the event described (WIND) or an unrelated control word (HUNTER). This probe word was presented either in left visual field targeting right hemisphere (lvf/RH) or in right visual field targeting left hemisphere (rvf/LH). The 2(relatedness) X 2(presentation side) experiment design included 40 stimuli per condition and 16 undergraduate participants. We observed similar amounts of processing facilitation in each visual field. That is, the amplitude of the N400 response to the causally related probe was reduced relative to the unrelated condition in both visual fields. The unrelated probe also elicited a large sustained negativity in both visual fields. Experiment 2 was identical to Experiment 1 except that the unrelated probes were replaced with probe words lexically associated with the final word of the context story (e.g., GRASS). This allowed us to compare two different types of contextual influences: local context in the lexically related condition, and global context in the causally related condition. The number of stimuli and participants was the same as in Experiment 1. In contrast to Experiment 1, there was a marked asymmetry in the brain responses to these two conditions. The N400 effect of probe type (causal more reduced than lexical) was about twice as large in lvf/RH compared to rvf/LH, perhaps due to the overlapping influence of an enhanced frontal positivity elicited by the lexically associated probes in rvf/LH only. On its own, Experiment 2 would suggest a special RH role for applying global context to word processing. Experiment 1 alone would suggest that the two hemispheres play an equal role in global context processing. Taken together, however, these data suggest that while both hemispheres are roughly equally sensitive to global contextual factors, such as causal inference, the LH in particular is more sensitive to local factors, such as lexical association. We interpret these data as consistent with the PARLO model of hemispheric asymmetry in language processing (Federmeier, 2007). References: Federmeier, K. (2007). Thinking ahead: The role and roots of prediction in language comprehension. Psychophysiology 44, 491-505.

B52 Effects of Reference and Syntactic Ambiguity in Spoken Discourse

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INTRODUCTION In isolation, temporarily ambiguous prepositional phrases (PP) (e.g. cut down the oak with the ___) are more readily attached to a preceding verb phrase (VP; chainsaw) than to a noun phrase (NP; mushroom). This can be explained by assuming that the most economical syntactic structure is assigned first, with revisions being made if this parse proves incorrect (during an interpretational phase; e.g., Frazier, 1987).

However, other work has suggested that parsing costs can be modulated by discourse context, such that NP-attachment is preferred when prior context contains more than one plausible referent (e.g., two oaks; Altmann & Steedman, 1988). In this event-related potential experiment, referential context and PP-attachment were manipulated in order to examine the impact of discourse context on the processing of temporarily ambiguous prepositional phrases. METHODS Participants (n=14) listened to spoken stories. We manipulated referential context (either VP- or NP-supporting) and target sentences (either VP- or NP-attached) (see examples below). VP-supporting context contained one possible referent for the critical anaphor in the target sentence; NP-supporting context provided two referents. Mean N400 (300-500ms) and P600 (500-800ms) amplitudes were measured to the critical nouns (capitalized) in the target sentences. EXAMPLE STORY VP-supporting context: 1a) A lumberjack hiked into a forest carrying a chainsaw. He was going to cut down a tree. In a clearing he found an oak that had a mushroom on it and an elm that had birds in its branches. / NP-supporting Context: 1b) A lumberjack hiked into a forest carrying a chainsaw. He was going to cut down a tree. In a clearing he found an oak that had a mushroom on it and an oak that had birds in its branches. / Target Sentence - VP-attached/ NP-attached: The lumberjack cut down the oak with the CHAINSAW/MUSHROOM and then headed back to his camp. RESULTS Referential context significantly modulated NP targets in both N400 and P600 windows (p's < .05); a larger N400 was observed to the critical words in the infelicitous relative to the felicitous condition, but a larger P600 was found in the felicitous than infelicitous condition. A different pattern of results was observed for VP targets; a larger P600 was found to VP targets following an infelicitous context (p's <.05). CONCLUSION This pattern of results supports two conclusions: 1) Processing VP-attached modifiers: Syntactically economical VP-attachment is preferred when the preceding discourse context contains only one possible referent (one oak) compared to when pragmatic constraints of the context promote referential ambiguity resolution (two oaks). 2) Processing NP-attached modifiers: When discourse context contains only one possible referent (one oak), an NP-attached modifier is neither preferred syntactically nor supported by the context; this leads to a semantic boggle (i.e., it is processed like an anomaly). When the discourse context contains two possible referents (two oaks), an NP-attached modifier is contextually supported, but the VP-attached structure is still preferred syntactically and activated; the resolution of this conflict is reflected by a larger P600 deflection.

B53 Costs and benefits of prediction: late ERP effects of lexical prediction error in noun phrases *Ellen Lau[1], Allison Fogel[1], Tania Delgado[1]; [1]University of Maryland*

Much previous work has demonstrated that the amplitude of the N400 ERP response to a word is reduced when the prior context is predictive of the word (Kutas & Hillyard, 1984; Federmeier, 2007), which is thought to reflect facilitated access from semantic memory when a predicted word is encountered. Generating a prediction could result in a cost when the predicted word is not the word that is actually presented, but the resulting error signal could also play an important role in learning. Interestingly, the violation of a strong contextual expectation does not appear to impact neural activity during the N400 time-window, but may affect subsequent activity (Federmeier et al., 2007). In the current study we further examined late effects of prediction error in lexical processing with ERP by using corpus measures to derive a stimulus set of adjective-noun phrases varying in adjective constraint and noun predictability. Together with previous work, our results suggest that late positivities may be associated with prediction error specifically in phrasal or sentential contexts that allow structured lexical combination. Prediction error responses in lexical processing can be assessed by comparing unpredictable words in constraining contexts (contexts in which a different word is highly expected) with unpredictable words in unconstraining contexts (contexts in which no particular word is highly expected). Previous work using sentence contexts has demonstrated a late frontal positivity for words in constraining contexts that violate a strong prediction, relative to their low-constraint controls (Federmeier et al., 2007). However, a recent study that modulated prediction strength in semantically associated word pairs (Lau et al. 2013) did not observe such an effect. One explanation for this discrepancy is that the late positivity is related to processes involved in structural combination of lexical items, which is possible in sentences but not in associated word pairs. The other possibility is that the process reflected by the late positivity is only invoked when a prediction is developed and maintained across a lengthy, multi-word context. To distinguish these possibilities, here we used a two-word adjective-noun phrase paradigm, in which the context is a single word but where the two words can be syntactically and semantically combined. Bigram counts from the Corpus of Contemporary American English were used to create phrases varying in noun probability and adjective constraint. To examine the effect of simple predictability on the N400, we compared high vs. low probability nouns. To examine the effect of prediction error, we compared low probability nouns following high-constraint vs. low-constraint adjectives. ERP results (n=33) demonstrate significantly reduced centro-parietal negativity in the 300-500ms time-window for high probability nouns vs. low probability nouns, and significantly increased centro-parietal positivity in the 600-800ms time-window for low probability nouns in high vs. low constraint contexts. These results suggest that the late positivity associated with

lexical prediction error reflects a computation that is only invoked during structured lexical combination, such as reanalysis of syntactic or semantic structure.

B54 A critical role for the angular gyrus in combinatorial semantics: converging evidence from patients and healthy subjects *Amy Price[1], Michael Bonner[1], Jonathan Peelle[2], Murray Grossman[1]; [1]University of Pennsylvania, [2]Washington University in St. Louis*

Thought and language rely on the brain's ability to flexibly combine concepts. This fundamental process allows for the construction of an unlimited number of complex cross-modal concepts from a limited set of basic constituents. For example, both "jacket" and "plaid" can be represented as individual concepts, but can also be combined to form the more complex concept "plaid jacket". This process is central to human thought and language, yet little is known about its neural basis. We hypothesized that the region of the angular gyrus would play a critical role in this process given that it receives converging projections from multiple modality-specific association cortices and is therefore well situated anatomically to perform this kind of integrative function in semantic memory. Here we present converging findings from three experiments that support a neuroanatomic model of conceptual combination that relies critically on the angular gyrus. In the first experiment, we asked healthy adults (N=22) to perform a combinatorial task during fMRI in which the subjects viewed word pairs on the screen and indicated whether the words combined to form a coherent concept (e.g., plaid jacket) or not (e.g., moss pony), as determined by a separate norming study. Words were matched on a number of psycholinguistic factors such as sum frequency, sum concreteness, and orthographic neighborhood density. We found that the processing of combined concepts specifically modulated activity in the angular gyrus ($p<0.05$ whole-brain corrected). Furthermore, activity in the angular gyrus also strongly correlated with a continuous metric of combinatorial strength in an item-analysis of the combinatorial word pairs ($p<0.05$ whole-brain corrected). In the second experiment, we examined the structural MRI data from the same healthy adults and found that increased cortical thickness in the angular gyrus correlated with a performance advantage in identifying combinations ($p<0.01$, corrected for multiple comparisons). In the third experiment, we examined patients with neurodegenerative disease (N=20), including patients with Alzheimer's and frontotemporal dementia, to determine whether atrophy in the angular gyrus resulted in impaired performance on combining word meanings. Patients completed the same combinatorial task as healthy adults, as well as an additional single word task, where they identified whether individual words were real (e.g., ship) or not (e.g., dranby). Specifically, we aimed to identify areas of atrophy that were associated with a relatively greater impairment for comprehending combined concepts, like "green boat", than for comprehending single word concepts, like "boat" and "green" individually. There were no repeated words between tasks, and the average frequency and concreteness as well as a number of other psycholinguistic factors were matched across tasks. We found that the degree of relative impairment on the combinatorial task compared to the single word task (i.e., a difference score) was strongly related to the degree of gray matter atrophy in the angular gyrus ($p<0.05$ whole-brain corrected). These patient findings overlapped to a large degree with out fMRI findings in healthy adults. These converging findings demonstrate that the angular gyrus plays a critical role in conceptual combination in semantic memory.

B55 The right to image: Hemispheric differences in the use of context and mental imagery to build meaning from words *Hsu-Wen Huang[1], Kara Federmeier[2]; [1]National Taiwan Normal University, [2]University of Illinois*

Building on work suggesting that the right hemisphere (RH) plays a critical role in eliciting sensory imagery to words (Huang et al., 2010), we conducted a series of studies combining visual half-field (VF) presentation methods with the measurement of event-related potentials (ERPs) to examine the role of the two hemispheres in using context information and inducing mental images as language unfolds. Participants read phrases consisting of two adjectives and a noun. On critical trials, half of the phrases had two abstract adjectives (e.g., "honorific military pin") and the other half had two concrete adjectives (e.g., "shiny metallic pin"). Either the second adjective (Expt. 1) or the noun (Expt. 2) was presented in the left or right VF to probe for hemispheric processing differences. Irrespective of position or part of speech, we find that words used in a concrete sense elicit a sustained frontal negativity (500-900 ms) that has been previously linked to imagery; however, this pattern is seen only with presentation to the RH (LVF). In contrast, with presentation to the left hemisphere (RVF), words preceded by the (more constraining) concrete modifiers are associated with larger P2 responses, a pattern that has been linked to context-based prediction (Federmeier, 2007). These results provide additional evidence for a critical role of the LH in the predictive use of context information and the RH for creating mental images during language comprehension.

B56 When meaning is not informative: Dissociating semantic composition from information processing in MEG *Ellen O'Connor[1], Liina Pylkkänen[2,3]; [1]University of Southern California, [2]New York University, [3]New York University Abu Dhabi*

INTRODUCTION: Although our ability to combine individual word meanings into larger semantic representations is a fundamental aspect of language, the brain correlates of semantic composition are challenging to disentangle both from higher and lower processes that closely correlate with it, such as lexical access, syntactic parsing and pragmatic inferencing. One particularly difficult representational state to dissociate from semantic

composition is the accrual of information: when a word composes with its context, the processor also generally converges on an increasingly specific and informative meaning. Thus, how could one test whether a neural effect of combination indexes the process of composition rather than the representation of a more specific, informationally richer meaning? In this MEG study we teased apart composition from information accrual by contrasting cases where composition yields an informationally impoverished or underspecified meaning to cases where composition increases informational specificity. Regions participating in composition were predicted to show increased activity whenever composition was present whereas regions sensitive to information accrual were expected to show no increase for the "uninformative" combinatory condition. Our analysis focused on the left anterior temporal lobe (LATL) and ventromedial prefrontal cortex (vmPFC), two regions recruited during composition (Mazoyer et al, 1993; Friederici et al, 2000; Bemis & Pylkkänen; 2011) but also implicated for conceptual specificity in a large hemodynamic and neuropsychological literature. Specifically, the LATL has been shown as important for processing unique or specific concepts (Damasio et al, 1996; Baron et al, 2010) while the semantic contribution of the VMPFC is likely to be related to its domain-general role in integrating or contextualizing output from other systems (Roy, Shohamy & Wager, 2012; Bemis & Pylkkänen, 2013). METHODS: To manipulate information content, we compared composition-related activity for the negative modifier never with two adjective types: those that have a clear opposite (e.g., never guilty = innocent) and those that do not (never blue = red, purple, green…). While the two phrase types compose in similar ways, the latter often yield highly uninformative meanings (Wason, 1961). Lexical properties of the adjectives, the targets of MEG analysis, were controlled and source activity in the negative conditions (never guilty/blue) was compared to that elicited during non-combinatory (xyxyxy guilty/blue) and positive controls (always guilty/blue) for 18 participants. During each trial, participants read the stimuli word-by-word. The task was to subsequently select the best match of two nouns (e.g.: never blue: cars vs. grass?). RESULTS: A nonparametric cluster-based permutation test (Maris & Oostenveld, 2007) on LATL activity identified a main effect of composition; there were no interactions with adjective type. By contrast, increased activity in vmPFC was detected only for the "informative" two-word conditions, with activity for never blue no greater than that for xyxyxy blue. CONCLUSION: Whereas LATL activity matched that expected for a region that actively participates in composition, vmPFC activity differed across computationally similar expressions depending on the amount of information encoded. This suggests that the vmPFC is sensitive to the output of composition; thus, damage in that region is correctly predicted not to substantially impair language processing.

B57 Reliability of gamma activity during semantic integration

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The gamma band of the human EEG has become a point of increasing focus in studies on language; however, many of these effects remain comparatively untested in their reliability. More established previous research on event-related spectral perturbations (ERSPs) has been especially focused on the theta (Bastiaansen et al 2005, Heine et al 2006), alpha (Roehm et al., 2001), beta (Davidson & Indefrey 2007), and to a lesser extent delta bands (Roehm et al., 2004). Recently, a number of studies have reported an effect for semantic integration (related to cloze probability in classical N400 paradigms) in the gamma band (>30 Hz) (Hagoort et al., 2004, Penolazzi et al., 2009, Wang et al., 2012). Given recent concerns about reliability of effects in the brain sciences (Killner 2013, Simmons et al., 2012, Vul et al., 2009), the present study aimed to test the reliability of the gamma effect in scalp EEG during semantic integration. We performed a reanalysis of data from ten existing studies involving two languages (ca. 300 subjects in total). Because previous findings are highly heterogenous in space, frequency and time, no specific prediction could be formulated, and we thus followed a bottom-up approach. In each study, for both semantically congruent sentences and the contrast congruent-incongruent, we identified the spatial-temporal feature with the strongest ERSP in the gamma band and then tested that effect in each of the other studies, so as to maintain statistical independence. Specifically, we found that the number of comparisons (5% of independent and 50% of circular analyses) reaching significance was equivalent to the number expected due to chance. In contrast, the same procedure reliably replicated results in the delta/theta, alpha and beta bands, confirming the sensitivity of our method. We conclude that the heterogenity of reported gamma effects requires more experimental testing before gamma should be considered a reliable marker of semantic integration.

Syntax, Morphology

B58 Broca's area shows a distance effect for both filler-gap dependencies and backwards anaphora in fMRI

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The processing of sentences sometimes requires the computation of long-distance dependencies, or relationships between non-adjacent elements of a sentence. One example is filler-gap dependencies, whereby a displaced element, the filler, must be linked with its original position in the sentence, the gap (Which song did the band play ___?) Another example is anaphoric reference, whereby an anaphor is linked with its antecedent (The man went to the store because he wanted a carton of milk). Previous research has documented increased activation in the anterior portion of Broca's area in fMRI

for increased distance in filler-gap dependencies, but not for increased distance in anaphoric dependencies (Santi & Grodzinsky, 2007). The authors interpreted these results to suggest that this portion of Broca's area responds selectively to filler-gap dependencies, and not to a more general processing mechanism. However, there are differences between filler-gap dependencies and canonical anaphoric dependencies in addition to syntactic structure. Namely, the dependency resolution processes involved in filler-gap dependencies are active (Stowe, 1986; Frazier, & Flores D'Arcais, 1989) given that the presence of a filler predicts a gap, whereas the dependency resolution processes involved in anaphoric dependencies are not active, given that antecedents do not predict their anaphors, (Kazanina, 2007). The lack of a distance effect obtained by Santi & Grodzinsky (2007) for the binding condition in Broca's area does not rule out the possibility that the activation for filler-gap dependencies results from these processing differences. The current study corrects for this by using backwards anaphora, wherein the anaphor precedes the antecedent, resulting in a prediction for the antecedent and active dependency resolution (Because he wanted a carton of milk, the boy went to the store; Kazanina, 2007). We implemented a 2x2 design with factors construction (filler-gap, backwards anaphora) and distance (short, long) in an event-related fMRI study with auditory presentation. Our results demonstrate a main effect of distance in the anterior portion of Broca's area, suggesting that this region's response reflects active dependency resolution, and not a selective response to sentence construction. Examining the simple main effects of construction revealed a distance effect for backwards anaphora in this region, confirming that the region shows distance effects for both filler-gap dependencies and backwards anaphoric dependencies. These results converge with Santi & Grodzinsky (2012) in positing that sentence-related activation in the anterior portion of Broca's area reflects prediction mechanisms.

B59 Neural Mechanisms Underlying the Computation of Hierarchical Tree Structures in Mathematics *Tomoya Nakai[1,2], Kuniyoshi L. Sakai[1,2]; [1]Department of Basic Science, Graduate School of Arts and Sciences, The University of Tokyo, Japan, [2]CREST, Japan Science and Technology Agency, Tokyo, Japan*

One of the fundamental properties common to mathematics and language is the presence of hierarchical tree structures. It has been a matter of controversy whether the computations in mathematics and language share the same neural mechanisms (Makuuchi et al., 2012; Maruyama et al., 2012). By examining various sentence structures, we recently demonstrated that activations in the left inferior frontal gyrus (L. IFG) and left supramarginal gyrus (L. SMG) were modulated by the Degree of Merger (DoM), a quantitative measure for the complexity of specified tree structures (Ohta et al., 2013). In the present study, we hypothesized that the DoM is also critical in mathematical thinking, and we used functional magnetic resonance imaging to elucidate how cortical activations were modified by the DoM. We tested the recursive computation by employing linear sequences. We prepared three mathematical tasks and a basic control task: a simple calculation (Simple), a linear sequence (Linear), a quadratic sequence (Quad), and a short-term memory (Memory), with an increasing DoM. In the mathematical tasks, participants were asked to silently perform a series of specified calculations, and to memorize two digits obtained from the calculations. In the Memory task, the participants simply memorized all of five digits. To examine the functional and anatomical networks, we further performed dynamic causal modeling (DCM) and diffusion-tensor imaging (DTI). We recruited 20 right-handed participants (15 males, aged 18-30 years), and we used 3.0 T MRI scanner (Signa HDxt; GE Healthcare). In both the Linear – Memory and Quad – Memory contrasts, significant activation was observed in the L. IFG, L. SMG, and R. SMG. By comparing the effect of various factors of the DoM, "number of operations," "number of nodes," and "number of encoding," we found that the model of DoM was the best to explain the modulation of activations. In the DCM analyses, we compared 18 possible models, and we found that a model with driving inputs into the L. SMG, and with a modulatory effect on the bidirectional connections between the L. IFG and L. SMG, was the best model. The left dominance was indicated by a top-down intrinsic connection from the L. SMG to the R. SMG. By using DTI, we confirmed the anatomical connectivity among the three regions assumed in these DCM analyses, such that the left superior longitudinal and arcuate fasciculi connected the L. IFG and L. SMG, and the posterior corpus callosum connected the L. SMG and R. SMG. These results indicate that mathematics and language share the network of the L. IFG and L. SMG for the specific computation of hierarchical tree structures, and that mathematics recruits the additional network of the L. SMG and R. SMG, with an information flow from the former to the latter. References: Makuuchi M, Bahlmann J, Friederici AD (2012) Phil Trans R Soc B 367:2033-2045. Maruyama M, Pallier C, Jobert A, Sigman M, Dehaene S (2012) Neuroimage 61:1444-1460. Ohta S, Fukui N, Sakai KL (2013) PLOS ONE 8, e56230:1-16.

B60 Syntactic violations for content versus function words in reading: ERP evidence *Bradley T. Marcinek[1], Karsten Steinhauer[2,4], Phaedra Royle[3,4], John E. Drury[1]; [1]Stony Brook University, [2]McGill University, [3]University of Montreal, [4]Center for Research on Brain, Language and Music*

[INTRODUCTION] Recently the status of so-called "left anterior negativities" (LANs) in syntax ERP research has been called into question (Steinhauer & Drury 2012). Here we investigate the question of whether such negative deflections for syntactic violations might be distinguishable in ways that depend on the difference between content/open-class versus function/closed-class status of target

words. [METHODS] We conducted an ERP reading study in English with native speakers (N=22). Correct/violation contrasts involved either: (i) content words (e.g., "He wanted to ENJOY/*MEAL..." and "He wanted the *ENJOY/MEAL...") or (ii) function words (e.g., "He ate from THE..." versus "He ate the *FROM..."). ERPs for (i) were examined by collapsing over the nouns/verbs, allowing for an inspection of violation effects independent of both lexical/target word differences and pre-target/context differences. Note that the word order flip for (ii) involves both lexical/target word differences AND pre-target/context word differences. Accordingly, all ERP analyses (for both (i) and (ii)) were conducted over 1700 ms epochs time-locked to the onset of the pre-target word (with a 200 ms baseline). This allowed us to make sure that violation effects for (ii) in particular were not due to either lexical or context differences independent of the syntactic violation itself. [RESULTS] Both the content and function conditions demonstrated biphasic negative/positive violation ERP effects. For content words, the negativity elicited by syntactic violations peaked around 450 ms, was left lateralized, and maximal over more posterior compared to more anterior recording sites (i.e., similar to what Steinhauer et al. 2010 refer to as a "left temporal negativity" or LTN). Function word violations, in contrast, yielded a negativity peaking earlier (around 320 ms) with a fronto-central scalp distribution (an anterior negativity/AN). Comparison of difference waves in time-windows centered on the peak of each negative wave in the two conditions revealed Condition x Topography interactions consistent with distinct underlying neural generators. The subsequent relative positivities (P600s) were similar in scalp distribution but differed in amplitude and onset latency (larger amplitude and earlier onset for the function word violations). Further, potential baseline/context problems or target word lexical differences in our function word contrast (discussed in Steinhauer & Drury, 2012) did not arise here (demonstrated by analyses of pre-target word latency ranges). Finally, no earlier syntax-related negativities were detected (i.e., no "ELAN" type effects) for either violation type (contra, e.g., Yamada & Neville 2007). [CONCLUSION] Our data are consistent with the idea that the neural systems underlying the detection of syntactic violations in real-time processing involve partly distinguishable systems in ways that depend upon lexical content/function word class differences. In addition to presenting this (to our knowledge new) finding, we also address how this data pattern relates to previous ERP studies of syntactic processing, neurocognitive models based on such data (e.g., Friederici 2002, 2011), and other investigations that have examined the content/function word class distinction using stimuli which do not introduce violations (e.g., Brown et al. 1999; Münte et al. 2001; Osterhout et al. 2002, among others).

B61 Neural interfaces between morphology and syntax: Evidence from Russian *Anastasia Klimovich-Smith[1], Mirjana Bozic[2], William Marslen-Wilson[3]; [1]University of Cambridge, [2]University of Cambridge, [3]University of Cambridge*

Functional and structural separation of the dorsal and ventral language streams has been supported by extensive developmental, neuroimaging and neuropsychological evidence. In sentence processing, the dorsal language stream, passing through to BA 44, is claimed to support hierarchical syntactic processing, while the ventral stream, linking to BA 45 and left opercular structures, is associated with linear syntactic processing (Friederici, 2011). At the word level, LIFG activation (centred around BA 45) has been linked to processing of grammatically complex stimuli made up of a stem plus an inflectional affix (Bozic and Marslen-Wilson, 2010). It is unclear, however, how much overlap there is between the LIFG activation elicited by single word and phrasal inputs and whether they differentially engage dorsal and ventral processing pathways. To address these questions (in an fMRI experiment using sparse imaging methods) we compared the activation patterns for inflected Russian words with those for short phrases that convey the same syntactic information, splitting these into simple and complex inflectional and syntactic conditions. The complex conditions invoked hierarchical syntactic relations – for example the Russian participle 'those who read' realised either as the three-word phrase 'te kto chitaut' or as a single complex inflected form 'chitaushie'. While processing of the simple conditions required only linear unification syntax, for example phases like 'chitat xorosho' 'to read well' and the inflectional forms like the verb infinitive 'chitat' 'to read'. These contrasts allow us to ask whether inflectionally and phrasally coded complexity elicit similar distributions of LIFG activation, especially in the two complex conditions. For comparison we also included two sets of derivationally complex words – simple forms like 'prikaz' 'an order' and complex forms like 'perevozshik' 'delivery man'. These were expected, following Bozic et al (2013), to elicit bilateral temporal activation but no selective LIFG effects. Univariate data analyses show that both phrasal and inflectional conditions elicited strong bilateral temporal activation (STG and MTG), with similar selective LIFG distributions, with effects seen in left BA 47, 45, and 44. No significant differences were found for the simple/complex distinction, designed to contrast hierarchical and linear syntax. The conditions that encoded syntactic structure (simple syntax, complex inflection and syntax) differed in STG and STS bilaterally. The derivationally complex forms behaved as predicted, with strong bilateral temporal effects, no LIFG activation, and no effect of complexity. In summary, these preliminary results do not support a ventral/dorsal distinction for syntactically complex versus simple processing in Russian phrases and inflected forms.

B62 Changes in neural oscillations during naturally-paced sentence processing *Julie M. Schneider[1], Alyson D. Abel[1], Jagger McCord[1], Mandy J. Maguire[1]; [1]University of Texas at Dallas*

Naturally-spoken English flies by at 6.19 syllables a second, yet an English speaker can process the phonology, semantics, and syntax of auditory signals with ease. How is this possible? Many theories point to a reliance on verbal working memory for this ability (Caplan & Waters, 1999; Just & Carpenter, 1992). Supporting this claim, Bastiaansen et al. (2002) reported a theta power increase with each word during word-by-word visual presentation of a sentence. They interpreted these theta changes as increasing engagement of working memory related to language comprehension. This study is the first to examine working memory engagement during sentence comprehension in children and the first to use naturally paced auditory sentences. Procedure. Thirteen right handed, monolingual English 8- to 12-year-olds (M=10.1 years, SD= 1.26) 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, because we are interested in typical processing, only data from grammatically correct sentences were analyzed. All sentences were at least 6 words long, but only the first 3500 msec (approximately 5 words) were analyzed to avoid wrap-up effects. Analysis. The EEG data were epoched from 500 msec before the onset of the first word of the sentence (baseline) to 3500 msec into the sentence. Time frequency analysis was used to quantify event-related spectral perturbations. Throughout the epoch, data were Fourier transformed, magnitude squared, and normalized to obtain the power spectral density in units V2/Hz. Data were then averaged across trials and subjects, and computed using log power values minus the baseline (Delorme & Makeig, 2004). Post-stimulus changes were statistically compared to baseline at p=0.001. Based on previous findings, we focused on alpha and theta (4-15 Hz) over left central areas. Results. The results demonstrated significant changes in power compared to baseline, theta increases during the sentence; however the largest increases surround the agent of the sentence, which occurs around 1.41 sec and the main verb, which occurs around 2.13 sec. Following the verb there is a significant increase in alpha power, which is thought to index neural idling. This is likely task related, suggesting that once participants noted the verb was grammatically correct, they disengage from processing. Conclusions. These are the first data to investigate processing of real-time auditory sentences in children. These findings are similar to Bastiaansen et al., (2002, 2010) for adults during word-by-word sentence reading, and as such highlight the importance of working memory in sentence comprehension. We expand on previous findings in three ways. First, auditory processing of sentences engages working memory, but not linearly throughout the sentence; instead the main noun and verb were points of enhanced theta changes. Second, our alpha increase after the verb highlights the importance of the task in sentence processing. Last, this study shows that theta indexes working memory changes during language processing by age 8. This information will be important as a baseline for studying children with language delays and disorders.

B63 ERP evidence for gap identification and filler-gap association in wh-island contexts *Dan Michel[1], Robert Kluender[1], Seana Coulson[1]; [1]University of California, San Diego*

The study of non-adjacent, mutually dependent constituents has been a major focus of modern linguistic theory, and one of its major successes has been the characterization of constraints that govern them [1-4]. One unresolved question is whether these constraints are an intrinsic feature of the grammar [5], or arise instead from inherent limits on human processing abilities [6,7]. __MATERIALS:__ (1a)Who had openly assumed [that the captain befriended the sailor before… (1b)Who had openly inquired [whether the captain befriended the sailor before… (1c)Who had the sailor assumed [that the captain befriended __ openly before… (1d)*Who had the sailor inquired [whether the captain befriended __ openly before… ……the final mutiny hearing]? __BACKGROUND:__ Who is the main clause subject of (1a,b) but the subordinate clause object of (1c,d). Successfully interpreting (1c,d) requires associating the "gap" (indicated by the underscore) with the displaced object 'who' (or "filler"). Acceptability studies suggest filler-gap dependencies into interrogative subordinate clauses (1d) are less acceptable than into declarative clauses (1c) [5,8]. Sentence constituents that block long-distance filler-gap dependencies are known as "island" structures (specifically "whether-islands" in (1d)). Reading time data have suggested that the parser does not posit gaps in island structures, consistent with the claim that island constraints represent an intrinsic prohibition of the grammar [9,10]. **Here we present ERP data indicating that the parser both attempts to assign fillers to gaps in whether-island structures and succeeds in doing so.** __METHODS:__ EEG was recorded from 29 electrodes as 31 participants read 40 trials each of (1a-d) (+80 fillers) in RSVP format with 500ms SOA. Noun phrases (e.g. 'the sailor,' presented as one word) were matched with adverbs of equivalent mean frequency to control for sentence position; norming acceptability was unaffected by presence/absence of adverbs. ANOVAs and paired comparisons were run on mean area amplitude in standard language ERP latency windows: 300-600ms(N400,LAN), 500-800ms(P600). __PREDICTIONS:__ In grammatical contexts, P600 effects are typically elicited at pre-gap verb positions ('befriended') [11-13], and LAN effects immediately post-gap ('before') [6,14], interpreted as gap identification and filler-gap association, respectively.

Grammar hypothesis: gap identification/association in grammatical, but NOT ungrammatical island contexts. Processing hypothesis: gap identification/association IN BOTH contexts. __RESULTS:__ _I_'befriended' (pre-gap) –> P600:(1c) >(1a)(p=0.008), (1d) >(1b)(p=0.023); indicates gap identification IN BOTH grammatical (1c) and ungrammatical island (1d). _II_'before' (post-gap) –> LAN:(1c) >(1a)(p=0.01), (1d) >(1b)(p=0.014); indicates filler-gap association IN BOTH grammatical (1c) and ungrammatical island (1d). _III_'openly' (post-gap) [adverbs only] –> N400:(1d) >(1c)(p=0.004); indicates semantic interpretation/processing difficulty following gap identification ONLY IN 1d); provides further evidence of gap identification – otherwise there should be no semantic processing difference. N400 effects often follow syntactic P600 effects when semantic interpretation/processing is impaired [15-16]. __CONCLUSION:__ Gap identification/association elicited the same brain responses in island and non-island contexts, with additional processing difficulty (N400 effects) in islands. This raises doubts about the claim that the parser does not posit (identify/fill) gaps in island contexts and lends credence to the notion that island constraints may arise from inherent processing limitations conspiring to rule out certain syntactic configurations as too difficult/impossible to parse. References:[1] Ross(1967),[2]Chomsky(1977),[3]Rizzi(1990),[4] Cinque(1990),[5]Sprouse,Wagers&Philips(2012),[6] Kluender&Kutas(1993a,b),[7]Hofmeister,Staum-Casasanto&Sag(2012a,b),[8]Michel(2013),[9] Phillips(2006),[10]Stowe(1986)[11]Kaanetal.(2000),[12] Fiebachetal.(2002),[13]Phillipsetal.(2005),[14] King&Kutas(1995),[15]Osterhout&Holcomb(1992),[16] Hagoortetal.(1993)

Language Disorders

B64 Prosodic production in right-hemisphere stroke patients: using temporal dynamics to characterize voice quality

Ethan Weed[1], Riccardo Fusaroli[1]; [1]Aarhus University

Brain injury to the right hemisphere can result in impaired communication, despite relatively well-preserved core linguistic skills. Impaired ability to produce a normal prosodic intonation has been reported, and impairment in prosody has been shown to correlate negatively with marital satisfaction in stroke patients with right-hemisphere damage (RHD). Because prosody is a key factor in conveying intentions, beliefs, and emotional states, it is important to understand how it is affected by stroke. More generally, studying the prosody of people with RHD can give insight into the role of the right hemisphere in prosody production. The aim of this project was to expand on traditional acoustic measures to refine our understanding of RHD prosody. First, we used Recurrence Quantification Analysis to allow us to quantify prosodic patterns over the time course of a speech production. Next, we used a combination of feature selection and supervised machine-learning to "diagnose" participants with RHD on the basis of voice quality alone, and to see to what degree voice quality predicts scores on a clinical test of functional independence (FIM). Our analyses were based on previously collected descriptions of the Frith-Happé triangles by 21 participants (11 patients with RHD, 8F and 3M, mean age=63, sd=8 and 10 matched controls) for a total of 151 video descriptions. Relying on previous studies, we selected basic measures of pause behavior (Number of Pauses, Average Length) and fundamental frequency (Minimum, Maximum, Mean and Range) as well as measures of stability and regularity for both (Recurrence Rate, Det, L, LMax, Entr, Lam, Vmax, T1, T2, Trend). In all cases we employed ElasticNet (10-fold cross-validation, Alpha=.5) to further limit the number of features selected. We employed a 10-fold cross-validated discriminant function (Mahalanobis rule), and a 10-fold cross-validated logistic regression to classify the selected features. We then used a 10-fold cross-validated multiple linear regression to predict scores on the FIM. The variance explained is balanced by individual variability and number of predictors. The classification and regression processes were iterated 1000 times and the results averaged. Diagnosis based on voice quality was good, with an average balanced accuracy of 88.43 percent (p=3.6035e-15, confidence intervals: 83.5-92.36 percent). Sensitivity was 89.6, and specificity was 96.75. Prediction of FIM scores was also good, with an adjusted R square of 70.80% (sd= 1.03%, p= 3.0e-05). The voice of participants with RHD was characterized by long and frequent pauses, as well as by a low speech rate. F0 was less varied and organized in longer repeated sequences grouped in shorter cycles. Automated voice analysis can offer insight into the nature of prosodic impairment in RHD, the role of the RH in prosody production, and may be developed as a tool for monitoring patients' progress post-stroke.

B65 Executive & coordination deficits contribute to language processing in Parkinson disease

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During many social interactions individuals have to reach the same conclusion without explicit communication. Game theory has formalized this critical ability as "Coordination". Parkinson Disease (PD) is traditionally considered a movement disorder, but can additionally be associated with executive and decision-making limitations. To investigate the cognitive mechanisms of coordination we administrated two tasks based on the same set of stimulus materials. During the first task (Production task), PD (N=9) patients and healthy seniors (HS; N=12) were presented with two-scene stories containing a target animal character that moves from one position to another. We manipulated two factors in a counterbalanced design. In half of the scenes the target animal was embedded in a set

of unique animals ("no-competitors") or in a set containing the same animal type differing by a single visual feature ("competitor"). In half of the trials participants described the scene to a "colorblind" partner or a "normal" partner. Participants were instructed to describe the scene with sufficient adjectives ("the pig"; "the large pig") so a partner could understand which animal was moving. In the second task (Multiple choice task), PD (N=8) patients and HS (N=13) were presented the same scenes of the Production task and asked to choose a sentence that best describes the scene to a conversational partner. Only one out of four sentences included the correct number of adjectives. The second task preserves the main features of the first one, but is hypothesized to require less executive resources. In both tasks we monitored accuracy and performed an error analysis. In the Production task PD patients had difficulty coordinating when faced with a complex situation. For example, with 3 competitors and the "colorblind" partner, PD patients omitted relevant information significantly more often than HS ($p < .05$). On the contrary, their performances in the Multiple choice task were comparable to HS and this was the case in the most complex trials (e.g., 3 competitors and a "colorblind" partner): PD were 76 % accurate compared to HS who were 86 %; $p > .2$). An ANOVA with Partner ("normal" / "colorblind") as within-subjects and Task as between-subjects variables, revealed a Partner and Task interaction that approached significance for PD patients ($p=.068$) and not HS ($p>.6$). These results revealed that PD patients' limitations in coordinating with other people are strongly related with their deficit in executive functions, because their errors become relevant when both the situation (e.g., the "colorblind" condition) and the request (Production task) are demanding in terms of executive resources.

B66 Structural and functional correlates of the left thalamus in dyslexia *Garikoitz Lerma-Usabiaga[1], Ileana Quiñones[1], Cesar Caballero[1], María P. Suarez-Coalla[2], Jon A. Duñabeitia[1], Manuel Carreiras[1,3,4], Pedro M. Paz-Alonso[1]; [1]Basque Center on Cognition, Brain and Language (BCBL), Donostia - San Sebastián, Spain, [2]Universidad de Oviedo, Spain, [3]IKERBASQUE, Basque Foundation for Science, Bilbao, Spain, [4]UPV/EHU, Bilbao, Spain*

Reading is a recent human evolutionary milestone that constitutes one of the central activities across many dimensions of our daily life. Reading deficits, however, are not uncommon. Over the last decades, neuroimaging research with typical and atypical readers, and in particular with readers with dyslexia, has underscored functional and structural differences within regions supporting cortico-subcortical interactions during reading processes. Specifically, compared to typical readers, individuals with dyslexia appear to exhibit left thalamic hypoactivation, and this activation is associated with phonological deficits in reading tasks in dyslexics but not in typical readers (Diaz et al., 2012). Similar findings in terms of thalamic hypoactivation have been also observed when comparing late versus early talkers on speech and reading tasks (Preston et al., 2010). Moreover, postmortem studies looking at structural differences have evinced the presence of alterations in the left thalamus of dyslexic individuals (Galaburda et al., 1994; Livingstone et al., 2004). This evidence is consistent with recent views indicating that the thalamus is a central hub tuned by cortical areas to the relevant properties of visual and auditory inputs (Suga & Ma, 2003), as well as with theoretical accounts proposing that reading difficulties arise from an inability to use contextual information to fine-tune visual and/or auditory processing for optimal performance (Chandrasekaran et al., 2009). Nevertheless, to date, no studies have specifically examined the relation between thalamic structure and function in typical readers and readers with dyslexia using a task that poses challenging cognitive demands, which appear to be crucial to detect phonological deficits in dyslexia (Ramus & Szenkovits, 2008). The present study was aimed at investigating structural and functional neural correlates of the rapid-automatized-naming (RAN) task in typical readers and readers with dyslexia. Importantly, the RAN task predicts reading skills and discriminates between individuals with dyslexia and normal readers, and relies on binding spoken and visual signals and on phonological access to stored representations (Norton et al., 2012). We collected MRI data from 51 children and adults while they overtly named blocks of numbers, letters, objects, colors and control conditions tailored to each participant's naming speed. Groups of typical readers and readers with dyslexia were matched on age, gender and IQ. BOLD parameter estimates extracted from a left thalamus functional ROI, identified across participants from RAN activation blocks versus control conditions, revealed that typical readers engaged this region more strongly than readers with dyslexia. Moreover, only for readers with dyslexia, left thalamic volume was associated positively with naming accuracy [$r(22) \geq 0.44$, $ps \leq .05$] and negatively with naming speed [$r(21) \geq -.56$, $ps \leq .01$] for all the RAN conditions (i.e., numbers, letters, objects, colors). Of interest, these effects were not observed in right thalamus. These results constitute the strongest evidence so far linking left thalamus structure and function in readers with dyslexia using a task that discriminates them from normal readers.

B67 A DTI study of chronic post-stroke aphasia *Sharon Geva[1,2], Marta Correia[3], Elizabeth A Warburton[1]; [1]Department of Clinical Neurosciences, University of Cambridge, Addenbrooke's Hospital, UK, [2]Developmental Cognitive Neuroscience Unit, UCL Institute of Child Health, London, UK, [3]MRC Cognition and Brain Sciences Unit, Cambridge, UK*

There is an ongoing debate whether post-stroke language reorganisation happens only in perilesional areas or in contra-lesional areas as well. Previous studies looked mainly at grey matter (GM) integrity. However, aphasia symptoms and their severity cannot be fully explained by

GM damage. Studies suggest that local damage can also cause local fibre displacement and reorganisation of white matter (WM), and that WM integrity influences aphasia symptoms as well as rehabilitation potential. Here, we studied the relation between WM integrity, as seen in diffusion tensor imaging (DTI), and aphasia symptoms and recovery in 15 chronic patients with post-stroke aphasia (language production deficits), and 19 age- and education-level-matched controls. We hypothesised that LH Fractional Anisotropy (FA) values would correlate with performance on two tasks in which these patients were impaired (word production and sentence comprehension), but not with performance on a task in which patients had relatively preserved performance (word repetition). Lastly, we hypothesised that RH FA would also correlate with behavioural performance, due to: (1) post-stroke reorganisation, or, (2) pre-stroke individual differences which serve as a protective factor. Data were acquired using a 3T Siemens Trio. The DTI acquisition sequence was a whole brain single-shot spin-echo planar imaging sequence (TE=90ms, voxel size: 2×2×2mm, 63 axial slices). The diffusion sensitising gradients was applied in each of 63 non-colinear directions (maximum b value of 1500 mm2/s) using a twice-refocused spin echo sequence to reduce eddy currents, along with five non-diffusion weighted (b=0) scans. We also acquired a Magnetization-Prepared Rapid Acquisition Gradient Echo scan (TR=2.3s, TE=2.98ms, FOV: 240x256mm, 176 sagittal slices, slice thickness: 1mm). In a whole-brain TBSS analysis it was found that, as expected, the control group had higher FA values in vast areas of the LH and some areas in the RH. In order to verify that the differences found in the RH are not a result of misregistration due to the lesioned hemisphere, we also analysed the RH separately by separating the left and right hemispheres for each patient individually and repeating the TBSS analysis for the right hemisphere images only. Here we found that the control group had higher FA values in the right anterior portion of the corpus callosum compared with the patient group, which can be explained as a result of Wallerian Degeneration. These results were further confirmed using a histogram analysis ($p<0.05$ corrected in all analyses). We then examined which language deficits correlate with LH damage. In the patient population, average FA in the LH correlated with performance on the auditory sentence comprehension ($R2=0.584$, $p=0.001$) and object naming ($R2=0.416$, $p=0.013$) but not word repetition ($R2=0.084$, $p=0.314$). Performance on the language tasks did not correlate with RH WM integrity measurements. In summary, while we have evidence that LH white matter damage can explain some of the behavioural deficits seen in aphasia, we have no evidence that RH WM integrity can explain the partial recovery of those functions. However, future studies should further explore this in more detail using tract-specific tractography or longitudinal imaging.

B68 Individually-Targeted Transcranial Direct Current Stimulation Enhances Fluency in Patients with Chronic Non-Fluent Aphasia *Catherine Norise[1], Gabriella Garcia[2], Olu Faseyitan[2], Daniel Drebing[2], Felix Gervits[2], Roy Hamilton[1,2]; [1]Perelman School of Medicine, University of Pennsylvania, [2]Center for Cognitive Neuroscience, University of Pennsylvania*

Introduction: Emerging evidence suggests that transcranial direct current stimulation (tDCS) may improve naming in persons with chronic left hemisphere stroke and nonfluent aphasia. Language improvements beyond naming have not yet been thoroughly investigated. Moreover, different investigations have employed different electrode polarities (anodal or cathodal) at different sites (ipsilesional or contralesional cortex), raising the question of whether optimal stimulation parameters vary across aphasic subjects. Methods & Procedures: Individuals with moderate to mild non-fluent aphasia have been recruited for this ongoing two-phase study. In Phase1, over the course of five non-consecutive days, participants underwent tDCS with four different stimulation montages (anode-F3, cathode-F3, anode-F4, cathode-F4) and a sham condition. During real stimulation, a 2.0mA current was delivered through 5cm x 5cm electrodes for 20min. Picture naming ability was measured before and after each stimulation session. Participants who demonstrated improvement in naming after stimulation with a specific electrode montage moved on to Phase2, a sham-controlled partial-crossover treatment trial employing the optimal stimulation montage identified in Phase1. Subjects in Phase2 completed three baseline behavioral sessions with the Western Aphasia Battery prior to treatment, and then received stimulation (20min, 2.0mA, 5x5cm electrode) for a total of 10days (Monday through Friday for two consecutive weeks). During stimulation, participants completed a constraint-induced picture-naming task, in which a barrier prevented the participant from viewing the experimenter. Subjects repeated the WAB two weeks, two months, and six months after treatment. Subjects in the sham arm received 10days of sham stimulation, and were tested at two weeks and two months, and then received real tDCS, with a two-week, two-month, and six-month follow-up. In addition to calculating the WAB aphasia quotient(WAB AQ; a composite assessment of speech production, comprehension, and repetition), the picture description component of the WAB was also scored using Quantitative Production Analysis(QPA), in order to further evaluate changes in language fluency across the categories of discourse productivity, sentence productivity, grammatical accuracy, and lexical selection. Outcomes & Results: To date, 12 subjects have completed Phase1 of this ongoing investigation. Of these, 7 demonstrated statistically significant transient improvement in object naming ability following stimulation and were thus enrolled in Phase2. Optimal montage placement was highly variable across subjects. To date 5 of these subjects have completed a six-

month follow-up. Compared to baseline, subjects showed significant improvement (paired-sample t-tests; $p<.05$) on the WAB AQ as well as measures of discourse productivity and grammatical accuracy at two weeks and two months following stimulation. Persistent improvement in the WAB AQ was also observed 6months following stimulation. The two subjects randomized to the initial sham treatment arm showed no significant change from baseline in post-sham testing. Conclusion: The preliminary results of this ongoing investigation support prior work indicating that tDCS enhances recovery from chronic post-stroke aphasia. The results further suggest that in nonfluent patients tDCS may specifically enhance elements of fluency such as discourse productivity and grammatical accuracy. Finally, optimal electrode arrangement appears to vary across participants, suggesting that individualized treatment may further improve language outcomes.

B69 Reorganized effective connectivity associated with recovery from acute aphasia *David Gow[1,2,3], Bruna Olson[1,2], David Caplan[1,2]; [1]Massachusetts General Hospital, [2]Athinoula A. Martinos Center for Biomedical Imaging, [3]Salem State University*

While a large body of work has examined changes in BOLD response associated with recovery from aphasia, very little work has examined changes in source space reconstructions of electrophysiological activity or effective connectivity. Here we report changes in effective connectivity that accompanied improved performance in a word-picture matching task in a patient recovering from acute aphasia. The patient, a left handed 53 year old woman, presented with phonemic paraphasias, word-finding difficulty, and intermittent aphasia following a patchy right hemisphere stroke affecting gray matter in the temporo-parietal region, basal ganglia, and occipital cortex above the calcarine fissure. We tested the patient twice on a word-picture matching task while collecting simultaneous MEG and EEG after presentation of auditory word stimuli that were subsequently combined with MRI data to create a high spatiotemporal reconstruction of activation during task performance. We applied Kalman-filter based Granger causation analysis to these data to examine patterns of time-varying directed causality. When tested one month after the onset of aphasia she performed the word-picture matching task with 59% accuracy. At this time task performance produced activation over a large primarily right hemisphere network with sparse left hemisphere involvement. When tested again at 6 months post-onset she performed with 85% accuracy, and showed a strikingly different pattern of activation with reduced activation in right hemisphere regions and strong contralesional activity over left hemisphere homologs of activated right hemisphere regions, and extensive strong activation of large left temporal and frontal networks with no right hemisphere counterpart. Granger analyses revealed a pattern of strong interactions between right hemisphere regions and weak interactions between left hemisphere regions at the initial testing. Connections between left and right hemisphere homologs were generally weak. At the second testing a pattern of strong intrahemispheric connections were found in the left hemisphere. These results show that the contralesional activation associated with improved function reflects the emergence of a well-integrated network as well as the loss of effective connectivity within the ipsalesional network.

B70 Abnormal Subcortical Components of the Corticostriatal System in Young Adults with DLI: A Combined Structural MRI and DTI Study *Joanna C. Lee[1], Peggy C. Nopoulos[1], J. Bruce Tomblin[1]; [1]University of Iowa*

[Introduction] Developmental Language Impairment (DLI) is a neurodevelopmental disorder affecting 12% to 14% of the school-age children in the United States (Tomblin et al., 1997). While substantial studies have shown a wide range of linguistic and non-linguistic difficulty in individuals with DLI, very little is known about the neuroanatomical mechanisms underlying this disorder. We have joined others in exploring the hypothesis that language development and disorders are grounded in general purpose learning systems (e.g., Ullman & Pierpont, 2005). We are particularly interested in the procedural learning system and the closely related reinforcement learning system, and have found empirical support for their possible involvement in DLI (Tomblin et al., 2007; Lee & Tomblin, 2012, under review). Given that individuals with SLI demonstrate impaired procedural and reinforcement learning that rely on the corticostriatal system, this neuroanatomical system has become a good candidate for further study in the etiology of DLI. The aim of the current study was to examine the subcortical components of the corticostriatal system in young adults with DLI, including the caudate nucleus, the putamen, the nucleus accumbens, the globus pallidus, and the thalamus. [Methods] Two groups of participants, one with DLI (n=12) and the other without (n=12), were recruited from a prior behavioral study, and all were matched on age (range: 19-21 yrs), gender, and handedness. We used conventional magnetic resonance imaging (MRI) to measure regional brain volumes, as well as diffusion tensor imaging (DTI) to assess water diffusion anisotropy as quantified by fractional anisotropy (FA). By combining the study of macrostructural abnormalities in MR volumetry with the potential of DTI in highlighting microstructural alterations, it should be possible to describe in detail subcortical abnormalities in DLI. All of the anatomical scans were processed using AutoWorkup, an automated procedure implemented in the software package BRAINS (Magnotta et al., 2002) developed at the University of Iowa. The diffusion tensor data were analyzed using the Guided Tensor Restore Anatomical Connectivity Tractography (GTRACT) software (Cheng et al., 2006). [Results] Volumetric analyses revealed region-specific abnormalities in individuals with DLI, showing pathological enlargement bilaterally in the putamen ($t=2.70$, $p=.01$, $d=1.07$) and the

nucleus accumbens (t=2.69, p=.01, d=1.00), and unilaterally in the right globus pallidus (t=3.19, p=.004, d=1.26) after the intracranial volumes were controlled. Regarding the DTI findings, the DLI group showed decreased FA in the globus pallidus (t=2.37, p=.03, d=.96) and the thalamus (t=3.57, p=.002, d=1.41), but these significant differences disappeared after controlling for the whole-brain FA, indicating that microstructural abnormality is diffuse and affects other regions of the brain. [Conclusion] Taken together, these results suggest region-specific corticostriatal abnormalities in DLI at the macrostructural level, but corticostriatal abnormalities at the microstructural level may be a part of a diffuse pattern of brain development. Future work is suggested to investigate the relationship between corticostriatal connectivity and individual differences in language development.

B71 Neurobiological Change Following Intensive Therapy for Chronic Mild Aphasia: An fMRI Study *Jennifer Mozeiko[1], Emily Myers[1,2], Carl Coelho[1]; [1]University of Connecticut, [2]Brown University*

Intensive aphasia treatment has been employed with equivocal results likely due to variability in the severity of participants as well as in the parameters that comprise intensity (e.g., session duration). Constraint Induced Language Therapy (CILT; Pulvermüller et al., 2001), one intensive aphasia therapy that has been replicated successfully, tends to demonstrate positive change in language production, and tends to use similar dosage parameters. Meinzer and colleagues (2007) found that it was their most severely affected participants who tended to benefit most from treatment of CILT, positing that those who had withdrawn from verbal communication the most were the most likely to benefit from the forced use inherent to CILT. However, it is also possible that since CILT and associated treatment materials was designed for more impaired participants, those with more mild symptoms were not been sufficiently challenged and thus did not demonstrate equal change. In this study, employing a single subject design study, CILT was delivered at a dosage of three hours per day for twenty days. Complex stimuli were created to pose adequate challenge for two individuals with mild aphasia. Discourse analysis and naming response time were used to quantify changes in language efficiency. This study investigates whether individuals with chronic mild aphasia can make appreciable expressive language gains following a course of CILT. Each participant underwent fMRI scanning at four time points during the treatment process to determine whether behavioral changes correspond with activation in left hemisphere perilesional areas or right hemisphere homologues. This is expected to add to the limited fMRI treatment data currently available. Methods Two participants were both more than five years post left CVA, native English speakers, right handed and with a negative history of mental illness. Both participants were classified as mild with scores on the Western Aphasia Battery Aphasia Quotient exceeding 87. CILT was administered according to the protocol described by Maher and colleagues (2006) and modified by the authors to include additional levels and greater lexical complexity. Three hour sessions were conducted five days a week, for two weeks for a total of 30 hours of treatment. After a five week break, thirty additional hours were administered. Participants were required to produce and respond to verbal communication with the verbal modality only. Standardized tests, performance on trained card sets, and assessments of generalization of treatment were administered pretreatment, posttreatment and during followup testing. FMRI scans were conducted at these same time points in order to observe activation during the naming process. Performance on trained, untrained stimuli and generalization to discourse were also video-recorded and analyzed after every six hours of treatment to assess progression of change over time. Discussion • Participants with mild, chronic aphasia made gains in both expressive and receptive language. • Generalization of treatment to untrained materials was demonstrated by both individuals. Generalization has not been demonstrated in previous CILT studies. • Decrease in naming response time was observed for trained stimuli only. • Preliminary analysis of fMRI data demonstrated effective left hemisphere compensation for both participants.

B72 Revisiting speech repetition with lesion-symptom mapping: contributions of insula, temporo-parietal cortices and the arcuate fasciculus *Katie McMahon[1], Carly Mayberry[2], Shiree Heath[3], Sophia Van Hees[1,4,5], Tracy Roxbury[1,4,5], David Copland[4,5], Greig de Zubicaray[6]; [1]Centre for Advanced Imaging, University of Queensland, Australia, [2]Queensland Cerebral Palsy and Rehabilitation Research Centre, Royal Brisbane & Women's Hospital, Australia, [3]ARC Centre of Excellence in Cognition and its Disorders (CCD) Department of Cognitive Science, Macquarie University, Australia, [4]UQ Centre for Clinical Research, University of Queensland, Australia, [5]School of Health and Rehabilitation Sciences, University of Queensland, Australia, [6]School of Psychology, University of Queensland, Australia*

Patients with aphasia following left-hemisphere lesions typically show impaired speech repetition. This impairment has classically been associated with lesions to a prominent white matter tract - the arcuate fasciculus. However, recent lesion-symptom mapping (LSM) studies have implicated cortical grey matter in the posterior superior temporal cortex and temporo-parietal junction (TPJ). The majority of these LSM studies have employed brief bedside screening tests of word and sentence repetition, or laboratory-based tasks, both of which have uncertain psychometric properties. In addition, patients with aphasia rarely present with isolated impairments, and their performance over a range of language measures tends to be highly correlated, hence a single test score is unlikely to reflect a 'pure' measure of repetition. In

order to investigate selective repetition impairments with LSM, we assessed 28 patients with left hemisphere lesions and chronic aphasia on the Western Aphasia Battery - Revised (WAB-R), a standardized clinical battery with well-established reliability and validity. All patients also underwent structural MRI. Two separate logistic regression LSM analyses were conducted including total lesion volume and age as nuisance covariates. The first LSM used repetition subtest scores from the WAB-R, while the second used residual repetition scores calculated by regressing out the shared variance with the other WAB-R subtests (auditory comprehension, spontaneous speech, naming). The results of the first LSM analysis identified a left posterior superior temporal cortex region as critical for repetition, with no involvement of the arcuate fasciculus. By contrast, the second LSM analysis using residual repetition scores identified critical regions in the left parietal operculum (OP1), posterior insula cortex (lg2) and arcuate fasciculus. Given that patients with aphasia typically present with a range of impairments, and their performance on behavioural subtests is usually highly correlated, we recommend LSM studies control for this shared variance when the aim is to investigate neuroanatomical correlates of specific aphasic symptoms.

Poster Session C

Thursday, November 7, 3:45 - 5:45 pm, Emerald Ballroom

Gesture, Prosody, Social and Emotional Processes

C1 Electrophysiological investigation of self-referential processing of emotionally laden language using a novel imagined-speaker paradigm

Daniel J. Frost[1], Marta Kutas[1]; [1]University of California, San Diego

Recent unfortunate events have brought bullying and victimization to national awareness. Although much research has addressed the antecedents and consequences, little is known about the in-the-moment neural events that take place when one is bullied. The current study utilized scalp-recorded event related brain potentials (ERPs) and a novel imagined-speaker paradigm to investigate verbal bullying; in particular, when and how emotional, referential, and social processes influence language comprehension. Participants read sentences beginning with "I am", "You are", and "S/he is" and concluding with a positive or negative adjective that described a personality trait, mental/emotional state, or physical attribute. After each sentence, participants indicated via a button press whether the sentence was about him/herself or about someone else. In one half of the experiment, participants imagined they were the speaker, and in the other half, they imagined someone else was the speaker. By changing the imagined speaker, to whom "I" and "You" referred changed. When the participant was the imagined speaker, "I" referred to the participant, while "You" referred to someone else. When the participant imagined that someone else was the speaker, "You" referred to the participant, while "I" referred to someone else. For both imagined-speaker conditions, "S/he" referred to someone else. Regardless of imagined-speaker, sentences that referred to the participant are considered participant-referenced, while sentences that referred to someone else are considered other-referenced. Following the EEG recording session, participants completed a pen-and-paper recognition memory test followed by an applicability assessment, indicating which words they considered accurately describe them. We found that participants remembered more participant-referenced adjectives compared to other-referenced adjectives and self-attributed more positive compared to negative adjectives. No speaker dependent ERP effects were observed for "S/he" sentences, for neither the stem nor the paired adjectives. By contrast, ERPs were sensitive to participant-referenced ("I", "You") versus other-referenced ("I", "You") within 300 ms of stem processing (greater Late Positive Complex [LPC] to participant-referenced) and within 75 ms of adjective processing (greater N1 and smaller P2 to participant-referenced as well as larger N400). Preliminary analysis also revealed effects of valence on the early and late adjective-locked LPC: negative adjectives paired with "I am" or "You are", but not with "S/he is", elicited a larger LPC compared to positive adjectives. Overall, these results suggest that self-relevance is assessed rapidly, enhancing attention, and possibly influencing access to semantic memory. Social relevance may be a prerequisite to emotional evaluation as "I" and "You" refer to either the participant or his/her "conversation" partner, while "S/he" refers to someone outside the imagined interaction. Finally, this study demonstrates the utility of the imagined-speaker paradigm for investigating emotional, referential, and social processes during language comprehension, thereby providing a tool to study verbal bullying.

C2 Neural substrates of affective language processing: an event-related fMRI study

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Navigating social and interpersonal experiences relies on the ability to accurately appraise emotional cues and content in language. Anger cues are conveyed through highly consistent acoustic characteristics and are especially critical for survival. Processing affect in discourse requires listeners not only to decode the literal meaning of phrases (semantics) but also to integrate additional cues to understand a speaker's intentions (prosody). Our understanding of affective language processing in the brain has been limited by the designs of prior studies; the present study employs a design that disentangles semantics and prosody. The primary aim of this work was to characterize neuroanatomical substrates of both semantic and prosodic contributions to affective language processing. Eight participants heard spoken sentences in an fMRI scanner.

In a two by two factorial, event-related design, two levels of semantics (neutral and angry) were crossed with two levels of prosody (neutral and angry), yielding four task conditions. A robust main effect of prosody, and a subtle but significant main effect of semantics were found. No interaction effects were found, but simple effects were examined to unpack the effects of prosody and semantics at each level of the other factor. Left posterior cingulate cortex and right precuneus were significantly more active when processing angry prosody than neutral prosody at the level of angry semantics. Left IFG, right thalamus, right insula, right STG, right cuneus/calcarine gyrus, and right cerebellum were significantly more active when processing angry prosody than neutral prosody at the level of neutral semantics. Left angular gyrus was significantly more active when processing angry semantics than neutral semantics at the level of angry prosody. Additionally, there was a trend for greater activation in right STG for angry semantics compared to neutral semantics at the level of neutral prosody. Individual activations were consistent with group results for each of the contrasts examined. Analyses also probe processing differences reflecting anger as a continuous variable, rather than a categorical one. While traditional language processing regions were implicated, this study also identified brain regions that may be responsible for parsing the intended communication of a speaker; we discuss this in the context of identifying complementary processing networks underlying communication. We also discuss results in the framework of lateralization of prosodic and semantic cues to affect.

C3 Using information from direct disgust experience to distinguish novel disgust metaphors from neutral metaphors with fMRI pattern analysis *Vesna Gamez-Djokic[1], Lisa Aziz-Zadeh[1], Srini Narayanan[2], Benjamin Bergen[3], Josh Davis[3], Tong Sheng[1]; [1]University of Southern California, [2]University of California, Berkeley, [3]University of California, San Diego*

Theories of grounded cognition (embodied semantics) propose that abstract meaning and thought are grounded in sensory-motor and affective systems of the brain and body. Previous work has focused mainly on whether sensory-motor systems are engaged during processing of language about actions and perceptible scenes or figurative language based on perception and action. Grounding in emotion-processing systems of the brain has received comparatively less attention in imaging work. Theories of embodied cognition including Conceptual metaphor theory hold that abstract concepts such as moral disgust are understood through systematic associations with concrete source domains acquired directly during affective experience. Feelings and behaviors typically associated with the emotion of physical disgust, such as nausea or visceral sensations and withdrawal responses, are transferred to an abstract entity that would not otherwise itself elicit disgust. Here we investigate whether comprehension of novel political disgust metaphors relies on such a putative semantic mechanism that is grounded in visceromotor systems of the brain. We asked whether emotion-related brain regions are involved in the comprehension of literal and novel metaphoric sentences describing scenes that are literally or figuratively disgusting. We focused on disgust because of its systematically observed association in the brain with the anterior insula, which is believed to take its interoceptive, nociceptive, and other somatosensory inputs and associate offensive information with internal bodily information. Processing isolated disgust-related words (e.g. infection, vomit) has been shown to activate the left anterior insula compared to neutral words, as does processing narratives describing disgusting scenes. But it remained to be seen if left anterior insula activity is also present during comprehension of metaphorical language based on disgusting source domains. We used both functional magnetic resonance imaging (fMRI) and Multivariate Pattern Analysis to investigate the recruitment of emotion processing brain regions, as well as activity patterns specific to our region-of-interest, during comprehension of disgust metaphors. We trained a binary classifier on patterns of activity in the left anterior insula while subjects viewed either disgust or neutral images and tested performance of the classifier on patterns of activity in the left anterior insula while they read novel disgust or neutral metaphors. We found that while traditional univariate analysis of fMRI data did not show activation in the left anterior insula during comprehension of novel disgust metaphors, a region-of-interest multivariate analysis revealed common neural patterns of activity in the left anterior insula under direct disgust experience and during the processing of disgust metaphors. The results show that the classifier could distinguish between novel disgust and neutral metaphors based on its ability to distinguish disgust and neutral images. Furthermore, performance of the classifier is correlated with the degree of subjectively reported disgust experienced when reading the novel disgust metaphors. These findings support the claim that abstract meaning specific to disgust engages semantic mechanisms whose neural representations involve grounding in systems of the brain closely connected with visceromotor systems. This sheds light on how abstract discourse including metaphoric discourse can powerfully alter human judgment–through its direct consequences on affective systems in the brain.

C4 When anticipation meets emotion: Top-down anticipation and bottom-up emotional word meaning impact early word processing similarly *Vicky Tzuyin Lai[1,2], Falk Huettig[1]; [1]Max Planck Institute for Psycholinguistics Nijmegen, [2]Donders Institute for Brain, Cognition, Behavior*

Past research showed that during reading, people are sensitive to both the anticipation built up via context and the affective information encoded in words. How do the two kinds of information interact with each other

to influence the processing of word in context? Here we investigated the extent to which anticipation and the processing of the emotional valence of the anticipated word feed into each other. We employed a 2 context (predictive, non-predictive) x 2 word (emotional, neutral) design. 97 emotional and neutral word pairs were selected based on their emotional valence, frequency, and length. Predictive contexts had a cloze probability of 80% (N=15). Non-predictive contexts were created by context swapping within a pair. Pretests (N=40) ensured that the emotional valence between the two contexts prior to the target words do not differ. Examples are (target words in single quotes): [p+e+] In Roald Dahl's book … Charlie … factory … 'chocolate' …; [p-e+] In Rapunzel's tale … Rapunzel … by a witch … 'chocolate' …; [p+e-] In Rapunzel's tale … Rapunzel … by a witch … 'tower' …; [p-e-] In Roald Dahl's book … Charlie … factory … 'tower' …. 28 participant passively read the sentences word-by-word while EEG was recorded. Comprehension questions appeared randomly to ensure reading. ERPs time-locked to the target words showed (1) enhanced P2 effects for predictive and/or emotional ([p+e+], [p-e+], [p+e-]) relative to non-predictive and neutral items [p-e-]; (2) N400 effects for non-predictive relative to predictive items, for in both emotional ([p+e+] vs. [p-e+]) and neutral ([p+e-] vs. [p-e-]) items, with the former significantly larger than the latter; (3) Late Positivities (LP), posteriorly distributed for non-predictive relative to predictive in neutral items ([p+e-] vs. [p-e-]), frontally distributed for emotional relative to neutral in non-predictive items ([p-e+] vs. [p-e-]), and both posteriorly and frontally distributed for predictive relative to non-predictive in emotional items ([p+e+] vs. [p-e+]). Thus, both context-based anticipation and target-word emotionality facilitate word processing, as reflected by P2s. Similar P2 amplitudes for [p+e+], [p+e-], and [p-e+] suggest that the influences of anticipation and emotional word valence are not additive. N400 effects (high- vs. low- cloze) were smaller for the emotional than the neutral items. However the N400 differences may be resulted from the LP introduced by the emotional items, pulling all waveforms toward positive polarity. Finally, the scalp distributions of the LP effects for emotional words in predictive context suggest two LPs from distinct neural sources: One sub-serving re-analysis of the input for event construction (Kuperberg, 2007; DeLong et al., 2011) and the other sub-serving emotionality (Field, Kuperberg, 2011). Overall, our data suggest that the neural generators underlying anticipatory and affective word processing are at least partly distinct and that the two do not feed directly into each other.

C5 Social coordination limitations impact language comprehension in behavioral-variant frontotemporal dementia

Stephanie Golob[1], Teagan Bisbing[1], Giulia Porcari[1], Nicola Spotorno[1], Robin Clark[1], Murray Grossman[1], Corey McMillan[1]; [1]University of Pennsylvania

Social coordination informally refers to the process of "getting on the same page" with another individual. Coordination games are a subset of game theory games in which the correct strategy cannot be determined from the structure of the game alone, but rather a salient source of information external to the game but known to both players must be incorporated in order to determine the correct strategy. Formally, game theory can be used to quantify the mechanisms involved in establishing a shared representation between a speaker and their conversational partner. Behavioral-variant frontotemporal dementia (bvFTD) is a neurodegenerative disease characterized by social and executive deficits with relative sparing of language. Previous experiments have demonstrated social coordination limitations in bvFTD related to a large-scale fronto-temporal network, however previous studies have not evaluated social coordination in the context of language comprehension. We developed a task in which bvFTD patients (N=13) and demographically comparable Seniors (N=16) were presented with two-scene stories containing a target animal character that moves from one position to another. The scenes were manipulated to contain "competitor" animals (e.g., multiple pigs) that differed in visual features (e.g., different coloror size). In a multiple choice task participants were asked to choose a sentence that best describes the scene to a conversational partner. Four sentence choices were provided that included (1) a correct number of adjectives, (2) too many adjectives, (3) too few adjectives, or (4) the correct number, but irrelevant adjectives (e.g., "large" instead of "red"). We monitored response accuracy and performed an error-type analysis. We also collected a battery of neuropsychological measures and volumetric MRI. Non-parametric tests revealed that bvFTD patients were less accurate than Seniors in the "colorblind" condition ($p<0.005$) compared to the "normal" condition. An error analysis revealed that bvFTD patients produced significantly greater irrelevancy errors than Seniors in the "colorblind" condition ($p<0.05$), suggesting a non-strategic selection of adjectives. These errors of irrelevancy can be attributed to the perspective-taking limitations demonstrated by the individuals with bvFTD. These limitations in perspective-taking appeared to be dissociable from general executive resources. However, the rate of irrelevancy errors correlated with the Visual Verbal Neuropsychological Task. ($p<0.01$) Visual Verbal requires subjects to group a set of four objects into two different groups of three based off of some visual feature. The ability to shift from the first to the second group requires cognitive flexibility, suggesting that cognitive flexibility may play a role in considering an alternative perspective when coordinating. Voxel-based morphometry analysis revealed significantly reduced grey matter density in bilateral frontal and anterior temporal cortex ($p<0.05$ FDR). A regression analysis related bvFTD patients' selection of irrelevant errors to right inferior frontal cortex ($p<0.001$). Together, these findings demonstrate that social coordination limitations in bvFTD impact

their comprehension of language in a discourse setting. Specifically, bvFTD patients do not strategically select appropriate adjectives to appropriately generate a shared mental representation with a conversational partner and this deficit appears to be related to executive dysfunction and right inferior frontal cortex.

C6 Affective Priming Effect of Music on Emotional Prosody in Williams Syndrome *Michael Pridmore[1], Cyrille Magne[1], Miriam Lense[2], Reyna Gordon[2], Alexandra Key[2], Elisabeth Dykens[2]; [1]Middle Tennessee State University, [2]Vanderbilt University*

The present study sought to determine whether the emotional valence of a musical context could influence processing of emotional prosody of words, in individuals with and without Williams Syndrome (WS). WS is a neurodevelopmental genetic disorder associated with hypersociability, musicality and cognitive impairments. Despite typically superior verbal skills than nonverbal skills, there is evidence for delayed early language acquisition and atypical prosody. Interestingly, neuroimaging research shows that music activates a broad network of brain regions in WS individuals, including those often associated with processing of emotions. Individuals with WS and controls matched for age, gender, and handedness performed a music affective priming task while their EEG was recorded from 128 scalp electrodes. Participants were presented with 500-ms happy or sad musical excerpts followed by pseudowords spoken with either a happy or sad prosody. The emotional valence of the musical excerpts either matched or mismatched the emotional prosody of the pseudowords. Participants were asked to attend to only the pseudowords and judge whether it was pronounced with a happy or sad intonation by pressing a response key. Results revealed a larger N400 component for pseudowords when the music-prosody emotional valence mismatched. Group comparison showed that this N400 effect was larger and more broadly distributed over the scalp for individuals with WS than for the control group. In line with previous studies, the present findings highlight the role music can play in binding emotion across different modalities. In addition, individuals with WS show an enhanced sensitivity to affective musical priming. Implications will be discussed for the conveyance of emotion in music, and connections between musical emotion and socio-emotional behavior in both WS and typically developing individuals.

Auditory Perception, Speech Perception, Audiovisual Integration

C7 Hemispheric contributions to auditory perception investigated by the modulation transfer function of speech *Adeen Flinker[1], David Poeppel[1]; [1]New York University*

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 transfer function of speech, providing a novel framework to parametrically manipulate speech stimuli and test psychophysical and neurophysiological responses. The modulation transfer function of speech intelligibility has been described using different computational approaches (Elliott et al. 2007; Chi et al. 1999). In brief, time-frequency representations of speech signals are further decomposed into temporal and spectral modulations (2D fft). We propose that the two hemispheres integrate different ranges of spectral and temporal modulations. In order to address this hypothesis, we first implemented a computational technique to filter sentences in the modulation domain (similar to Chi and Elliott). The degree of spectral and temporal modulations in the signal was varied parametrically to produce new sentences materials that were presented in psychophysical and neurophysiological paradigms. We characterize the temporal-spectral modulation space as a function of intelligibility as well as pitch (here: gender) identification. The fine-graded parametric steps reveal an intelligibility cutoff as well as more detailed psychometric functions than previously reported. We also provide the first report of spectral modulation parametrically influencing the perception of pitch. We interpret the results of psychophysics, dichotic listening and neurophysiological data in a computational framework of hemispheric asymmetry.

C8 Neural oscillations, temporal modulation rate filters, and periodicity maps in human auditory cortex *Gregory Hickok[1], Alyssa Brewer[1], Kourosh Saberi; [1]Dept of Cognitive Sciences, University of California, Irvine*

Temporal regularities are a property of neural signaling (oscillations), are readily detectible psychophysically (AM rate discrimination), and are reflected in the organization of human auditory cortex (periodicity maps). Building on previous work, we propose a link between these observations in the form of a neurally inspired model that uses a simple excitatory-inhibitory network to build a temporal modulation rate filter bank. Rate tuning of each filter is accomplished by varying the transmission delay between excitatory and inhibitory units. Filters exhibit phase resetting, amplify signals that are modulated at their preferred frequency, and when presented with complex modulated signals separate out the component modulation frequencies. We suggest this as a possible neural mechanism for temporal modulation rate filtering and as the basis for the formation of periodicity maps in human auditory cortex.

C9 A Computational Model of the Peripheral Auditory System from Cochlear Stimulation to Auditory Nerve Spiking *Feng Rong[1], Grant Walker[1], Kristofor Carlson[2], Jeff Krichmar[2], Gregory Hickok[1]; [1]Auditory & Language Neuroscience Lab, Center for Cognitive Neuroscience, Department of Cognitive Sciences, University of California, Irvine, [2]Cognitive Anteater Robotics Lab, Department of Cognitive Sciences, University of California, Irvine*

The neural circuits supporting speech perception receive highly processed acoustic information from the auditory periphery. To correctly model high-level processes, it is important to understand and accurately model the low-level neuronal activity that serves as inputs to the high-level processes. The main function of the early stages of the peripheral pathway is to transform the analog acoustic signal into neuronal spikes carried by auditory nerve. In this study we built a biologically realistic model to simulate the transduction of simple and complex acoustic signals into auditory nerve spiking responses via cochlear mechanics. We tested the model using simple sounds like tones, complex sounds like frequency-modulated (FM) sweeps, and speech sounds such as syllables and sentences. The model consists of three major components. The first component is a gammatone filter bank (Patterson et al. 1995), which simulates basilar membrane motion induced by acoustic signals. The filter bank contains 100 infinite impulse response (IIR) filters in which the center frequencies are linearly distributed in equivalent rectangular bandwidth (ERB) space from 100 Hz to 5000 Hz. The second component simulates the mechanoconduction procedure that transforms the basilar membrane motion to the discharge probabilities of inner hair cells by simulating the production, release, re-uptake and depletion of the neurotransmitters (Meddis 1986). The third component transforms the inner hair cell discharge probability to spikes across a network of 100 neurons carried by the auditory nerve using a Poisson spike generating mechanism. Because neurons in the third component of the model receive input from hair cells in different regions of the cochlear model, the output of the model encodes different spectral channels which can be activated as a function of time. This allows us to assess whether the spectrotemporal features of the acoustic input are accurately modeled in the spatiotemporal pattern of spike trains. We used synthetic acoustic stimuli that included tones and FM signals as well as recorded speech sounds as inputs to the model and assessed the output in terms of action potentials carried by auditory nerve. The simulation results demonstrate that the output spiking patterns characterize the spectral-temporal aspects of the inputs precisely with a high signal-to-noise ratio. References Patterson, R D., Allerhand, M. H. and Giguere, C. (1995). "Time- domain modelling of peripheral auditory processing: A modular architecture and a software platform." J.Acoust.Soc.Am. 98:1890-1894. Meddis, R. (1986) "Simulation of mechanical to neural transduction in the auditory receptor." J Acoust Soc Am 79(3): 702-711.

C10 Causal Inference in Multisensory Speech Perception *John Magnotti[1], Wei Ji Ma[2], Michael Beauchamp[2]; [1]University of Texas Medical School at Houston, [2]Baylor College of Medicine*

During speech perception, humans integrate auditory information from the voice with visual information from the face. This multisensory integration increases perceptual accuracy only if the two cues originate from a common cause, a requirement largely ignored by current quantitative models of speech perception. The temporal relationship between two cues provides strong evidence about the causal relationship between auditory and visual speech events. We developed a generative model of multisensory speech perception that uses asynchrony to accomplish the critical step of determining whether the auditory and visual information arise from a common cause. In the model, observers integrate the auditory and visual cues according to the likelihood that these cues have the same underlying cause, giving them weight proportional to their reliability. The model makes specific predictions about how temporal information should be used to determine the likelihood that two speech events originated from a single talker. We tested these predictions with data from thirty-seven participants that performed a synchrony judgment task using audiovisual speech stimuli that had varying asynchrony, visual cue intelligibility, and visual cue reliability. We compared the causal inference model with a popular alternative approach for assessing synchrony perception, Gaussian curve fitting. The causal inference model provided a better fit to the behavioral data with fewer free parameters than the Gaussian method across four conditions and two experiments. The causal inference model achieves this better fit by adding constraints derived from a principled analysis of how an optimal observer should solve the causal inference problem using the asynchrony and reliability of the cues. Because the causal inference model is derived from a principled understanding of the task, model parameters are directly interpretable in terms of stimulus and subject properties.

C11 How common is the McGurk-MacDonald effect? *Debshila Basu Mallick[1], John F. Magnotti[2], Michael S. Beauchamp; [1]Rice University, Houston, Texas, [2]University of Texas Health Science Center At Houston*

The McGurk-MacDonald effect or McGurk effect (McGurk & MacDonald, 1976) is an illusion that demonstrates the influence of visual cues on speech perception. While there have been many studies of the illusion, estimates of susceptibility to the illusion have varied widely. This could be due to differences in the stimuli used in different studies (the original McGurk stimuli are not available) or differences between the subjects used in different studies. To create a definitive population reference, we

assessed McGurk susceptibility across a sample of 165 fluent English-speaking adults using a battery of fourteen different McGurk stimuli gathered from various published articles and the Internet. Surprisingly, we found very large variability in McGurk susceptibility across participants. Across dozens of trials, six participants never perceived the effect while one participant always perceived the effect. We also found large variability across stimuli. The strongest stimulus elicited McGurk responses on 81% of trials, while the weakest stimulus evoked the effect on only 17% of the trials. The grand mean McGurk susceptibility estimate across stimuli and participants was 43%. However, this grand mean did not accurately describe the population because many participants almost always perceived the illusion or almost never perceived the illusion. Therefore, we classified participants into weak McGurk perceivers (59%) with low susceptibility and strong McGurk perceivers (41%) with high susceptibility. Next, we examined which stimuli were most effective at classifying participants using a receiver operating characteristics curve analysis. We found that participants' percepts on a single stimulus (M6) could accurately classify susceptibility group 89% of the time. Stimuli such as M6 with high classification accuracy were intermediate-strength stimuli that evoked the effect in some participants but not others. The ability to classify subjects with only a few presentations of a single stimulus suggests that the McGurk illusion has the potential to be a useful assay of intersubject differences in audiovisual integration.

C12 MVPA of Phonetic Features During Speech Perception

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Within the cognitive neuroscience of language, there is a debate regarding the role of the motor system in speech perception [1-3]. While studies of speech perception using functional magnetic resonance imaging (fMRI) have often found elevated activity in the motor system (e.g. Broca's area and premotor cortex), we still know little about what information is encoded in the activity of both the auditory and premotor/motor cortices. Unlike the standard univariate approach to fMRI analysis, multivoxel pattern analysis (MVPA) identifies patterns of activity that are reliably evoked by different stimuli or task conditions. Thus, while activation and deactivation of the motor and auditory cortices during speech perception says little about the underlying neural code supported by these regions, MVPA can provide a more detailed description. Specifically, this study aimed to explore the activity patterns associated with the auditory perception of 16 consonants that share varying levels of feature similarity and acoustic confusability [4]. Rather than simply identifying activation of the motor cortex during speech perception, the goal was to identify how the similarity of consonants as assessed by acoustic confusability (e.g. /m/ is confusable with /n/ but not /b/) is mirrored by the similarity among patterns of brain activation in the motor and auditory cortices, respectively. Sixteen CV syllables were aurally presented one at a time to participants in the fMRI scanner. Different speakers and different versions of each syllable were repeated such that 120 trials per syllable were collected for each participant over the course of a 1.5-hour scan. MVPA using an 8mm roving "searchlight" [5] was performed on three different features – place of articulation, manner of articulation, and voicing. Results suggest a gradient along the anterior-posterior axis of the superior temporal lobe corresponding to voicing, place of articulation, and manner, respectively. Thus, information about voicing was most pronounced in the anterior portion of the STG bilaterally, place of articulation in the mid-STS bilaterally, and manner of articulation was associated with pattern information in left posterior STS and planum temporale. Some frontal regions showed weak pattern information, such as middle frontal gyrus; however, no significant patterns were identified in premotor cortex. These results lend support to the claim that auditory cortex is the primary locus of the representational code underlying high-frequency acoustic information relevant for the perception of consonants. References 1. Liberman, A. M., Cooper, F. S., Shankweiler, D. P., & Studdert-Kennedy, M. (1967). Perception of the speech code. Psychological Review, 74 431-461. 2. Meister, I. G., Wilson, S. M., Deblieck, C., Wu, A. D., & Iacoboni, M. (2007). The essential role of premotor cortex in speech perception. Current Biology, 17(19), 1692–6. doi:10.1016/j.cub.2007.08.064. 3. Hickok, G. (2009). The functional neuroanatomy of language. Physics of Life Reviews, 6(3), 121–143. doi:10.1016/j.plrev.2009.06.001. 4. Miller, G. A., & Nicely, P. E. (1954). An analysis of perceptual confusions among some English consonants. The Journal of the Acoustical Society of America, 27, 338–352. 5. Kriegeskorte, N., Goebel, R., & Bandettini, P. (2006). Information-based functional brain mapping. PNAS, 103, 3863-3868.

C13 A meta-analysis of semantic and syntactic processing in language comprehension

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The localisation of higher level language processes, including semantic and syntactic processes, has been extensively debated, and yet there is still relatively little agreement as to how these processes are organised within the brain. In particular there is disagreement about whether different regions of the left Inferior Frontal Gyrus (LIFG) are recruited for semantic and syntactic aspects of sentence comprehension, and there is also disagreement about the different contributions made by anterior and posterior regions of the temporal lobe. We conducted an Activation Likelihood Estimation (ALE) meta-analysis of 44 functional MRI studies that explicitly varied the processing demand on the semantic or syntactic aspects of language comprehension, using one of the following

experimental manipulations: (i) the introduction of a syntactic/semantic ambiguity or anomaly, (ii) the use of a priming manipulation that specifically reduced the load on semantic/syntactic processing, or (iii) a contrast between sentences of different levels of syntactic complexity. The main ALE analysis, including all 44 studies, revealed a large network of brain regions that includes the LIFG (pars opercularis, triangularis and orbitalis, extending into premotor cortex, the Middle Frontal Gyrus and the insula), and the left posterior Middle Temporal Gyrus (extending into the Superior Temporal Gyrus, STG). Smaller clusters were found in the Right IFG/Insula and Right STG. Additional subtraction analyses were conducted to reveal differences in the networks of brain regions associated with semantic and syntactic processing. The results confirmed the critical role of LIFG in processing both semantic and syntactic aspects of language, but the results only provide partial support for the claims in the literature that there is an anterior-posterior dissociation within this region, such that syntactic processing is primarily associated with posterior LIFG while semantic processing is primarily associated with anterior LIFG. Our results confirm that the most posterior/ventral aspect of the main LIFG cluster is preferentially associated with studies of syntactic processing, but the reverse contrast (semantics > syntax) did not reveal any significant clusters within the frontal lobe, indicating that the 44 studies included in this analysis did not identify a sub region of the LIFG that is uniquely associated with semantic processing. Perhaps most importantly, when the semantic studies were analysed separately, the peak of the cluster with the highest ALE-score fell within Pars Opercularis (i.e., posterior LIFG). This finding seems inconsistent with the prevailing view that it is the anterior LIFG that is most strongly associated with semantic processing. The second key finding was the clear emphasis on the posterior (and not anterior) temporal lobe for both semantic and syntactic processing. These two findings are discussed in the context of the debate on higher-level language processing and in the context of models that emphasise the role of the anterior temporal lobe in processing sentence-level semantics and syntax.

C14 Modality dependence in sentence level and word level processing: an FMRI study *Julia Udden[1,2], Annika Hulten[1,2], Karl Magnus Petersson[1,2], Peter Hagoort[1,2]; [1]Max Planck Institute for Psycholinguistics, Nijmegen, The Netherlands, [2]Radboud University Nijmegen, Donders Institute for Brain, Cognition and Behaviour, Donders Centre for Cognitive Neuroimaging, Nijmegen, The Netherlands*

Written and spoken language comprehension are both parts of the general language domain but they are also different in many ways, not the least because the primary visual (V1) and auditory (A1) input regions are different. It has been suggested that visual and auditory language processing streams converge in modality independent language regions, but the evidence is so far not conclusive. Modality independence is observed in e.g. bilateral superior and middle temporal gyrus (STG and MTG, excluding A1), the inferior parietal lobe (IPL) as well as the left inferior frontal gyrus (LIFG) under some conditions. In this study, we characterize modality dependence in sentence level and word level processing separately. It is an empirical question whether word level representations in the temporal lobe are modality dependent, independent or whether both modality dependent and independent representations are present. As the V1 and A1 are connected to the STG and ITG/MTG, respectively, modality specific word level processing beyond that of sensory processing is likely to be found in these areas. If the brain instantiates syntactic and semantic combinatorial mechanisms in a modality independent manner, which would indeed be economical, modality dependence should be more prominent in word level processing compared to sentence level processing. We used a between-subject design with an auditory and a visual input modality group (30 participants in each group) scanned with FMRI. Sentences and word lists were auditorily presented in a natural pace, or presented visually, word-by-word. Sentence level processing was assessed by the contrasting sentences vs. word lists whereas word level processing was assessed by contrasting word lists vs. visual fixation. The group-level statistical comparison of auditory vs. visual results as well as a conjunction analysis was performed both for the word level and sentence level contrasts. Supporting the view of two converging processing streams, we found more prominent modality dependence at the word level than at the sentence level. The word level showed modality independent activity in the LMTG, extending into the posterior part of the STG and the IPL. There was significantly more activity in bilateral STG for auditory compared to visual input and in bilateral inferior occipital, lingual and fusiform gyrus, extending into the inferior and posterior MTG, particularly on the left side, for visual compared to auditory processing. At the sentence level, the anterior bilateral MTG showed modality independence. The bilateral STG was significantly more activated in the auditory vs. visual modality and the opposite comparison showed no activations. Our results show both modality dependent and independent processing of words in the temporal cortex. The mid and posterior LMTG was modality independent at both the word and sentence level, but the anterior bilateral MTG showed modality independence only for sentence level processing. The anterior MTG might therefore be the interface between lexical processing in MTG and combinatorial operations that are under the influence of LIFG.

C15 Lexical tone processing in Chinese reading *Veronica Kwok[1,2], Li-Hai Tan[1,2]; [1]State Key Laboratory of Brain and Cognitive Sciences, University of Hong Kong, [2]Department of Linguistics, University of Hong Kong*

The question of how the brain processes speech tone is central to our understanding of the hemispheric specialization for language in the human brain. Two prominent hypotheses have been proposed. The acoustic hypothesis assumes that pitch patterns are processed according to their acoustical structures, regardless of their functions, and are preferentially processed in the right hemisphere. Alternatively, the functional hypothesis assumes lateralization depends on the function of pitch patterns; cues that carry linguistic information are preferentially processed in the left hemisphere. Previous neuroimaging findings demonstrated that for tonal language speakers of a particular language (e.g. Thai), their auditory perception of Thai tones is lateralized to the left hemisphere. Yet, these past studies only focused on tone perception of spoken language, and little is known as to the lexical tone processing of written scripts and its neural basis. In the present study, we introduce the first fMRI study in examining neural substrates for lexical tone processing in Chinese reading. A simple tone judgment paradigm was used in which native Mandarin Chinese speakers were required to judge whether or not the viewed character in each trial carries the forth (i.e. high-falling) tone. The results show that lexical tone perception in Chinese reading involves distributed neural networks in both hemispheres. Many of the activated areas that contributed to lexical tone processing in Chinese reading have been implicated in previous findings on tone perception of spoken language, for instance, the fronto-parietal network and visual areas. Yet, the two hypotheses accounting for hemispheric laterality of auditory tone perception are not eligible to explain for tone perception in reading, since neither side of the brain showed hemispheric dominance while processing character tone information. Most importantly, our subjects did not show any significant cortical activation in the temporo-parietal region (i.e. superior temporal cortex), which is crucial in auditory lexical tone perception as well as for phonological processing of spoken language in both alphabetic and non-alphabetic languages. Thus, our findings suggest that neural network for language tone processing is not universal across modalities.

C16 Electrophysiological measurements of letter-sound congruency effects *Emily Coderre[1], Zachary Fisher[1], Barry Gordon[1], Kerry Ledoux[1]; [1]Johns Hopkins University School of Medicine*

The mapping between letters and sounds is crucial to reading, and yet mastery of these relationships is relatively difficult to acquire due to their arbitrary nature. Previous work investigating letter-speech processing in EEG has mainly focused on the mismatch negativity (MMN), an early response to a deviant sound which, in an audiovisual paradigm, is thought to index integration of letters and speech sounds. However, MMN oddball paradigms necessitate the use of a restricted set of stimuli, and often investigate only two vowels. In contrast, we employed an N400 congruency paradigm to assess implicit measures of knowledge of all English letters and their associated sounds. Visual letters were presented, followed by an auditory recording of either a congruent or incongruent phoneme. A reduced N400 was expected in response to congruent letter-sound pairings as compared to incongruent pairings. Preliminary data from five normal adult (NA) subjects supports this prediction: a reduced negativity occurred in the congruent conditions from 400-600 ms after sound onset. We also present preliminary data from a low-functioning individual with autism spectrum disorder, AI, who has been engaged in a letter training intervention for the past 1.5 years. AI has been trained on 19 letters of the English alphabet, which were classified as 'known' letters, with 7 untrained letters classified as 'unknown'. We hypothesized a reduced N400 effect for known congruent letters compared to known incongruent, but no difference between congruent and incongruent letters for unknown letters. Preliminary data analysis shows a delayed N400 effect, identified as a later negativity from approximately 600 to 900 ms to known incongruent letters compared to congruent. In contrast, no differences were found between the congruent and incongruent conditions in the unknown letters. This suggests that this N400 congruency paradigm can be used to assess implicit knowledge of letter-to-sound mappings in individuals learning to read, and holds important implications for assessment of teaching interventions in both typically-developing children and low-functioning individuals.

Motor Control, Speech Production, Sensorimotor Integration

C17 High gamma analysis of cortical responses to voice pitch feedback perturbation reveals network driving error correction. *Naomi S Kort[1], Srikantan S Nagarajan[1], John F Houde[1]; [1]University of California, San Francisco*

Introduction: The question of functional lateralization in speech production has created one of the most intriguing discrepancies in speech neuroscience. While neuroimaging studies consistently show bilateral neural activity during speech, lesion studies have provided overwhelming evidence for a left-dominant model of speech production. Neuroimaging studies on the role of auditory feedback in speech production have proposed an intriguing resolution to this discrepancy, suggesting that the left hemisphere generates feed-forward production of speech, while the right hemisphere, specifically right frontal regions, monitors and responds to feedback for ongoing control. In this study, using real-time pitch altered auditory feedback and magnetoencephalography (MEG), we study the role of auditory feedback in the control of pitch production. Methods: The experiment was administered in a block design with a Speaking Condition and Listening Condition. In the Speaking Condition, subjects were instructed to speak the vowel /a/ until the termination cue. The subjects spoke into an MEG-compatible optical microphone and

received auditory feedback through earplug earphones. During the phonation the subjects heard one 100-cent pitch perturbation lasting 400ms whose onset was jittered in time from speech onset. An equal number of pitch shifts that either raised or lowered the perceived pitch were pseudorandomly distributed across the experiment. In the Listening Condition, subjects received the same visual prompts but passively listened to the recording of their perturbed voice feedback obtained in the previous Speaking Condition block. The auditory input through earphones in both conditions was identical. The experiment contained 4 blocks of 74 trials. The NUTMEG time-frequency spatial adaptive filter algorithm was used to localize the induced activity in the high gamma band (65-150Hz) to the individual subject's spatially normalized MRI's. Results: During ongoing phonation, speakers respond rapidly to pitch shifts of their auditory feedback, altering their pitch production to oppose the applied pitch shift. Following the onset of the pitch shift, bilateral speech-motor cortex shows an increase in high gamma power. By 200ms following the onset of the pitch shift, the high gamma power increase in the left hemisphere was restricted to one region of left posterior temporal cortex. During the time between 100-200ms following the onset of the pitch shift, the high gamma power in the right hemisphere increases in premotor cortex, ventral supramarginal gyrus, inferior and middle frontal gyrus. Conclusion: These findings provide evidence for key roles for right premotor, right frontal and right supramarginal gyri in making small, rapid compensations to feedback errors.

C18 Monitoring of emotional information during spoken word production: an fMRI study

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Speakers continuously monitor their speech output to verify that it is appropriate. While the lexical processes involved in speech errors and their repair have been subjected to considerable investigation, little research attention has been devoted to how words' emotional valence might influence the monitoring process. The dominant model of verbal self-monitoring assumes monitoring is performed by the speech perception system, although other domain-general mechanisms have also been proposed. Does perceiving spoken words of different emotional valence during production influence the verbal self-monitor? To answer this question, we employed an adapted Stop-Signal Task (SST) in an fMRI experiment. 18 healthy participants continuously named two neutral 'go-signal' pictures (a bucket or a cactus) and were required to halt their naming response to infrequently presented auditory stop-signals comprising words varying in emotional valence (positive, negative or neutral). Behavioural results revealed significant differences between both emotional conditions and the neural conditions in terms of unsuccessful stops (20% negative, 18 % positive, 14% neutral), although the emotional conditions did not differ from each other. Despite the high proportion of successful stops across conditions, stop-signal reaction times (SSRTs) were able to be calculated for a subsample of participants with sufficient errors (37% negative, 36% positive, 27% neutral). This group of participants was used for analyses of the neural correlates of unsuccessful stops. There were significant differences between successful emotional and neutral stops within bilateral hippocampus (emotional>neutral) and bilateral inferior parietal lobe (IPL; neutral>emotional). Collapsed across conditions, all unsuccessful stops induced activation within the right inferior frontal gyrus (IFG; conjunction analysis) relative to fixation. Unsuccessful emotional>neutral stops revealed differences within the right IPL, inferior temporal gyrus, anterior rostral and orbital ACC and the left fusiform gyrus. The opposite contrast (neutral>emotional) showed differences within the right superior temporal gyrus and left IFG. The results of the current study highlight the influence of emotional information on monitoring and response inhibition during spoken word production. Emotional stop-signals led to higher error rates in comparison to neutral ones, suggesting interference between emotional processing and response inhibition, i.e., emotional stimuli capture more attentional resources that are in consequence not longer available for successful response inhibition. Successful stops to emotional compared to neutral information recruited hippocampal regions, consistent with research implicating medial temporal lobe regions in explicit memory for emotional information, while neutral stimuli evoked increased responses in classic parietal selective attention/response inhibition regions. Unsuccessful stops to emotional versus neutral information elicited differential activation in a large cortical network comprising regions implicated in monitoring/response inhibition as well as emotional processing. Especially signal changes within medial prefrontal regions reflect the interaction between response inhibition and emotional processing networks for emotional information supporting the suggestion of more effortful and attention-related response inhibition.

C19 Second language communication and anxiety: An fMRI study

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Verbal communication is both linguistic and social. Second language (L2) learners may compensate their limited L2 linguistic ability, making full use of their communicative ability or strategy. Or they also may not make use of their communicative ability due to their limited linguistic capacity. Emotional factors such as L2 anxiety are one of the important factors to influence L2 communication. Previous neuroimaging studies have exclusively focused on linguistic aspects of L2 production (e.g., syntactic construction, lexical selection). However, little is known

about brain mechanisms for social/communicative aspects of L2 production (e.g., generating communicative messages). In this fMRI study, we attempted to (a) identify the cortical mechanisms involved in L2 communicative speech production compared to L2 speech production without communicative intention and (b) inspect how L2 anxiety influences the brain networks of L2 communication. Subjects were 27 healthy right-handed native speakers of Japanese, who have learned English as an L2. Two separate experimental sessions were conducted for L2 and L1 (first language) conditions with a block design. Each session consisted of three production tasks: communication (COM), description (DES), and object-naming (OBJ). We presented short movie clips in which actors were using various objects (e.g., A man playing a guitar). In the COM task, subjects were asked to speak to an actor (e.g., "What kind of music are you playing?"). The DES task required subjects to describe what the actor was doing with the object (i.e., "He is playing the guitar now"). In the OBJ task, participants were required to say an objects' name three times (e.g., "guitar, guitar, guitar"). The DES task was used as a control to isolate communicative/social processing from linguistic processing. The OBJ task was used as a baseline to control articulatory motor processing and visual processing in each session. We obtained communication anxiety scales for L1 and L2 using the questionnaire developed by Yashima (2001 in Modern Language Journal). Statistical analyses were performed with SPM5, using a random effects model (p 0.001, corrected to p 0.05 using the cluster size). This study was approved by the Institutional Review Board at the Graduate School of Medicine, Tohoku University, Japan. Three major findings emerged. First, L1 and L2 communication similarly induced activation in the social cognition areas. Second, L2 communication produced greater activation in the left posterior supramarginal gyrus, which may be involved in goal-directed speech planning. Finally, negative correlation between L2 anxiety and brain activity under L2 communication was found in the orbitofrontal cortex which plays a role in monitoring social behavior. These results suggest that L2 communication relies on social skills mediated by anxiety, rather than on linguistic-based skills.

C20 The Effects of Perceived Similarity and Training on Novel Speech Acquisition: an fMRI study *Victoria Wagner[1], Ferenc Bunta[1], Pilar Archila-Suerte[1], Arturo E. Hernandez[1]; [1]University of Houston*

The current study sought to understand brain plasticity in adults associated with acquiring novel speech sounds. The Speech Learning Model (SLM) suggests that the perceived similarity between L1 and L2 sounds will affect the acquisition of L2 sounds (Flege, 1995). L2 sounds that are perceived to be part of the L1 category are less fully acquired in terms of production (Flege, 1987). Thus the acquisition of L2 speech stimuli should be affected by similarity to L1 and affect neural recruitment. In the current study, the effects of perceived similarity of speech sounds and training on novel speech production were examined. We expected differences in neural recruitment for more and less similar novel stimuli across training, with less similar stimuli recruiting speech production regions later in training. English monolinguals underwent a covert repetition training session for native and novel bi-syllabic non-words of varying perceived similarity while undergoing fMRI. Novel non-words were composed on Hungarian phonemes and were recorded by native Hungarian speakers. The fMRI training was preceded and followed by overt production sessions of the native and novel sounds that were recorded. Participants' recordings were rated for accuracy. Behavioral results showed improvement for novel sounds after the short training session with significant improvement for less similar sounds as predicted by the Speech Learning Model. Imaging result showed participants robustly recruited bilateral superior temporal gyrus, bilateral cuneus and left SMA for covert speech compared to baseline. Participants recruited additional regions based on the perceived similarity of the novel speech sounds. For more similar stimuli compared to less similar stimuli, participants recruited right hippocampus, right insula, left inferior frontal gyrus and right premotor cortex. These regions suggest that the participants are calling on memory to prepare to produce the more similar sounds, possibly by accessing L1 category speech commands. Contrasting more similar stimuli at the beginning compared to the end of training, participants recruited a region extending from the right middle temporal gyrus to inferior parietal regions, as well as the left inferior parietal cortex extending into superior temporal gyrus; no significant regions were active in the later portions of training. However, the less similar stimuli showed a different pattern across time, with more activation for the end of training in bilateral putamen. These results suggest that perceived similarity affects the neural recruitment involved with the acquisition of novel speech sounds. Participants appear to recruit regions associated with memory for sounds that are more similar to L1, while less similar sounds require continued activation in regions associated with motor control during the final phase of training, which suggests the continued acquisition and formation of L2 categories, in line with the SLM.

C21 Characterizing preoperative hemispheric asymmetries of cortical structures and language functions in left-hemisphere tumor patients via navigated transcranial magnetic stimulation *Noriko Tanigawa[1], Nico Sollmann[2], Theresa Hauck[2], Sebastian Ille[2], Bernhard Meyer[2], Florian Ringel[2], Sandro M. Krieg[2]; [1]University of Oxford, [2]Technical University of Munich*

Navigated transcranial magnetic stimulation (nTMS) during the object-naming task has been used to map cortical areas causally related to language functions in the preoperative context. The left-hemisphere nTMS langauge mapping has shown to have high specificity

when evaluated against the intra-operative language mapping by direct cortical stimulation (DCS) as gold standard (Picht_et_al_2013, Tarapore_et_al_2013). The predominantly negative DCS language-mapping results (Ius_et_al_2011, Sanai_et_al_2008) suggest that language functions might have shifted to the right hemisphere. To test this hypothesis, the present study quantifies the volumetric asymmetry of gray matter (Watkins_et_al_2001) and white matter (Ellmore_et_al_2010) of language-related cortical structures and investigates to what extent observed volumetric asymmetries were associated with object-naming performance in preoperative nTMS language mapping using the NexSpeech® module with the NBS system 4 (Nexstim Ltd., Helsinki, Finland). Data from 10 right-handed, German-speaking, left-hemisphere perisylvian tumor patients were analyzed (3 frontal-lobe, 3 parietal-lobe, 4 temporal-lobe patients). For each patient, anatomical magnetic resonance images were taken preoperatively on a Philips Achieva 3T scanner. These MR images were processed in FreeSurfer v.5.1.0 for automatic segmentation, parcellation, and volume measurement. The volume asymmetry quotient was calculated as (L-R)/(L+R) and categorized as leftward asymmetry (> 0.025), rightward asymmetry (< -0.025), or symmetry (-0.025 to 0.025), adapting Foundas_et_at_1998. The same set of MR images were used for the 3D navigation and tracking of stimulation points during the preoperative nTMS language mapping. Patients were asked to name familiar objects presented on a computer screen. Only the correctly responded pictures without nTMS were presented in the nTMS condition. A 5-Hz 5-pulse or 7-Hz, 5 or 7-pulse train started at 0 or 300 ms post picture presentation onset. All object-naming error types (Corina_et_al_2010) were collapsed. Regarding the gray matter volume, for the parietal-lobe and temporal-lobe structures (e.g., supramarginal gyrus, transverse temporal gyrus, and planum temporale), the rightward asymmetry was observed in the tumor-affected regions. In contrast, for the frontal lobe structures, the rightward asymmetry of the pars opercularis (opIFG) was observed as the tumor size increased within each of the tumor-affected lobes, whereas the rightward asymmetry of the pars triangularis was constantly observed (9/10 patients). When all the mapped cortical regions were collapsed, the overall object naming error rate was constantly higher for the right hemisphere than for the left hemisphere (8/10 patients). The gray matter asymmetry quotient (GMAQ) in the opIFG was negatively correlated with the overall object-naming error rates. This negative correlation was driven by the error rate in the inferior parietal lobe (IPL). In contrast, the GMAQ in the left opIFG was positively correlated with the error rate in the inferior frontal gyrus (IFG), which was constantly higher for the right IFG than the left IFG. Taken together, combined with a gray matter volumetric analysis, the present nTMS language-mapping study revealed that overall object-naming deficit was caused jointly by the right IFG disruption and the IPL disruption. The results suggest cortical reorganization associated with slowly-growing tumors and increased functional connectivity between the left and right IFGs as well as between the inferior frontal and interior parietal structures.

C22 Neural basis of the word frequency effect in a picture naming task. *Ana Sanjuán[1,2], María-Ángeles Palomar-García[1], Kristof Strijkers[3], Noelia Ventura-Campos[1], Elisenda Bueichekú[1], César Ávila[1], Albert Costa[3]; [1]Grupo de Neuropsicología y Neuroimagen Funcional, Departamento de Psicología Básica, Clínica y Psicobiología, Universitat Jaume I, Castellon, Spain, [2]Language Group, Wellcome Trust Centre for Neuroimaging, University College of London, UK, [3]Departamento de Psicología Básica, Universitat de Barcelona, Spain*

Introduction: The word frequency effect in picture naming has been a central property of speech production models. While the amount of psycholinguistic research exploiting word frequency is abundant, much less research has been dedicated to exploring the neurophysiological correlates of word frequency in language production and results are unclear. For this reason, the aim of the present study was to explore the neural basis of the word frequency effect in a picture naming task using event-related fMRI. Method: The sample consisted of 25 Spanish speakers (average age 19.9 years old). A slow event-related fMRI task was used and consisted on a picture naming task performed in Spanish. The pictures were manipulated for word frequency, half of them were high frequency words (mean lemma frequency 3.9) and the other half low frequency words (mean lemma frequency 52). fMRI data were acquired using 1.5T Siemens Avanto (Erlangen, Germany) with an gradient-echo-EPI sequence (TR=3000ms, TE=55ms, matrix=64x64, voxel size = 3.5x3.5 mm, slice thickness 3.5 mm and 0.3 mm gap). Data analysis was performed using SPM8. In the first place, we performed the preprocessing including slice-timing correction, realignment, coregistration, segmentation, spatial normalization to the MNI space (3 mm3), and spatial smoothing with an isotropic Gaussian Kernel of 8 mm FWHM. Then, for the statistical analyses we performed a paired t-test for the comparison between conditions. Result: The behavioral results showed the expected word frequency effect (i.e. pictures whose names occur more frequently were uttered faster than pictures whose names occur less frequently). Differences in the conditions were observed in the fMRI analysis, revealing increased activation in the anterior cingulate cortex/supplementary motor area (ACC/SMA), left inferior frontal gyrus (IFG) and insula when the low frequency condition was compared to the high frequency condition. We also observed that high-frequency pictures yielded higher activations in the right inferior parietal lobule when compared with low frequency pictures. Conclusion: Our results showed that picture naming of low frequency words would require the overactivation of language control structures (ACC/SMA, IFG, and Insula).

Orthographic Processing, Writing, Spelling

C23 The Role of the Visual Word Form Area in Spelling: fMRI Evidence for a Lexical Route from Phonology to Orthography

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Theories of spelling propose two distinct processes for translating from phonology to orthography: the spelling of a word is either retrieved directly from an orthographic lexicon (lexical route) or is assembled through rule-based phoneme-grapheme conversions (sublexical route). Although there have been neuroimaging studies investigating the general neuronal substrate of spelling, the present fMRI study is the first to explore whether the distinction between lexical and sublexical spelling processes is reflected in different brain activation patterns. In the scanner, twenty-one German-speaking subjects heard a word (lexical route) or a pseudoword (sublexical route) and then decided whether a visually presented letter is included in the written form of the word. In the control task, the same auditory words were presented and subjects evaluated whether the visually presented letter (M or F) corresponded to the male or female voice of the speaker. In line with previous studies, the present spelling task (compared to the control task) primarily engaged left temporal, parietal, and frontal brain regions. Critically, the only region reliably more activated by word than pseudoword spelling was located in ventral occipitotemporal cortex roughly corresponding to the putative Visual Word Form Area (VWFA). No brain regions were found to be more activated by pseudoword spelling. The higher activation of the VWFA for word compared to pseudoword spelling is consistent with the position that the VWFA serves as long-term memory for familiar word spellings (i.e., orthographic lexicon).

C24 Suppression of Phonological Recoding for High Frequency Words: Evidence from Single Unit Firing in Human Left Superior Temporal Gyrus

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Theories of reading propose that visual words can access meaning via either a 'direct' visual route or an 'indirect' route through phonological re-coding (PR). In PR, graphemes (encoded in ventral occipitotemporal cortex) are re-coded to phonemes (encoded in superior temporal cortex) after which the PR word would join the auditory language stream for lexical access. This PR process could cause interference if a word produces an inappropriate phonology due to irregular orthography. Such words do have longer reading times, but this is mainly true for uncommon words in poor readers (Seidenberg, 1985). This result is consistent with two models. One suggests that PR is always performed but for common words the direct visual route is faster, and thus PR cannot interfere. An alternative is that PR does not interfere in these situations because it is actively suppressed. Recently, we showed that cells in the anterior superior temporal gyrus (aSTG) are selectively responsive to particular auditory phonemes, and that some of these cells also respond to the orthography typically associated with those phonemes (Chan et al., 2013, Cerebral Cortex). Here, we compared the firing of these cells to common versus uncommon visual words. Approximately 170 cells were simultaneously recorded from a 96-channel microelectrode array implanted in the left aSTG of a 31 year old, right-handed man with epilepsy. The patient made semantic size judgments of 400 visually presented nouns. 200 words were presented 1 time each (Novel words) and 10 words were presented 20 times each (Repeated words). Visual inspection suggested suppression of firing immediately after word onset in many cells. A Wilcoxon sign-rank test identified 38 cells which showed a significantly suppressed firing pattern ($p<0.05$) of firing rates from 100 to 400ms post-stimulus compared to baseline (-500 to -200ms). To identify the effect of word-frequency on this pattern, we performed a median split for word frequency for both the novel and repeated words (word-frequency averages for Novel Low-Frequency: 1.06 ppm, Novel High-Frequency: 9.39 ppm, Repeated Low-Frequency: 3.33 ppm, Repeated High-Frequency: 10.94 ppm; Brysbaert & New, 2009, Behavior Research Methods). We assessed the percent change in average firing rate from baseline to post-stimulus period in each cell. Using a Wilcoxon sign-rank test comparing low- and high-frequency words in both the novel and repeated groups we found a greater percentage decrease in firing for high- compared to low-frequency words for both novel ($p < 0.001$) and repeated ($p < 0.001$) groups. Here we present evidence that early activity in a phoneme-responsive area of the aSTG is reduced when processing high-frequency words, suggesting that the PR process may be actively suppressed when words are familiar. Interestingly, this effect is present even for words that have been recently repeated several times. Since many behavioral effects of word frequency disappear when words are repeated, this suggests that this early suppression may be an automatic response to orthographic word frequency, independent of modulation by repetition. More generally, these data suggest that during reading, lexical access does not depend on dual-route processing unless a word is unfamiliar.

C25 An ERP investigation of adjacent and non-adjacent transposed-letter priming

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Visually presented primes formed by transposing the position of two letters in a word facilitate the recognition of that word compared with appropriate control primes. TL priming is reliably observed both when transpositions involve adjacent and, albeit to a lesser degree, non-adjacent letter positions (e.g., Perea & Lupker, 2003; Schoonbaert & Grainger, 2004 and Perea & Lupker, 2004, Perea et al., 2008, respectively). According to some accounts of orthographic processing, TL effects reflect the operation of a flexible position-coding mechanism that represents information about within-word position and is specialized to letter-string processing (Grainger & van Heuven, 2003; Whitney, 2001). A rather different account, however, attributes TL effects to positional noise operating on an otherwise rigid mechanism for encoding letter position information, the so-called noisy-slot coding (Gómez et al., 2008; Norris, 2006; Norris et al., 2010). It is believed that this generic noise derived from the nature of the perceptual system creates positional uncertainty that resolves itself over time as the noise diminishes (Norris & Kinoshita, 2012). We tested this account in an ERP study where we explored the temporal evolution of adjacent and non-adjacent TL priming. In particular, we used the sandwich priming technique to contrast effects of adjacent (e.g., atricle-ARTICLE) and non-adjacent (e.g., actirle-ARTICLE) TL primes. TL priming was measured relative to the standard double-substitution condition. Behavioral data (lexical decision latencies) revealed significantly stronger priming effects for adjacent transpositions than non-adjacent transpositions (with 2 intervening letters), consistent with previous results in the literature. A time-scale analysis on the ERP signal revealed that adjacent TL priming effects emerged earlier than non-adjacent ones, at around 200-250 ms post-target onset. Non-adjacent TL priming effects of similar size emerged about 50 ms later and were short-lived, being significant only in the 250-300 ms time-window. Adjacent transpositions on the other hand continued to produce priming in the N400 time-window (300-500 ms post-target onset). These results reveal a qualitatively different pattern in the evolution of adjacent and non-adjacent TL priming that challenges any single mechanism account of TL effects, such as the noisy slot-coding account. We suggest that transposed-letter effects reflect the operation of a flexible, letter-specific, position encoding mechanism that operates on top of generic positional noise. We provide an interpretation within the Grainger and van Heuven (2003) framework of orthographic processing where a limited amount of noise at the level of location-specific letter detectors gives rise to the initial adjacent TL priming effect, and flexibility in coding for location-invariant position-in-word information produces both the adjacent and non-adjacent TL priming that are subsequently observed. Finally, selective top-down feedback from lexical representations is thought to determine the different longevity of adjacent and non-adjacent TL priming.

C26 Decoding Letter Position in Word Reading *Ori Ossmy[1,2], Michal Ben-Shachar[3,4], Roy Mukamel[1,2]; [1]Sagol School of Neuroscience, Tel-Aviv University, [2]School of Psychological Sciences, Tel-Aviv University, [3]The Gonda Multidisciplinary Brain Research Center, Bar-Ilan University, [4]English Department, Linguistics Division, Bar-Ilan University*

A fundamental computation underlying the process of reading is the ability to transform a set of letters into a visual word form. Cognitive modeling and neuropsychological studies of peripheral dyslexia posit that separate modules are involved in encoding letter identity and letter position within a visually presented word. We used functional magnetic resonance imaging and supervised machine learning techniques to predict letter position based on activation patterns evoked during reading. Across the entire brain, activity patterns in the left posterior intraparietal sulcus (LIPS) were most informative yielding classification accuracy of 80%. Importantly, the same set of voxels in LIPS that showed highest classification performance of letter position using one target letter also showed highest classification performance using a different target letter. Furthermore, significant classification performance (63%) was achieved in LIPS when we trained the classifier on data from one target letter and examined its accuracy on data of a different target letter. A functional connectivity analysis revealed that the letter localization region in the left IPS was most strongly correlated with the Visual Word Form Area (VWFA), confirming cross-talk between these regions during visual word recognition. The results converge with data from neuropsychological patients with left parietal lesions who are selectively impaired in encoding letter positions. Taken together, these findings provide direct and novel evidence for the role of left IPS in processing letter positions within written words.

C27 The Visual Word Form Area is Functionally Connected to the Language System: The Importance of Individual Variability *W. Dale Stevens[1], Cynthia S. Peng[1], Alex Martin[1]; [1]National Institute of Mental Health, National Institutes of Health, Bethesda, MD, US*

The general category-related organization of human ventral occipitotemporal cortex (VOTC) is remarkably consistent across individuals. However, recent work suggests that relatively subtle individual variability in the precise location of category-related regions across VOTC significantly impacts the methods that can be used to accurately identify functional dissociations in this region of the brain. We recently demonstrated that category-related functional dissociations in VOTC regions during task performance are associated with differential intrinsic functional connectivity (FC) with other cortical regions that store and/or process category-relevant properties. There is currently considerable debate regarding the function and connectivity of the visual word form area (VWFA), a

region located in the left occipitotemporal sulcus thought to be specialized for visual word recognition. If the VWFA is specialized for processing written words, then it should show preferential FC with the language system. Using functional MRI, we tested this hypothesis, and assessed the degree to which individual variability is a factor in identifying the FC of the VWFA. Healthy adult participants (n=33) were scanned during a multi-category functional localizer (10 runs) and a "resting-state" run (> 8 min). We used the functional localizer to define category-related regions of interest (ROIs), and then used these ROIs in seed-based FC analyses of the resting-state data in these same participants. A number of left lateralized regions involved in language processing showed increased activity for written words relative to nameable object pictures, including the left occipitotemporal sulcus (VWFA), superior temporal gyrus overlapping the planum temporale (Wernicke's area), inferior frontal gyrus overlapping the pars opercularis and often the par triangularis (Broca's area), and the precentral gyrus. Using seed-based FC analyses, we compared the FC of the VWFA when the ROIs were defined using three different methods: 1) individually defined using the functional localizer, 2) defined at the group-level using the functional localizer, or 3) based on coordinates from the literature. Across participants, the VWFA showed preferential FC with language regions, including Wernicke's and Broca's areas and the precentral gyrus, relative to several control regions. Further, the method used to define ROIs had a significant impact on the specificity of FC of the VWFA with language regions, with individually defined ROIs showing the strongest effects. These results are consistent with the idea that the VWFA is specialized for visual word recognition through preferential connectivity with a larger distributed language system. The results also demonstrate the importance of taking individual variability into account in FC analyses by individually localizing category-related ROIs in each participant using a functional localizer.

Language Development, Plasticity, Multilingualism

C28 Proficiency and L1 background effects on L2 prosodic processing: ERP evidence from German and Chinese learners of English

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While a number of studies have investigated the interplay between syntactic and prosodic information in monolinguals, little is known about the temporal integration of these sources in bilinguals. Event-related potentials (ERPs) provide the necessary temporal resolution to examine the possible differences between first (L1) and second language (L2) processing of prosodic and syntactic cues during sentence comprehension. The specific aim of this study was to compare languages that differ considerably in their prosodic organization to test (a) whether L2 learners process prosodic cues in the same way as native speakers and (b) how different prosodic systems in L1 and different proficiency levels in L2 influence syntactic parsing. To address these questions we investigated native English speakers and three groups of L2 speakers: high-proficient (HP) German speakers, low-proficient (LP) Chinese speakers, and high-proficient (HP) Chinese speakers. Participants performed an acceptability rating in four conditions containing prosodic information that either matched or conflicted with the syntactic structure of the sentence. In conditions A and B, syntactic boundaries were correctly marked by prosodic boundaries at which all four groups elicited a CPS (Closure Positive Shift). In conflicting condition C, the omission of a disambiguating pause led to a P600 garden-path effect in the native speakers as well as the HP German and Chinese groups. The LP Chinese speakers, however, elicited no response to this mismatch. Conflicting condition D contained a superfluous boundary that resulted in a strong biphasic N400-P600 garden-path response in the L1 group and in the German group. The LP Chinese group only showed the N400, but not the P600, while the HP Chinese group exhibited the reverse pattern of an absent N400, but a significant P600. From this study it becomes clear that (a) prosodic boundaries are processed in a similar way in all groups as indicated by undistinguishable CPS components but that (b) both the prosodic organization of L1 as well as proficiency levels shape online processing of prosody-syntax mismatches in L2. Even at high proficiency levels, speakers of Chinese – a tonal language differing strongly from English – showed only partially similar patterns compared to native speakers, while the German group using a similar prosodic system elicited comparable ERPs. This work is also of particular importance for the debate about whether L2 learners can show native-like neurocognitive markers. While differing prosodic backgrounds seem to be an additional hurdle for L2 speakers, we predict that once native-like proficiency has been established in L2, even those groups with a distant prosodic background will converge on the ERP pattern demonstrated by native speakers.

C29 How our emotions affect our first and second language? An ERP study

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Transient mood is known to affect integration at both semantic and syntactic level. In a previous study we showed that transient mood can affect also low-level visual word processing, and we proposed that the cost of meaning activation could increase under sad mood. The present study tested if emotional states affect differently to first (L1) and second language (L2) processing in late second language learners. The experiment consisted of four separate blocks in which the participants had to read single words presented in the centre of the screen and only press a button when they recognized the name of an

animal. Each block contained forty high, and forty low lexical frequency words and forty animals. Before the start of each block we presented ten clustered pictures that were sad (valence=2.37, arousal= 5.09), or happy (valence=7.89, arousal=4.90). The results showed the classical lexical frequency effect in the N400 component for the L1 words, but this effect was maximal at a later time-window (500-700) in the case of L2 words. Interestingly ERPs under the sad transient mood showed larger negative amplitudes than under the happy transient mood in both L1 and L2 conditions. As the lexical frequency effect, the mood effect was larger in the N400 time-window for L1 words, but reaches its maximum in the 500-700 time-window with the L2 words. These results replicated the findings of the previous monolingual study for as well the lexical frequency as well as the transient mood effect in L1 words. Interestingly, although for L1 both effects were in the N400 time window, for L2 they appeared later; starting in the N400 time window they reached their maximum about 100-200 ms later. The results suggest that mood can affect word processing in L2 later in time because in unbalanced bilinguals it requires more cognitive recourses.

C30 Culture-specific inter-lexical relations in the bilingual's lexicon : an ERP study

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Research on a bilingual lexicon has focussed on the issue of a shared vs. separate conceptual store for each of the bilingual's language. However, little attention was given to the nature of links between words (or more precisely, between concepts that words refer to) and to their language-specificity. Generally speaking, thematic relations between words (e.g., cow – milk) arise via associations between concepts that are present in the world that the speaker lives in, i.e. in the speaker's culture. Whereas some associations are shared across cultures (such as cow – milk), others are more culture-specific. For example, in the Chinese culture there is an association between concepts 'bride' and 'red' (as brides traditionally wear a red dress), whereas in the Western cultures the association is between 'bride' and 'white' (Dong et al., 2005). Hence, examination of inter-lexical relations in the lexicon of a late bilingual enables a peek into whether they internalise new facts about their L2 culture into their L2 lexicon. The present study addresses this issue by exploring inter-lexical connections of twenty advanced Chinese learners of English who lived in the UK for at least 12 months (L1 = Chinese, L2 = English). The participants read prime-target pairs consisting of English words that were either related only in their L2 (English-related: white – bride), or in both languages (both-related: groom – bride), or not related at all (unrelated: chair – bride). The amplitude of the N400 response to the target in each condition was a dependent variable. Our results demonstrated that the N400 in the L2-related condition was significantly smaller than in Unrelated condition and did not differ from Both-related condition. This suggests that newly-learnt associations between concepts that are specific to the L2 culture can serve as a basis for constructing inter-lexical links in the bilingual's lexicon. We discuss implications of our findings for theories of the bilingual's lexicon, in particular, the issue of degree of integration vs. separation of two languages in the bilingual's mental lexicon.

C31 Shape or detail? An electrophysiological investigation of object recognition processes related to language development in 20-month-olds

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Introduction: Object recognition based on overall shape information has been suggested to play a role in language development between the age of 1 ½ and 2 years. Research on the phenomenon called the "shape bias" has found that the ability to recognize objects based on shape increases with productive vocabulary size (Gershkoff-Stowe & Smith, 2004; Pereira & Smith, 2009). The present study hypothesized that differences in attention to shape, and object identification based on shape, would be seen as differential electrophysiological processing in children at different stages of language development. Method: We tested how regular pictures and pictures containing reduced visual information influenced young children's expectations of an upcoming word. ERPs related to word processing (primarily the N400) and attentional processing (the Nc) were measured in 20-month-olds (n = 29) in an experiment containing familiar objects and words based on a paradigm by Torkildsen et al (2008), Children were presented with pictures of common objects, for example a dog or a chair and auditory word stimuli. During a learning phase each picture was presented 5 times together with its correct label. In a test phase directly following the learning phase, the same pictures were presented with a label that was incorrect but equally familiar. The test phase also contained modified versions of the original pictures, displaying either only the overall shape (a black silhouette), or a few salient details (e.g. a wheel, steering wheel and headlights of car). We hypothesized that the N400 incongruity effect would be related to vocabulary size in the silhouette condition specifically, with large vocabulary children displaying a stronger effect. EEG data was recorded with Electrical Geodesic's (EGI) HydroCel Geodesic Sensor Nets (HCGSN) with 128 channels. To test the relationship between ERP responses and vocabulary, participants were divided into two groups based on productive vocabulary size. Repeated-measures ANOVAs were carried out to test the statistical effects of differences in ERP waveforms, and productive vocabulary group was entered as a group factor. Results/ Conclusion: A typical N400 semantic incongruity effect was seen, regardless of vocabulary size, in response to words presented in an incongruent context containing either a whole picture or only details. The incongruity effect in the silhouette condition was found to be related to

the children's productive vocabulary size, $F(1, 26) = 5.00$, $p < .05$ (in the 500-600 ms time window), which supports the hypothesized link between shape recognition and language development. However, in contrast to results from previous behavioral research, the ERPs suggest that the children with smaller vocabularies were able to correctly identify the objects based on a silhouette, but their ERP pattern differed from that of the large vocabulary group. Only the large vocabulary group produced both a parietal N400 response to the incongruent word, and a frontal negative response to the congruent word that may be interpreted as an Nc. This may be understood as a reflection of increased attention and interest to the correct label for a pure shape object.

C32 When shark is closer to bat than to whale: The structure of second language lexicon *Katy Borodkin[1], Yoed N. Kenett[1], Miriam Faust[1], Nira Mashal[1]; [1]Bar-Ilan University*

Theoretical Background: For many individuals, learning a second language (L2) has become a familiar experience, a large part of which involves the acquisition of new words. With increasing L2 proficiency, L2 words become less dependent on their translation equivalents in native language (L1), and an independent L2 network is established. The present study focuses on this network in proficient L2 speakers and examines using network tools how its structure differs from the structure of L1 lexicon. The use of network tools provides a quantitative method that allows exploring general principles governing lexicon structure that are difficult to explore via classical qualitative methods. It also allows for more careful comparison between groups, such as in the research of L1-L2 lexical organization. In this study, we apply a novel computational model to compare the lexical organization of a semantic category in L1 and L2 lexicons. Methods: The study included 25 native Hebrew speakers (mean age = 24.98, SD = 3.30) and 24 English-Hebrew bilinguals (mean age = 22.63, SD = 1.53), who learned Hebrew as L2 from childhood. Participants performed a semantic fluency task, in which they had one minute to generate as many words as possible belonging to the animal category. Bilinguals completed the task in both languages whereas native Hebrew speakers–in Hebrew. The verbal fluency data was analyzed using the correlations between word profiles generated either matched to each group (Sample-Matched Correlation Networks, SMCNs) or to words generated by both groups (Word-Matched Correlation Networks, WMCNs). These analyses allowed us to compare the three SMC networks (English as L1, Hebrew as L1, and Hebrew as L2) and to examine specific differences between L2 and L1 WMCNs (Hebrew as L2 vs. English as L1; Hebrew as L2 vs. Hebrew as L1). Finally, we independently compared the WMCNs of Hebrew as L2 in high- and low-proficiency bilinguals to the WMCN of Hebrew as L1. Results: SMCN analysis revealed that lexical organization of Hebrew as L2 of the animal category is less developed than both L1 SMCNs, in the sense that it is smaller and less ordered (based on measures of network structure such as the network diameter and average shortest paths length). Specific WMCN analyses supported these findings and revealed that, in general, L2 lexical organization is underdeveloped (i.e., less structured) compared to its L1 equivalent. This pattern was also found when comparing both low- and high-proficiency WMCNs of Hebrew as L2 to the WMCN of Hebrew as L1. Conclusions: Bilingual performance on a semantic fluency task demonstrated that the lexicon of Hebrew as L2 was less organized compared to both English as L1 lexicon in bilinguals and Hebrew as L1 lexicon in native speakers. This was observed even after matching the words produced across languages and across groups and regardless of L2 proficiency. These structural characteristics of L2 lexicon may have negative effects on some aspects of language processing in L2, especially those requiring a more complex lexical network, such as nonliteral language.

C33 N400 evidence of word learning from context in adolescent children *Mandy Maguire[1], Alyson Abel[1]; [1]University of Texas at Dallas, Callier Center for Communication Disorders*

INTRODUCTION: Around 3rd grade, children shift from acquiring new vocabulary through explicit teaching to relying on learning from context for vocabulary growth. When learning from context, the child has only linguistic information to identify the boundaries of a novel concept and attach a new label to that concept. As such, it is an incremental process (Nagy et al., 1985) making it difficult to assess using traditional behavioral measures that evaluate the outcomes of learning. Previous work has used ERPs to study this process in adults, but to date it has not been applied to children. This study uses ERPs to examine the online process of learning from context in 13-14yearolds, an age at which learning from context accounts for a large portion of vocabulary growth (Nagy et al., 1985). METHODS: EEG was collected while 13-14 year old participants completed a learning from context task based on previous work by Mestres-Misse et al. (2007). Participants read 126 triplets of sentences presented word-by-word. The last word of each sentence was the target word - either a novel word or a real word control. There were three conditions: Meaning Plus (M+), Meaning Minus (M-) and Real Word (RW). In the M+ condition, the sentences increased in their support of the meaning for the novel word, with the last sentence providing a great deal of support (ex. "The evil witch gave Snow White a zat"). In the M- condition, the three sentences did not establish the meaning of the novel word. The RW condition paralleled the M+ condition, except with a real word target instead of a novel word. After reading each set of triplets, participants identified the real word represented by the target novel word or provided a synonym for the real word. RESULTS: Response accuracy for the M+ condition was 80.9% (SD=8.5). The N400 significantly

decreased between the first presentation and the third presentation, t(5)=2.89, p<0.02 indicating word learning. Interestingly, the second presentation fell in the middle and was not significantly different from the first or third. The N400 for the third presentation of the novel word was not significantly different from the real word, p=0.83, also indicating learning. Importantly, the M- condition did not show significant attenuation; thus, the changes in the M+ condition relate to attaching meaning to the word, not just exposure. CONCLUSION: Behavioral findings indicate that 13-14 year olds have some difficulty in learning from context, even when the sentence context supports learning. ERP findings distinctly show the incremental process of learning from context, evidenced by an attenuation of the N00 with more presentations of the novel word in contexts that support learning (M+) but not contexts that do not (M-). Together, these data indicate that even as late as 13-14 years of age, children only slowly acquire a word's meaning. Findings will be important to better understanding the development of word learning and problems in word learning for children with language delays.

C34 The influence of imagery-based training and individual variability on foreign vocabulary learning

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The purpose of this study was to investigate the influence of both training method and individual variability on foreign vocabulary learning. Specifically, two imagery-based techniques were employed: interactive mental imagery and picture imagery training. Functional magnetic resonance imaging (fMRI) was used to examine the cognitive constructs underlying these pedagogies, as well as the individual differences that predict successful learning. Using a within-subjects design, 21 English monolinguals were trained on novel German vocabulary using two different imagery-based learning techniques for four consecutive days. Both the order of training and the German word set paired with each training method were counterbalanced. During picture imagery training, participants simply visualized a picture of an object paired with a novel German word, whereas in interactive imagery training, participants visualized a first-person interaction with the object displayed. Vocabulary tests assessed learning after each session. At the end of training, neural activation was examined during an auditory recognition task of learned and unlearned words. Two weeks post-training, vocabulary retention was again assessed. Behavioral results revealed a steady increase in learning; ceiling scores were reached by session three in both paradigms. Accuracy differences between learning methods were only significant across the five assessments for one of the two German word sets that were taught. For one word set, learning through interactive imagery was more difficult and resulted in decreased accuracy during the first two sessions, and in retention two weeks post-training. While no words were cognates and word characteristics were controlled for, some German words were simply more difficult to learn using interactive imagery techniques. Moreover, imaging results also revealed distinct differences related to the different pedagogies, specifically when individual differences in success of learning were taken into account. FMRI regression analyses showed that retention of vocabulary information after picture imagery training was correlated with increased activity in regions associated with the cognitive control of language, such as the superior frontal gyrus, putamen, and anterior cingulate, as well as the precuneus. These results suggest that learners may initially be more successful using picture imagery training, as this method allows recruitment of regions common to the higher-level control of the language system, which may allow for greater information retention. Behavioral and imaging results indicate that for some individuals, vocabulary content may be difficult to learn through a less familiar interactive imagery technique. Taken together, these findings support the conclusion that foreign vocabulary learning cannot be simplified to finding one best method of instruction for all; learning requires consideration of myriad factors; both content and method of learning, as well as individual variability in learning influence short-term and long-term success of foreign vocabulary acquisition. Picture imagery may initially be an easier mode of learning in general as it is easier to link to higher-level language control, but when individual learning differences are considered, other more interactive and embodied learning techniques may also be successful in the long run.

C35 Timing is everything in the bilingual brain: The effect of language exposure on using meaning and language membership information during lexical access

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Introduction. Some models of word comprehension (e.g., Bilingual Model of Lexical Access; Bilingual Interactive Activation model) assume that meaning retrieval is the last stage of lexical access. Yet, Ng and Wicha (2013) have shown that adult balanced bilinguals can, in some cases, access/use the meaning of written words before their language membership (i.e., what language a word is in). The relative timing of information retrieval, they suggested, might depend on language exposure: while semantic access is automatic and time-invariant, bilinguals may become more sensitive to phonological and orthographical information of words with increased use, which would in turn allow earlier access to language membership information. Here, we used event related potentials (ERPs) in a novel target-detection paradigm to test the impact of language proficiency and frequency of use on the timing of access to lexical information in the bilingual brain. Methods. Bilinguals read a list of mixed

(Spanish and English) words and responded by button press upon detecting words that referred to people in only one of the languages (e.g., maid). All bilinguals performed the task with English and Spanish as the target language in separate blocks. Significant differences in P300 amplitude across conditions (measured from word onset) were considered the point at which words were classified as targets or non-targets. Adult Spanish-English bilinguals (n = 54) were classified into 3 groups: balanced bilinguals who used English more frequently than Spanish (BB-En), balanced bilinguals who used Spanish more frequently than English (BB-Sp), and Spanish dominant bilinguals who used English and Spanish equally (Dom-Sp) [dominant English bilinguals who use both languages equally were too rare to include in our sample]. Results. In all groups, the P300 differed significantly based on semantic information (people versus non-people) by 250 msec and was largest for target words by 400 msec. The difference across groups was in the relative timing of accessing semantic versus language membership information. The BB-En group showed a P300 effect based on language membership information (target versus non-target language) before semantic information when 'English people' were the targets, but showed a P300 effect based on semantic before language membership information when 'Spanish people' were the targets. The BB-Sp group showed the opposite pattern. The group that used both languages equally (Dom-Sp) accessed semantic information before language membership information regardless of the target language. Conclusion. The time course of semantic access was not affected by language use or language proficiency. However, the amount of exposure to a language modulated the relative timing of access to language membership versus semantic information. Contrary to predictions from lexical access models, semantic information was accessed prior to language membership information in all cases, except for a language that was used more frequently than the other. This indicates that access to meaning in the bilingual brain is rapid and not thwarted by form-level features. Moreover, the role of exposure on language processing reflects cognitive plasticity in bilinguals: bilingual lexical access is dynamic, with the amount of environmental input modulating the relative timing of access/use to lexical information.

C36 Lateralization and Language Creativity: Developmental Transition from Adolescence to Young Adulthood

Smadar Patael[1], Katy Borodkin[1], Miriam Faust[1]; [1]Bar-Ilan University

The unique human ability to cope with both the conventional and the more creative aspects of language (e.g. metaphors, humor, ambiguity) is essential for cognitive processes and for communication. However, while there is much research on the neurodevelopmental basis of conventional language, little is known about the neural mechanisms underlying the development of language creativity, particularly during adolescence when these abilities develop rapidly. Several neurolinguistic models suggest that the right hemisphere (RH) plays a major role in processing the creative aspects of language, mainly those involved in semantic creativity, while others suggest that both hemispheres are crucial for such processing. However, these models are based mainly on studies with adults. The developmental aspects of language creativity have generally been overlooked. The current study examines the links between changes in hemispheric processing patterns and the development in semantic creativity during adolescence. We hypothesized that mastery of semantic creativity depends on the intricate interplay between the two hemispheres. Forty adolescents and 39 adults performed a divided visual field (DVF) paradigm and language tasks battery. Since ambiguity resolution has been thought to be an important component of creativity, the DVF was combined with priming of dominant and subordinate meanings of ambiguous words. The language tasks battery included language creativity tasks such as Remote Associative Test (Mednick, 1967), novel metaphor comprehension test and more basic language tasks such as naming. To rigorously determine whether changes in hemispheric dynamics underlie development of language creativity, we used regression models with three-way interactions to predict performance on language creativity and naming tasks. Specifically, the predictors of these models were the RT for subordinate meanings in each hemisphere and age group as well as the interaction between them. We found that adolescents and adults performing well on creativity-demanding tasks exhibit an inherently different lateralization pattern. Namely, a three-way interaction specifically predicted language creativity performance. A follow-up analysis to explicate this interaction indicated the significant moderating role of the RH in the relationship between LH processing and language creativity throughout adolescence. For young adults with fast processing of subordinate meanings in the RH, the faster the LH, the better they performed on language creativity tasks. In contrast, adolescents with fast RH did not present this relationship. Moreover, adolescents who showed slow processing in the RH, the faster LH was, the better they performed on language creativity test. In other words, whereas young adults showed better performance in creative language tasks when the level of synchrony between the two hemispheres was higher, adolescents succeeded better on these tasks when there was a discrepancy between the speeds of the hemispheres. These results suggest that the transition from lateralization to hemispheric synchronization may enable the mastery of language creativity. The current study thus sheds light on the processing mechanisms of developing and mature brains and has implications for clinical and educational practices. Understanding these normal phenomena of

development of language creativity is essential for creating evidence-based education programs and for proper interpretation of studies of populations with disabilities.

C37 Cross-language verb-noun priming in the bilingual brain *Isel Frederic[1,2], Engel Andreas K[2], Schneider Till R[2]; [1]Institute of Psychology, Sorbonne Paris Cité - Paris Descartes University, France, [2]Department of Neurophysiology and Pathophysiology, University Medical Center Hamburg-Eppendorf, Hamburg, Germany*

The present study aimed to investigate the neurofunctional organization of the bilingual mental lexicon. Here we questioned whether French verbs (e.g. courirto run) and nouns (e.g. piedfoot) share a common semantic-conceptual representation, and if so, to what extent this representation may differ in the first (L1) and in the second (L2) languages. Furthermore, we studied how different ages of second language acquisition (AoA) are influencing neuronal processing of language in French-German bilingual speakers. In an associative priming paradigm, we examined the influence of semantically related and unrelated primes and targets within and across languages. We recorded neuronal activity using magnetoencephalography in 16 participants with early onset of bilingual (French-German) language acquisition (7 years). We presented verbs in French and German paired with nouns in French or German so that four possible priming directions could be tested (French-French, German-French, French-German, German-German). Prime and target words were presented in close temporal proximity (300 ms SOA) and were either semantically related or unrelated. In each trial participants were asked to judge whether the target word was denoting a man-made or a natural object. In the event-related fields we found interactions between the AoA and the priming direction in a time window between 250 and 450 ms. Around the N400m (300-600 ms) we found an interaction between the priming direction and the semantic relatedness between prime and target. Additionally around 200 ms we found a trend for an interaction between AoA and relatedness between prime and target. These results suggest that verbs and nouns share a common semantic-conceptual level of processing, but that the strength of the link between lexical and semantic-conceptual information (1) might differ in the L1 and L2, and (2) might be modulated by the AoA of the L2. Taken together, our findings lend support to models of bilingual language processing postulating a common semantic-conceptual level of representation for L1 and L2.

Lexical Semantics

C38 Non-Motoric Aspects of Action Concepts *Anna Leshinskaya[1], Alfonso Caramazza[1,2]; [1]Harvard University, [2]University of Trento*

Reading an action verb elicits the retrieval of its associated body movements, as well as its typical goal—the outcome to which it is directed. Much prior work characterizes the neural basis of verb-associated motor knowledge, for example in premotor cortex, and, to that end, has focused on concrete actions (e.g., kicking), in which body movements and goals are tightly related. However, goals can be conceived of abstractly and independently of body movements (e.g., enjoying a pleasant drink, which can be done with various body movements), but these more conceptual, non-motoric aspects of action knowledge are less well investigated. The present fMRI experiment was designed to isolate goal-related aspects of action knowledge from motoric ones. Participants read names of actions which are either done intentionally (e.g., drink) or by accident (e.g., hiccup). The intentional action verbs conveyed information about goals, while the latter did not. As a second, orthogonal factor, actions also differed in their amount of body movement (e.g., drink vs. imagine). Across both levels of motoricity, the goal-directedness of an action influenced the activity of a portion of left posterior IPL (angular gyrus). Motoricity, on the other hand, had no influence on the activation of this region. To examine the relationship of this region to the mentalizing network, a localizer scan was given to the same participants. Although nearby, the portions of angular gyrus involved in theory of mind and the presently reported regions were clearly distinct in individual subjects. This is consistent with the observation that IPL contains many functionally distinct sub-regions. The relationship of the presently reported region to other IPL areas implicated in the awareness of intentions, action planning, and semantic processing has yet to be tested. Nonetheless, the results reveal that a particular portion of the angular gyrus is involved in processing highly conceptual components of action knowledge—specifically here, their goals—that are distinct from motoric ones. This lends further evidence to semantic processing in the angular gyrus. Furthermore, these findings inform accounts of the neural representation of actions, to suggest that it includes abstract, conceptual information in addition to sensorimotor properties.

C39 2 X 3 = six: An ERP study of written words in multiplication-fact retrieval *Amanda Martinez-Lincoln[1], Charlie Giattino[2], Curtiss Chapman[3], Nicole Wicha[1,4]; [1]The University of Texas at San Antonio, [2]Duke University, [3]Rice University, [4]The University of Texas Health Science Center - San Antonio*

Arithmetic facts, such as single-digit multiplications, are ostensibly stored as language specific memories in a complex arithmetic memory network (Campbell & Xue, 2001). Most models of arithmetic propose a verbal representation for arithmetic facts (Campbell & Epp, 2004; Dehaene & Cohen, 1995), but the influence of language on arithmetic-fact retrieval is not fully understood. Previous research with bilinguals showed a processing difference between digits and number words in solving simple multiplications (i.e., the N400 congruency effect for digits peaked earlier than words, Salillas & Wicha, 2012). Salillas and Wicha (2012) proposed that this timing difference

reflected bilinguals' slower performance on language tasks compared to monolinguals, rather than a cost for accessing arithmetic facts through written language. Here we tested access to multiplication facts as a function of format, digits versus written words, in an English monolingual population, using event related potentials (ERPs) – a direct and multidimensional measure of cortical brain activity. Single and mixed format problems were used to assess 1) the efficiency of accessing multiplication facts in each format and 2) the connection between formats within the complex arithmetic memory network. Methods. Simple multiplication problems were presented visually one operand at a time without symbols. ERPs were time-locked to solution onset; participants made a delayed correctness judgment on the solutions, which were correct or incorrect. Numbers were presented as digits or lower-case number words. Each problem was presented in a single format (e.g., Digit to Digit, 2 3 6; English to English, two three six) and mixed format (e.g., Digit to English, 2 3 six; English to Digit, two three 6). In Experiment 1, the stimuli from Salillas and Wicha (2012) were used, including Spanish word trials as a control. In Experiment 2 the Spanish word trials were removed. 24 English monolinguals participated in each experiment (17 participated in both). Results. The pattern of effects was consistent across experiments. As reported by Salillas and Wicha (2012), the N400 congruency effect (difference ERP for incongruent minus congruent trials; Niedeggen, Rosler, & Jost, 1999) peaked ~35 milliseconds earlier for digits than words. In addition, the amplitude of the N400 was modulated by format and congruency in an additive manner, with incongruent and word solutions eliciting larger negativity than congruent and digit solutions, respectively. Switching between formats (mixed format) affected processing only for incongruent, but not congruent trials. Conclusion. Replication of the latency delay for words versus digits in this monolingual population eliminates slower bilingual language processing as an explanation, and implies instead an intrinsic processing difference between digits and written number words. Yet, the slower latency and larger amplitude for words than digits imply quantitative, not qualitative, processing differences between formats. Finally, the format switching cost, which occurred only in incongruent trials, implies that 1) arithmetic fact retrieval can occur in a format independent manner, and 2) the underlying processes for judging the correctness of congruent and incongruent trials appear to be qualitatively different. The implications of these findings for models of lexical access and arithmetic-fact retrieval will be discussed.

C40 Differential time-course for prediction and integration during sentence comprehension

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Previous studies have suggested that readers use language context to pre-activate upcoming words in a text (Delong et al., 2005). In this experiment, we wished to investigate facilitation due to lexical prediction and its relationship to discourse-level integration processes. Specifically, we combined ERP recording with a novel behavioral technique to dissociate these factors and assess their unique contribution to the timing and amplitude of the N400 component. In this study, participants (N=24) read short passages in which the final word was either moderately predictable (50% cloze probability) or unpredictable. After each trial, participants indicated with a button press whether they had correctly predicted this final word. We then used these behavioral responses to separately average ERPs for predicted and unpredicted completions. Using this technique, we observed an increased frontal positivity for incorrect predictions that was largely independent of sentence context. This result provides additional evidence that this frontal component indexes the costs of disconfirmed prediction. In addition to this frontal effect, we also observed two temporally distinct sub-components of the N400: an early prediction effect beginning 200ms post-stimulus and a later negativity that correlated significantly with 1) sentence plausibility and 2) the word's semantic relatedness to an alternative completion. The difference in onset latency between these effects suggests that correct lexical predictions can facilitate very early stages of lexical access, while other factors such as semantic feature overlap and discourse coherence primarily impact reading at a later processing stage.

C41 Repetition of form and meaning in sentence contexts: An ERP study of repetition priming using ambiguous words

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Introduction: The repetition of word forms results in repetition priming, the processing benefit on the second (or subsequent) presentation of a word relative to the first. Behaviorally, repetition priming might be expressed in reduced reaction times and/or increased accuracy. Electrophysiologically, repetition priming results in a reduction of the amplitude of the N400 component, both in lists and in sentence or discourse contexts. This outcome presents an important question: can the repetition priming benefits observed within meaningful contexts be attributed to the repetition of the word form, meaning, or both? We examined lexical repetition priming in prime and target sentence contexts that biased the same or different meanings of ambiguous words to determine the extent to which repetition priming depends on the repetition of lexical form versus lexical semantics, and to look at interactions between repetition priming and sentence context. Method: ERPs were recorded as participants read two sentences on 160 trials (followed by a true/false comprehension question referring to one of the sentences). The prime sentence was one of four types: repetition of meaning and form (see Ex. 1a); repetition of form only (i.e., contained the ambiguous word, but the sentence context biased a different meaning; Ex. 1b); repetition of meaning only (i.e., contained a synonym of the ambiguous

word; Ex. 1c); or unrelated (Ex. 1d). The target sentence (Ex. 1e.) was the same across prime conditions; the critical word was the final word of the sentence, and was always an ambiguous word. The target sentence context biased either the dominant or the subordinate meaning of the ambiguous word. Results: The largest N400 priming effects (relative to the unrelated condition) were observed in the repetition of form and meaning condition. The repetition of lexical form (but not meaning) also resulted in reductions in the amplitude of the N400; these reductions (i.e., priming effects) were larger than those observed in the repetition of meaning only condition. Repetition modulations were also observed on the slow negative wave (associated with working memory). Finally, differences were observed to dominant and subordinate targets, with generally larger repetition effects observed to targets that appeared in sentences that biased the subordinate meaning of the word. Conclusion: The repetition effects observed to ambiguous words are modulated by the sentence context in which they appear. Ambiguous words receive the largest repetition benefit when both their form and their meaning are repeated. Lexical form may provide a larger contribution to repetition priming effects than lexical meaning. Example 1: Primes: a. Jan could just feel all the tangles in her hair, so she ran it through with a brush. b. The wildfire spread quickly, fueled by dead leaves that accumulated under the brush. c. Jan could just feel all the tangles in her hair, so she ran it through with a comb. d. For breakfast Wade tried to make his mother pancakes but failed miserably. Target: e. The dog's coat was terribly matted, so the groomer pulled out his best brush.

C42 Semantic priming in temporal lobe epilepsy: an ERP study. *Amanda Guadalupe Jaimes Bautista[1,2], Mario A. Rodríguez Camacho[2], Yaneth Rodríguez Agudelo[1], Iris Martínez Juárez[1], Rubén Torres Agustín[1,2]; [1]Instituto Nacional de Neurología y Neurocirugía de México, [2]Universidad Nacional Autónoma de México*

The access and retrieval of semantic memory is influenced by mechanisms of automatic activation and controlled attention. Research has shown that the semantic priming effect obtained by lexical decision tasks (LDT) include an automatic mechanism fast-acting, driven only by semantic/associative relationships and a strategic mechanism that reflects the subject awareness over contextual factors extending beyond the relationship between the prime and the target. The automatic mechanisms occurs with stimulus onset asincrony (SOA), shorter than 300 ms, and with a low relatedness proportion, whereas the controlled mechanisms occurs with long SOA and when the relatedness proportion is high. The memory and language dysfunction had been widely researched in temporal lobe epilepsy (TLE); however the contribution of the automatic processing and the controlled attention to semantic memory dysfunction has not been determined. Two semantic priming tasks, designed to isolate automatic and controlled mechanisms, were utilized to investigate the contribution of each mechanism to semantic memory dysfunction in TLE. Ten patients with TLE recluted from the National Institute of Neurology and Neurosurgery of Mexico and ten age-matched controls participated in the study performing a visual LDT, in which semantic relationship (related and unrelated pairs of words), stimulus onset asynchrony (250 and 700 msec) and expectancy (low and high relatedness proportion) were varied. The TLE group in the priming controlled condition, showed a N400 effect indicating normal semantic priming. But in the automatic condition the difference in amplitude between the related and unrelated words pairs was not found. The control group demonstrated both intact automatic and controlled semantic priming. These results further clarify the impact of TLE on semantic memory, suggesting that automatic lexical processing is reduced in TLE. These findings can be explained taking in to account the role of the posterior temporal cortex in storing lexical representations.

C43 White matter disease correlates with lexical retrieval deficits in primary progressive aphasia *John P. Powers[1], Corey T. McMillan[1], Caroline C. Brun[1], Paul A. Yushkevich[1], James C. Gee[1], Murray Grossman[1]; [1]University of Pennsylvania*

Primary progressive aphasia (PPA) is a clinical syndrome characterized by progressive loss of language most commonly due to Alzheimer's disease or frontotemporal lobar degeneration. The semantic and logopenic variants of primary progressive aphasia (svPPA; lvPPA) are both associated with lexico-semantic impairments. The underlying pathologies of these PPA variants can impact white matter (WM) in addition to gray matter. We examined fractional anisotropy (FA) changes associated with svPPA and lvPPA and related these to measures of lexical retrieval. We collected neuropsychological testing, volumetric MRI, and diffusion-weighted imaging on svPPA (N=11) and lvPPA (N=13) patients diagnosed using published criteria. We also acquired neuroimaging data on a group of demographically-comparable healthy seniors (N=34). FA was calculated and analyzed using a WM tract-specific analysis approach. This approach utilizes anatomically-guided data reduction to increase sensitivity and localizes results within canonically-defined tracts. We used non-parametric, cluster-based statistical analysis to relate language performance to FA and determine regions of reduced FA in patients relative to healthy seniors. We found widespread FA reductions in WM for both variants of PPA. FA was related to confrontation naming performance in bilateral uncinate fasciculus and corpus callosum in svPPA and left inferior fronto-occipital, superior longitudinal, and inferior longitudinal fasciculi in lvPPA. Additionally, category naming fluency was related to left uncinate fasciculus and corpus callosum in svPPA and corpus callosum, left inferior and superior longitudinal fasciculi, and right corona radiata in lvPPA. We conclude that svPPA and lvPPA are associated with disruptions of a large-scale network implicated in lexical retrieval.

Specifically, white matter disease in a ventral network mediating connectivity between various frontal and temporal regions may contribute to language impairments including lexical retrieval in svPPA and lvPPA.

C44 White matter structural connectivity underlying semantic processing: Evidence from brain damaged patients *Zaizhu Han[1], Yujun Ma[1], Gaolang Gong[1], Yong He[1], Alfonso Caramazza[2,3], Yanchao Bi[1]; [1]Beijng Normal University, China, [2]Harvard University, [3]University of Trento, Italy*

Widely distributed brain regions in temporal, parietal and frontal cortex have been found to be involved in semantic processing, but the anatomical connections supporting the semantic system are not well understood. In a group of 76 right-handed brain-damaged patients, we tested the relationship between the integrity of major white matter tracts and the presence of semantic deficits. The integrity of white matter tracts was measured by percentage of lesion voxels obtained in structural imaging and mean fractional anisotropy values obtained in diffusion tensor imaging. Semantic deficits were assessed by jointly considering the performance on three semantic tasks that vary in the modalities of input (visual and auditory stimuli) and output (oral naming and associative judgement). We found that the lesion volume and fractional anisotropy value of the left inferior fronto-occipital fasciculus, left anterior thalamic radiation, and left uncinate fasciculus significantly correlated with severity of impairment in all three semantic tasks. These associations remained significant even when we controlled for a wide range of potential confounding variables, including overall cognitive state, whole lesion volume, or type of brain damage. The effects of these three white matter tracts could not be explained by potential involvement of relevant grey matter, and were (relatively) specific to object semantic processing, as no correlation with performance on non-object semantic control tasks (oral repetition and number processing tasks) was observed. These results underscore the causal role of left inferior fronto-occipital fasciculus, left anterior thalamic radiation, and left uncinate fasciculus in semantic processing, providing direct evidence for (part of) the anatomical skeleton of the semantic network.

C45 The degree of imageability of abstract nouns and verbs influences processing in Alzheimer's disease and healthy aging *Jet M. J. Vonk[1,2], Roel Jonkers[1], Loraine K. Obler[2]; [1]University of Groningen, [2]The Graduate School and University Center of the City University of New York*

Concrete and abstract words have a different semantic nature, which plays a role in language processing. A concreteness effect has frequently been demonstrated in both neurologically unimpaired individuals and patients with Alzheimer's disease (AD) whereby concrete (i.e., high imageable) words are easier to process than abstract (i.e., low imageable) ones (e.g., James, 1975). However, the division within imageability is generally restricted to high versus low in studies with either healthy subjects or patients with AD. We argue that within abstract words a continuum of imageability can be distinguished and predicted that the degree of imageability of a word would influence its processing in both healthy and AD populations. We tested 13 Dutch-speaking individuals with AD and 16 matched healthy elderly individuals on a semantic similarity judgment task including different noun and verb subcategories, measuring both accuracy and response time. Imageability ratings were derived from Van Loon-Vervoorn's (1985) norms for the Dutch language with imageability ratings on a 7-point scale. The subcategories of abstract nouns and abstract verbs contained very low imageable words (imageability rating 1-3), low imageable words (imageability rating 3-4) and moderately imageable words (imageability rating 4-5). The concrete nouns and verbs tested had an imageability rating higher than 5. All word subcategories were controlled for frequency and word length. In addition to the expected concreteness effect, a Repeated Measures ANOVA showed significant differences among the different imageability categories for both nouns and verbs. In both the AD and control groups there was a significant gradual increase in accuracy and decline in response time scores for abstract noun and abstract verb categories with the very low imageable nouns processed the least accurately and slowest and the moderately imageable words the most accurately and quickest. Regarding grammatical classes, we found no significant difference in accuracy and response time between abstract nouns and abstract verbs, for either the control group or the AD group. However, the control group did show a significant difference in accuracy and response time on concrete words such that performance on concrete nouns was better than that on concrete verbs. In sum, it appears that the degree of imageability of abstract words has a significant effect on the processing abilities of both healthy and neurologically impaired individuals. When imageability has previously been shown to influence lexical processing, only coarse differences in imageability were tested; this study shows that it is important to recognize a gradient in imageability. Whereas, for both healthy older adults and individuals with AD, the results showed no accuracy or response-time difference between abstract nouns and abstract verbs, a dissociation between concrete nouns and concrete verbs was seen in controls, but not in patients with AD. Thus caution is needed when comparing nouns and verbs without any subcategorization according to degree of imageability. References: James, C.T. (1975). The role of semantic information in lexical decisions. Journal of Experimental Psychology: Human Perception and Performance, 104, 130–136. Van Loon-Vervoorn, W.A. (1985). Voorstelbaarheidswaarden van Nederlandse Woorden (Imageability Ratings of Dutch Words). Lisse: Swets & Zeitlinger.

C46 Damage to gray and white matter is associated with distinct semantic interference effects in language production and comprehension. *Denise Y. Harvey[1], A. Cris Hamilton[1], Tatiana T. Schnur[1]; [1]Rice University*

Naming pictures or matching words to pictures belonging to the same semantic category negatively affects language production and comprehension performance (semantic interference). By most accounts, semantic interference arises at a lexical level in naming (e.g., Damian et al., 2001) and a semantic level in comprehension (e.g., Campanella & Shallice, 2011). However, damage to the left inferior frontal gyrus (LIFG), a region implicated in resolving interference (Novick et al., 2010), results in exaggerated semantic interference in both language modalities (Jefferies et al., 2007), suggesting that the LIFG supports cognitive control over lexical and semantic representations presumably processed in the temporal lobe (TL) via white matter connections. To investigate which gray matter structures and white matter connections when damaged result in exaggerated semantic interference, we compared production and comprehension performance in the same individuals with language impairments (aphasia) as a result of left hemisphere stroke. We collected behavioral and neuroimaging data from 12 chronic aphasic speakers. Behavioral indices of semantic interference included: (1) a semantic context effect (individual t values of % error in semantically related vs. unrelated conditions) hypothesized to occur at a semantic (comprehension) and/or lexical (production) level, and (2) a semantic growth effect (individual t values reflecting a linear increase in the semantic context effect across item repetitions) hypothesized to reflect increased control demands. We used voxel-based lesion-symptom mapping (VLSM) to identify voxels that when damaged (false discovery rate: q = .05) result in exaggerated semantic interference (higher t values), and diffusion tensor imaging (DTI) to investigate whether reduced white matter integrity (lower fractional anisotropy (FA) values) relates to patients' performance. We examined three white matter pathways connecting the fronto-temporal cortices: the inferior longitudinal fasciculus (ILF), connecting the posterior with anterior TL, the inferior fronto-occipital fasciculus (IFOF), connecting the posterior TL with the LIFG, and the uncinate fasciculus (UF), connecting the anterior TL with the LIFG. The VLSM analyses revealed that posterior TL damage was associated with exaggerated semantic context effects in naming ($t > 3.07$), whereas more anterior TL damage was associated with exaggerated semantic context effects in comprehension ($t > 3.68$). The VLSM did not identify the LIFG, but a comparison of those with and without LIFG lesions revealed larger semantic growth effects for language production ($t(10) = 3.01$, $p = .013$), but not comprehension ($t(10) = 1.01$, $p = .33$). Critically, IFOF integrity predicted semantic context effects in naming ($r = -.66$, $p = .035$), but not comprehension ($r = -.39$, $p = .25$). However, UF ($r's < .26$, $p's > .48$) and ILF ($r's < -.53$, $p's > .05$) FA values did not predict semantic context effects in either task. Together, these findings highlight the separable components of the language system that when damaged result in semantic interference. The VLSM results support the assumption that semantic interference arises at different levels in naming and comprehension. That LIFG damage and IFOF integrity related to naming but not comprehension performance suggests that different mechanisms may subserve the resolution of semantic interference in each language modality.

C47 Effects of Contextual Priming on Novel Word Learning in Healthy Adults *Amy Rodriguez[1], Emma Finch[1], Anna MacDonald[1], David Copland[1]; [1]The University of Queensland*

Introduction: Priming has been shown to influence word retrieval, with the nature of that influence (i.e., facilitation or interference) depending on the task, the type of prime, and the timing and mode of presentation (Martin et al., 2004). Contextual priming, or massed repetition of related or unrelated stimuli, has demonstrated inhibitory effects on learning novel words for familiar objects in healthy adults (Finkbeiner & Nicol, 2003). However, the effect of contextual priming on word learning that requires instantiation of new phonological representations as well as new semantic representations is unknown. In this study we investigated the effect of contextual priming on learning nonword names for unfamiliar tools and animals. Methods: 71 healthy adults (4 males, 67 females), aged 18-40 years, participated in the study. The experiment comprised a learning phase followed by a recall phase. Participants were assigned to one of four conditions that differed on prime/target congruency and semantic category (Related: ANIMAL-ANIMAL or TOOL-TOOL; Unrelated: ANIMAL-TOOL, TOOL-ANIMAL). In the learning phase, the participant viewed seven familiar animals or tools followed by seven unfamiliar animals or tools that were paired with a nonword (i.e., target name). In the recall phase, the seven unfamiliar stimuli were randomly presented and participants were instructed to type the corresponding target names. The learning and recall phases were repeated over five cycles. Results: A mixed linear model was utilized with accuracy as the dependent variable and participant as a random factor. Fixed factors included recall cycle (one to five), congruency (prime/target related, prime/target unrelated), and category (animal, tool). Results revealed a significant main effect of recall cycle (p less than .001), demonstrating increased naming accuracy across the five cycles. No significant main effects were noted for congruency ($p = .517$) or category ($p = .764$); however, there was a significant recall cycle X congruency X category interaction, ($p = 0.018$). Further analysis revealed a significant interaction for tools ($p = 0.043$) but not for animals ($p = .849$). Conclusion: We demonstrated that contextual priming can influence word learning that requires instantiation of novel phonological and semantic representations. Interestingly, however, this effect was only

evident for tools (not animals) in the congruent prime/target condition over learning cycles. Our results may be attributed to differences in the visual structure of living vs. non-living things (Gaffan & Heywood, 1993; Laws and Gale, 2002) or to differences in the sensory-motor representations of animals and tools (Martin & Chao, 2001). These findings have implications for theories of new word learning in healthy adults and may also have implications for re-learning of words in individuals with post-stroke aphasia.

Syntax, Morphology

C48 Individual differences in discrimination of musical rhythms relate to expressive language skills in children

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Background: Children with specific language impairment (SLI) have been reported to show a number of difficulties with linguistic and musical rhythm, such as using speech rhythm cues to disambiguate syntax and tapping to the beat in music. Dynamic attending theory postulates that when a person listens to rhythmically organized stimuli such as music or speech, brain rhythms synchronize with auditory input and generate temporal expectancies for future events by directing attention to specific points in time. These rhythmic fluctuations in temporal attention may create scaffolding for the acquisition of important speech features such as morphemes and for the development of appropriate phonological representations. Therefore, language deficits in SLI may be related to inefficient or faulty dynamic attending mechanisms. This project tests the link between rhythmic processing and language skills in children with typical language development (TLD), in order to establish a framework for studying dynamic attending in typical and atypical language acquisition. Methods: Twenty-five six-year-olds with TLD participated in this study. Participants' morpho-syntactic production was assessed with the Structured Photographic Expressive Language Test-3 (SPELT-3), and their phonological awareness was measured with the Comprehensive Test of Phonological Processing (CTOPP). Rhythm perception was assessed using the Primary Measures of Music Audiation (PMMA) rhythm aptitude measure and a same-different rhythm discrimination task modified for use with young children. Non-verbal IQ was measured with the Primary Test of Nonverbal Intelligence (PTONI). Correlations were tested between the scores on the linguistic and musical measures, using non-verbal IQ as a control variable. Independent t-tests were used in the median split analysis to compare rhythm perception in high versus low scorers on the CTOPP. Results: Morpho-syntactic levels (SPELT-3) were significantly correlated with both simple ($r = .64$, $p<.01$) and complex (.54, $p<.01$) rhythm items of the rhythm discrimination test, and also with rhythm aptitude levels from the PMMA (.51; $p<.01$); the correlations remained significant when controlling for non-verbal IQ (PTONI). In addition, a median split analysis also revealed that children who scored high on the phonological awareness composite from the CTOPP also performed better on discriminating complex rhythmic sequences ($p<0.05$). Summary/Conclusion: This study is the first to our knowledge to demonstrate a strong association between (musical) rhythm perception and (linguistic) syntactic production in children with typical language development, coinciding with the literature showing shared neuro-cognitive resources for processing speech and music in children. The present findings suggest that domain-general dynamic attending mechanisms may play a role in enabling acquisition of morpho-syntactic structures and phonological awareness, as predicted by other studies showing that temporally predictable speech facilitates syntactic processing in adults. We are currently exploring this hypothesis further by studying the behavioral data in relation to EEG data collected during listening to rhythmic tone sequences in the TLD group, and also testing children with SLI in the same behavioral and brain paradigms.

C49 Actor-Undergoer Asymmetry in Learning Case Marking Strategies

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The human brain is highly attuned to entities that cause events. In visual perception, it rapidly identifies potential "agents" (or "actors") via cues such as biological motion (e.g. [1]). Similar principles hold for language processing: electrophysiological studies from various languages suggest that the parser attempts to identify actors quickly and unambiguously [2]. Thus, there is a general asymmetry – in language and beyond – with regard to the perception of (potential) event causers (actors) as opposed to entities affected by actions (undergoers). The importance of actors is even manifest in grammars, with case-marking in some languages serves to identify prototypical (e.g. animate) actors, while other case systems mark undergoers when they would make for good actors (e.g. when they are animate) to distinguish them from actors. In view of these widespread actor-undergoer asymmetries, we hypothesized that they should also be observable in second language learning. To test this, we trained German students (n = 21) to learn an artificial language (ALg) with actor and undergoer case-marking based on animacy. The ALg had an NP1-NP2-verb (actor-initial or undergoer-initial) order. Animate actors (identification) and animate undergoers (distinguishability) were case-marked. After initial vocabulary training, in which participants learned to match nouns to pictures of animate and inanimate entities,

sentence-learning commenced. This phase comprised two sessions (within 3 days), in which participants first viewed (grammatical) sentence-picture combinations and, in a second block, made grammaticality judgments for novel grammatical and ungrammatical (case violation) sentences (without pictures) while their EEG was recorded. Case violations engendered an N400-Late Positivity (LPS) pattern [cf. 3], which was modulated by animacy and argument role. At NP1, actor versus undergoer case violations showed a larger LPS. For NP2, we examined sentences with case-marked NP1 such that the role of NP2 was unambiguously specified in the sentence context. Here, N400 effects were only observable for superfluous case marking (i.e. for marked inanimates), but not for missing case marking (i.e. for unmarked animates). A late positivity was only observed for actor case violations, with a larger effect for erroneously marked inanimate actors than for unmarked animate actors. Our findings support an interpretation of the N400 in terms of a top-down/bottom-up information mismatch [4]: when argument role is unambiguously specified by the context and no conflicting (bottom-up) case-marking information is encountered, no increased N400 effect ensues. The LPS, we interpret as an instance of a P3, reflecting the subjective significance of behaviorally relevant events [5]: results suggest that this significance is higher for actor as opposed to undergoer case violations. The consistent ERP differences between actor and undergoer marking observed in this learning paradigm thus lend further support to the notion of a general actor-undergoer asymmetry. References [1] Frith, U, & Frith, CD (2010). Phil Trans R Soc B, 365, 165-176. 176. [2] Bornkessel-Schlesewsky, I & Schlesewsky, M (2009). Lang Ling Compass, 3, 19-58. [3] Frisch, S & Schlesewsky, M (2001). NeuroReport, 12, 3391-3394. [4] Lotze, N et al. (2011). Neuropsychologia, 49, 3573-3582. [5] Nieuwenhuis et al. (2005). Psych Bulletin, 131, 510-532.

C50 Matching utterances with visual scenes: neurocomputational investigation of the language-vision interface

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Humans can do a great amount of things with their languages. But among these, talking about the world one perceives, describing in a compact way what has caught one's attention and conversely matching descriptions with a visual scene are key both from an evolutionary and developmental perspective. We present a new model of situated comprehension that establishes a bridge between the dynamical incremental processing approaches of neural net models (e.g., CIANet, Mayberry et al 2009) and the cognitive analyses of the relations between linguistic knowledge and sensory-motor systems (e.g., ECG, Feldman & Narayanan 2004), while adding the architectural constraints necessary to simulate the functional consequences of brain lesions. Specifically, based on a conceptual analysis by Barrès and Lee (2013), we present an implemented schema-level neurocomputational model of language comprehension during sentence-picture matching tasks in both normal subjects and agrammatic patients that rests on three key elements. (1) Construction grammar and visually anchored semantics. The model uses the formalism of Template Construction Grammar, a visually grounded construction grammar that bridges between schema theory and linguistic theory (Arbib & Lee 2008). Semantic structures extracted from or matched against the cognitive representation of visual scenes are represented as SemReps, a graph structure that incorporate conceptual elements (nodes), their thematic or spatial relations (edges), their relevance (activity levels), and their link to visuo-spatial regions. Grammatical knowledge is modeled as a network of constructions schemas defined as mappings between linguistic forms and SemReps. (2) Neural architecture. Going beyond Arbib & Lee, the two-route functional architecture of the new model reflects neuropsychological data showing that: (a) world knowledge plays a role alongside grammatical knowledge during comprehension and can survive lesion to a "grammatical route" (Caramazza & Zurif 1976) and (b) that world knowledge ("heavy" semantics) should be distinguished from that form of "light" semantics engaged in characterizing the semantico-syntactic categories of slot fillers in constructions (Kemmerer 2000). (3) 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. Sentence-picture matching is therefore simulated in state-space as a temporal trajectory of schemas activity levels. It rests on a dynamic self-organized search for a semantic interpretation of linguistic inputs (received one word at a time) that satisfies both world and grammatical knowledge constraints. The two parallel routes process these constraints separately and cooperate online to build a SemRep. The emerging sentence-based SemRep is dynamically compared to the SemRep representing the output of the visual system to determine whether or not the picture matches the sentence. Within the context of sentence-picture matching tasks, we replicate core patterns of agrammatic comprehension performances. We simulate and quantitatively compare conceptual accounts of agrammatic comprehension such as thematic-role assignment deficits and working memory limitations. We show their limits by outlining the central role that complex temporal interactions between distributed systems play during the comprehension process. Finally, we model comprehension under adverse conditions in normal subjects and analyze its similarity with agrammatics' performances.

C51 The Role of Syntagmatic and Paradigmatic Relations in Noun-Verb Dissociation: an fMRI study

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Nouns-verb dissociation following brain damage has been interpreted as evidence for distinct cortical representation of nouns and verbs: nouns in temporal and temporo-parietal regions and verbs in frontal lobe. But recent aphasiological and neuroimaging studies have failed to support this claim. We hypothesized that this noun-verb dissociation can be explained in terms of the paradigmatic/syntagmatic relations. Traditionally, in order to assess word-class deficit neuropsychologists use picture naming test with different sets of images: single object pictures for nouns and complex action pictures for verbs. In the first case the participant has to rely on paradigmatic relations (differentiation) and in the second case – on syntagmatic relations (syntactic context) for word retrieval. As we know, syntagmatic relations suffer after frontal lobe damage and paradigmatic - after temporal lobe damage. Thus, in the current study we investigate whether different world retrieval strategies (paradigmatic vs. syntagmatic) rather than world class per se (nouns vs. verbs) contribute to noun-verb dissociation. Participants: 22 healthy right-handed native Russian speakers (15 females; mean age 23 years) completed two runs of task. Method: Both structural T1-weighted and functional T2*-weighted volumes (EPI sequence parameters: TR/TE/FA – 2520 ms / 50 ms / 90°; 36 slices oriented parallel to AC/PC plane, slice interval 0.75 mm; voxel size 3.6x3.6x3.8 mm) were obtained using Siemens 1.5 T Magnetom Avanto scanner, 225 volumes per run were acquired. Each run lasted about 9 minutes and included 20 blocks of activation task alternating with 5 blocks of baseline. Activation task: To investigate noun-verb dissociation we conducted a 2x2 factorial block design experiment with four conditions, created by manipulating grammatical category (Nouns/Verbs) and retrieval strategies (Syntagmatic/Paradigmatic relations). The task was to complete overtly two words (presented in print on the screen for 4 sec) with a semantically appropriate word. The type of word presented depended on retrieval strategies to be implicitly used: (1) retrieval using syntagmatic relations - sentence completion ("Girl eats …"/"Girl … apple"); (2) retrieval using paradigmatic relations - completion of series of two words via association ("apple, pear, …"/"to go, to run, …"). Participants were requested to press a button after retrieval of an appropriate word. As a baseline we used series of crosses. Imaging data was processed using SPM8 and Marsbar for ROI analysis (pars triangularis and pars opercularis of inferior frontal gyrus (IFG), superior temporal gyrus (STG), temporo-parietal region). Results: According to the response time data retrieving verbs using paradigmatic relations is more difficult than using syntagmatic ones. There are no significant differences in the response time for nouns retrieval. The factor "Syntagmatic/Paradigmatic relations" influenced percent of BOLD signal change in: pars opercularis of IFG $F(1, 21)=5.19$, $p=0.033$, STG $F(1, 21)=5.19$, $p=0.033$ (more for syntagmatic processing) and temporo-parietal region $F(1, 21)=4.75$, $p=0.04$ (more for paradigmatic processing). The grammatical category influence was found only in pars triangularis IFG $F(1, 21)=28.9$, $p<0.001$, it's more active for noun retrieval and independent of the type of relations. Summary: The hypothesis about the crucial role of paradigmatic/syntagmatic relations in dissociation of noun-verb retrieval was partially confirmed.

C52 Patients with Lesions in Broca's Area can Produce Syntactically-Complex Sentences

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Historically, patients with lesions in Broca's area have been characterized with "telegraphic" speech output and concomitant deficits in the comprehension of syntactically-complex sentences. Later research has shown that a much larger lesion is required to produce this disorder -- neighbouring parts of the frontal and superior temporal lobes, as well as underlying structures and white matter -- and that Broca's area need not necessarily be involved. To further examine the syntactic output potential of patients with lesions to Broca's area, we examined the oral productive speech in patients who, despite a lesion in Broca's area, were able to produce complex syntactic structures in their oral speech. We questioned the extent to which these patients could produce these structures and what types of constructions they were able to use. Video recordings of seven aphasic participants with lesions involving Broca's area but whose speech could not be described as telegraphic were analysed. All had suffered aphasia due to a single left hemisphere stroke and all were English-native speakers. All were assessed with the Western Aphasia Battery including the description of a picnic scene picture, and had at least 10 minutes of additional recorded conversational speech. We also elicited narrative speech using the sixteen-page wordless book, Frog where are you? by Mercer Mayer by having participants describe the book's storyline. A linguistic inventory of the grammatically-correct sentences they produced was then compiled, allowing for a closer examination of the types of clauses produced. For each utterance, we considered every clause that expressed a single action. Phrases that included an infinitive, participle, or modal verb were considered as eligible sentences as well as those with a double verb but single subject. Narrative expressions ("Once upon a time") were considered to be attached to the main clause. Subordinate clauses were of particular interest due to the complexity of their construction. Results showed that a lesion in Broca's area may not necessarily affect the formulation of sophisticated grammatical structures. All of the patients were able to produce proper verb phrase (VP) clauses either with finite verbs, auxiliaries or modals (e.g., "The dog, he looks he might get hit."). The use of the -ing form was preserved

in all subjects (e.g., "The frog is getting out of the jar"). Of note, were subjects who could produce sentences with complex clauses such as "The gopher is wondering why they are looking.", or "And the boy, he is picking up the dog because he broke the jar, and he looks kinda mad, but the dog is kissing him". In sum, the ability to use complex structures in English can be spared in patients with a lesion in Broca's area. This confirms earlier findings, but also provides a linguistic inventory of the types of clauses that can be produced. Given the complexity of the clauses, despite the lesion in Broca's area, we can assume that the production of these clauses is not dependent solely on this region.

C53 Introducing grammar tests to the intracarotid amobarbital procedure

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Introduction: Grammar lies at the heart of the language system, yet it receives little or no testing during the intracarotid amobarbital (Wada) procedure. Grammar has been shown to engage the left hemisphere (LH), particularly the inferior frontal and posterior middle temporal cortex (Griffiths et al. 2013, Justus et al. 2011). However, between 20-33% of patients with temporal lobe epilepsy have right hemisphere (RH) or bilateral language representation (Gaillard et al. 2007). It is hypothesized that adding grammar tests to the standard Wada language tests may increase the overall sensitivity of language testing, including for RH contribution to linguistic processing. Method: Fourteen individuals (five females) with temporal lobe epilepsy participated in the study. The mean age of the participants was 41.2(SD=10.51) years. Thirteen subjects were right-handed, one was left-handed. One patient had a bilateral ictal zone, five had seizures originating in RH, and seven in LH. The average age of epilepsy onset was 24.5(SD=11.72) years and the mean duration was 11.9(SD=7.44) years. All the participants underwent the Wada test during which standard language tests (naming, repetition, simple comprehension) were administered along with a new test of grammar, the CYCLE-N concentrating on investigating syntax and morphological inflection. The grammar stimuli contained comprehension and production items, presented in random order. Each item included a pair of drawings with simultaneous verbal cues. The CYCLE-N was conducted after the standard memory protocol and it was followed by the standard tests. There were nine RH injections and 13 LH injections. We compared our subjects' performance on the standard test and the CYCLE-N for each hemisphere using nonparametric Wilcoxon tests. Results: Scores for comprehension were significantly higher on the standard tests compared to the CYCLE-N. The difference between standard and the CYCLE-N performance was significantly different from zero, both when LH and RH were analyzed together (difference score median (DSC)=0.25, p=0001), as well as separately for (LH: DSC=0.23, p=0.02; RH: DSC: 0.25 p=0.008). The standard and grammar scores did not differ significantly for production. Examining the comprehension and production scores for the standard and grammar tests taken together for each hemisphere, the comprehension scores were not significantly different between LH and RH. In contrast, the standard test production scores were higher after RH injection (median=0.85) compared to LH injection (median=0.48, p=.04). Grammar production scores were also higher after RH (median=0.83) injection compared to LH injection (median=0.33) but not statistically significantly so (p=.1). Conclusion: If grammar solely followed language dominance then we would expect that individuals would perform the same for grammar as standard tests during the RH injection, as the majority of individuals have left hemisphere dominance for basic language. This, however, was not the case, because grammar seemed to be affected after injection in each hemisphere. This result indicates that the CYCLE-N was more challenging and may be a more refined measure of linguistic performance, regardless of hemisphere. The findings indicate that grammar may be more widely distributed in the brain in the epileptic population and not follow the standard model of language dominance.

Control, Selection, Working Memory

C54 Response time and language cortex response in a one-back memory task for words depends on trial history further back

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INTRODUCTION: Cognition is perhaps best understood as a self-organizing dynamic system with long-term contextual dependencies. In this experiment we investigate the contextual effects on a simple one-back word memory task. We hypothesized that new words would be more demanding that repeat words, but we also hypothesized that there would be an effect of trial history. We therefore looked for lingering effects of the previous two stimuli at trial T. This resulted in a 2x2x2 ANOVA model with effects of New/Repeat words at trials T, T-1 and T-2. STIMULI AND PROCEDURE: Stimuli consisted of 250 concrete nouns. The experiment was a one-back word comprehension task with 400 trials consisting of concrete nouns (200 read, 200 heard). Participants responded as fast as possible (using right index/middle finger) to whether the current word was the same as the previous, regardless of perceptual modality. 250/150 trials were new/repeat words. Stimulus onset asynchrony was 2500-5000 ms, order of words and modality of presentation was randomized. PARTICIPANTS: 59 healthy, young, Danish speaking volunteers took part in the experiment (1 excluded for technical reasons). fMRI ACQUISITION AND ANALYSIS: A 3T Siemens Trio system (12 channel head coil) was used

to acquire both BOLD-EPI and structural images. 610 EPI volumes were acquired (40 slices, 3x3x3 mm voxels, TR 1990 ms). Data were preprocessed and analyzed using SPM8. RFX group analysis was thresholded at P<0.05, FWE-corrected (except T-2, which was FDR-corrected). BEHAVIORAL RESULTS: A repeated-measures ANOVA revealed a main response time effect of New/Repeat words at trial T ($F(1,57)=888.88$, $P<0.0001$), a main effect of New/Repeat at trial T-1 ($F(1,57)=240.85$, $P<0.0001$) and a main effect of New/Repeat at trial T-2 ($F(1,57)=14.97$, $P<0.0001$). We also found an interaction between trial T and T-1 ($F(1,57)=27.37$, $P<0.0001$) and an interaction between T-1 and T-2 ($F/1,57)=82.02$, $P<0.00001$). See figure 1. fMRI RESULTS: We found a main effect of New>Repeat words at trial T in both left inf. front. gyrus (BA44 – figure 2a) and left sup. temp. sulcus (figure 2c. We also found a main effect of New>Repeat at trial T-1 at the border between the left inf. front. gyrus (BA47) and insula (figure 2b) as well as in the sup. temp. gyrus (figure 2d). In the posterior region we also found a main effect of Rep>New at trial T-2 (figure 2d). We also found a number of interactions. DISCUSSION: These results constitute strong behavioral evidence for trial history playing an important role even in the processing of this simple short-term word memory task. A "new" response costs approximately 90 ms compared to a "same" response. But it also costs 70 ms on the next trial, regardless of whether this trial is a new or same trial, and there is even an additional cost two trials later (approx. 10 ms). Broca's region (BA 44/45) and primary auditory regions seem to be less susceptible to trial history whereas insula/BA47 and posterior temporal regions display a greater trial history sensitivity. This may be an important key to understanding the functional differences between these brain regions.

C55 If so many are "few", how few are "many"? *Stefan Heim[1,2,3], Corey T. McMillan[4], Robin Clark[4], Stephanie Golob[4], Nam Eun Min[4], Christopher Olm[4], John Powers[4], Murray Grossman[4]; [1]RWTH Aachen University, Germany, [2]Research Centre Juelich, Germany, [3]JARA - Translational Brain Medicine, Juelich and Aachen, Germany, [4]University of Pennsylvania, US*

The processing of quantifiers involves a numerical component. Moreover, relational quantifiers like "many" or "few" may involve additional cognitive resources since the truth value of these quantifiers depends in part on a reference. In order to decide that "many" circles are yellow in a pictorial display one has to assess the number of all circles and that of the subset of yellow circles, identify the internal criterion for "many", and evaluate the subset of yellow circles relative to the entire number of circles according to the subjective criterion of what constitutes "many" (e.g. > 50% of all circles). Recent neuroimaging findings (McMillan etal. 2013; Heim etal. 2012) indicate that such decisions involve a fronto-parietal network. Moreover, there seems to be a distinction between the function of parietal regions for numerical estimation and that of the frontal cortex in the processing of the meaning of a quantifier which may involve working memory and other components that contribute strategically to disambiguating the quantifier. Here, we present a novel paradigm focusing on the frontal component of the quantifier neuroanatomic network. Specifically, we investigate the role of frontal cortex in support of the meaning of a relational quantifier as it changes during learning a new value of "many." In the present study, healthy young adults performed a truth value judgment task on pictorial arrays of varying amounts of blue and yellow circles, deciding whether the sentence "Many/few of the circles are yellow" is an adequate description. There were six blocks. In a first baseline block, each individual's criterion for "many" and "few" was assessed. In block 2, subjects received feedback about their decisions. Contrary to their initial notion, a proportion of 40% yellow circles was reinforced as "many". In block 3, the effect of this training on their judgments of "many" and "few" was assessed. The same logic held for blocks 4-6, but in block 5, the criterion for "few" was changed such that 60% of yellow circles was reinforced. Data from 11 healthy young adults showed that the subjects learned the new criterion for "many" in block 2, and this also affected their criterion for "few" even though the criterion for "few" had not been trained. Likewise, in block 5, they changed their criterion for "few", with a comparable effect on the criterion for "many". These findings demonstrate that the meaning of relational quantifiers like "many and "few" can be altered. Most importantly, altering the criterion for one quantifier (e.g. "many") also affects the reciprocal quantifier (in this case, "few"). A subsequent fMRI experiment examined the neuroanatomic basis for this learning effect in 15 healthy young volunteers. Preliminary findings in one subject indicate the involvement of left frontal but not left parietal areas when shifting the new criterion, thus supporting the hypothesis that frontal regions support cognitive resources contributing to the relational component of quantifier meaning. Thus, the paradigm seems a promising tool to investigate the portions of the fronto-parietal network concerned with the representation of numerical and resource components of quantifier meaning.

C56 Language and Task Switching in the Bilingual Brain: Bilinguals Are Forever in a Stay Trial *Gali H. Weissberger[1], Tamar H. Gollan[2], Mark W. Bondi[2,3], Christina E. Wierenga[2,3]; [1]San Diego State University and University of California, San Diego Joint Doctoral Program in Clinical Psychology, [2]University of California, San Diego, [3]VA San Diego Healthcare System*

OBJECTIVES: Bilinguals outperform monolinguals on executive control tasks including paying smaller switch costs in cued task switching paradigms. A possible mechanism for the bilingual switch advantage is that shared neurocognitive mechanisms may underlie task and language switching. We investigated this hypothesis by comparing neural correlates of task-switching and language-switching in young bilinguals. PARTICIPANTS

AND METHODS: Nineteen (13 females) Spanish-English bilinguals (M age = 20.8; SD = 1.7) performed task-switching and language-switching paradigms while undergoing a functional Magnetic Resonance Imaging (fMRI) hybrid (event-related and blocked) design. Participants covertly named numbers 1-9 in English or Spanish based on a cue (Language-switching) or named the color or shape of a figure based on a cue (Color-Shape switching). Participants were cued to switch on 25% of trials in both tasks. RESULTS: Percent signal change (PSC) of the blood oxygen dependent level (BOLD) response was extracted for three separate trial types within each task: nonswitch trials within single-task blocks (single); nonswitch trials within mixed-task blocks (stay); and switch trials within mixed-task blocks (switch). We compared Language and Color-Shape switching using within-subject voxel-wise t-tests for each of these three trial types. Brain response was greater for Language than Color-Shape for single trials in the right and left thalamus, parahippocampal gyrus, and posterior cingulate gyrus and for switch trials in the thalamus, right caudate, and cingulate gyrus (all corrected ps ≤ .025; volume threshold >1088mm3). In contrast, for stay trials PSC was greater for Color-Shape than Language switching, and this comparison revealed widespread differences in multiple brain regions including frontal, parietal, temporal, occipital, cingulate, insular, and subcortical areas (all ps ≤ .025; volume threshold >1088mm3). CONCLUSIONS: Though there were some unique regions active for language on switch trials, differences between tasks on switch trials were relatively small– a result that is consistent with shared switch mechanisms for task and language control in bilinguals. In contrast, stay trials revealed striking differences between the two tasks, with greater brain activation for stay trials in Color-Shape switching than Language switching. The finding that bilinguals require less widespread recruitment of brain regions on stay trials suggests greater efficiency in bilinguals for maintaining two languages, versus two non-linguistic tasks, available for response. This efficiency of language control might arise from bilinguals' need to constantly control dual language activation during natural language use to avoid mixing languages even when speaking to monolinguals – effectively placing bilinguals in an "endless language stay trial".

C57 Conceptual proposition mechanisms in primary progressive dynamic aphasia with Parkinsonism

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A case of dynamic aphasia (MC) is reported in the context of non-fluent progressive aphasia with Parkinsonism. MC's language profile was characterised by the hallmark propositional language impairment despite well-preserved naming, reading, repetition and comprehension skills. The severity of MC's propositional language deficit was comparable to other dynamic aphasic patients. MC presented with a selection deficit as word and sentence generation performance was severely impaired only when many competing responses were activated by a stimulus. Thus, when a dominant response was available verbal generation was satisfactory. This was documented in both the oral and written output modalities. In addition, discourse generation was extremely reduced and perseverative. MC's verbal generation performance was consistent with concurrent deficits in two mechanisms thought crucial for conceptual preparation processes; namely impaired selection and impaired fluent sequencing of novel thoughts. These two mechanisms have been associated with the left inferior frontal region (selection) and bilateral frontal areas (fluent sequencing of novel thought). MC's generation impairment was not restricted to the language domain as his non-verbal fluency task performance was perseverative and motor movement selection was abnormal. This pattern of performance is discussed in relation to the organisation of conceptual preparation processes, accounts of dynamic aphasia and the neural substrates supporting verbal and non-verbal generation.

C58 Characterizing Alexia and Aphasia Using Eye-Movements

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Relatively few studies have examined eye movement control in patients with aphasia and alexia; yet, all visual-cognitive tasks, including reading and many language tasks, require the dynamic control of eye movements (Just & Carpenter, 1980; Rayner, 1998, 2009; Rayner & Pollatsek, 2013). Eye movements have proven useful in the study of attention, reading, memory, and search in normal individuals, and are thought to provide a means for evaluating online cognitive processing (Henderson, 2006, 2013; Land & Hayhoe, 2001; Schutz et al., 2011). Many patients with aphasia and alexia have sensory-motor problems but it is unclear if they present with normal eye movement control. If eye movement control is impaired in aphasia and acquired alexia it may contribute to the overall impairment seen in patients. Currently, reading impairments in individuals with aphasia are attributed to a language-based etiology and traditional assessment and treatment approaches have been developed with this view in mind. However, many individuals with chronic alexia demonstrate negligible benefit following treatment (Cherney, 2004, 2010), suggesting there may be additional contributing factors. The present study sought to characterize saccadic eye movements of individuals with aphasia by comparing their performance on various eye-tracking tasks to healthy control participants, and by investigating the relationship of their eye movements with behavioral assessments and lesion size. In addition to behavioral assessments, participants with aphasia and normal control participants completed a vision screening

and an eye-tracking protocol. The healthy control participants reported normal speech and language skills. The eye-tracking protocol consisted of four tasks each taking approximately twelve-minutes: scene memorization, in which participants were instructed to memorize images of real-world scenes; visual search, in which participants were instructed to search for an "O" embedded in a real-world scene; reading, in which participants were instructed to read paragraphs of text; pseudo-reading, in which participants were instructed to "read" through pseudo-texts in which each letter was replaced by a geometric shape (Henderson & Luke, 2012; Luke & Henderson, 2013; Nuthmann et al., 2007). Relative to controls, individuals with aphasia had smaller saccade amplitudes for connected text reading and pseudo-reading tasks. Additionally, individuals with aphasia had shorter fixations relative to controls for the scene memorization task. Individuals with aphasia also showed a positive correlation between lesion size and fixation durations during the search task, indicating individuals with larger lesions tend to have longer fixations during search. As well, fixation durations during search were negatively correlated with the Reading Comprehension Battery for Aphasia (LaPointe, 1998) scores, suggesting that longer fixations during search may be indicative of impaired reading comprehension. Our results demonstrate eye-movement control in aphasic patients differ from that of normal control participants on both reading and non-language related tasks, as well as the presence of task specific differences between healthy control and brain-damaged individuals. Characterizing eye-movements of individuals with aphasia may provide insight into the neurobiological correlates of alexia, inform current clinical practices, as well as contribute to the growing body of knowledge pertaining to neuroplasticity, neural reorganization, and behavioral factors, such as treatment after brain damage.

C59 Common but not familiar: hippocampal amnesia reduces subjective familiarity of common words *Melissa Duff[1], Nathaniel Klooster[1], David Warren[1]; [1]University of Iowa*

Semantic memory describes a highly interconnected system of conceptual knowledge, and many of these concepts are linked to unique word-forms through language. Neuropsychological studies have demonstrated that the hippocampus supports the acquisition of new semantic knowledge and new words, but older, well-learned knowledge is generally believed to be intact even after hippocampal injury. However, recent investigations into role of the hippocampus in on-line processing have demonstrated that the hippocampus contributes to ongoing cognition in a wide variety of domains, potentially including judgments about the contents of sematic memory. We investigated whether hippocampal on-line processing might contribute to the subjective familiarity of even well-learned concepts such as those associated with common words. Word familiarity ratings and descriptions were obtained from amnesic patients with hippocampal damage (N=4) and healthy comparison participants (N=10) for both common words (e.g., rose, dolphin, corn) and uncommon words (e.g., numbat, chayote, longan). All participants rated uncommon words as being similarly unfamiliar ($p>0.1$), but amnesic patients rated common words as less familiar than did healthy comparisons ($p<0.001$). This reduction in the subjective familiarity of common words in amnesic patients implies that the hippocampus may continue to mediate access to preexisting semantic knowledge or facilitate subjective evaluation of familiarity even with common, well-learned concepts and memories. We suggest that in the healthy brain, the hippocampus may potentiate the sense of familiarity by contributing to on-line relational processing of familiarity probes, facilitating the relating together of the familiarity probes with new and existing knowledge.

C60 Deficits in semantic processing and verbal memory correlate with imaging biomarkers: A multimodal imaging study for Alzheimer's disease *Fan-Pei Gloria Yang[1], Ya-Fang Chen[2], Ta-Fu Chen[3], Tien-Wen Tseng[3], Jia-Chun Chen[3,4], Kai-Yuan Tzen[5,6], Mau-Sun Hua[3,4], Ming-Jang Chiu[3,4,7,8]; [1]Department of Foreign Languages and Literature, National Tsing Hua University, Taiwan, [2]Department of Medical Imaging, College of Medicine, National Taiwan University, [3]Department of Neurology and College of Medicine, National Taiwan University, [4]Department of Psychology, National Taiwan University, [5]Department of Nuclear Medicine, National Taiwan University Hospital, College of Medicine, [6]Molecular Imaging Center, National Taiwan University, [7]Institute of Brain and Mind Sciences, College of Medicine, National Taiwan University, [8]Graduate Institute of Biomedical Engineering and Bio-informatics, National Taiwan University*

Neuronal death and tissue loss caused by Alzheimer's disease (AD) drastically affect cognitive functions. Brain volume shrinkage and white matter disruption are the most significant signs of brain damage in AD. Mild cognitive impairment (MCI) patients also display similar but less pronounced changes in brain structure. Although weaker verbal memory and poor neurocognitive performance of MCI patients have been reported in previous research, the relationship between brain damage and cognitive impairments remains unclear. In order to study the atrophies in these three groups, we performed volumetric measurement, voxel-based morphometry (VBM), and tract-based spatial statistics (TBSS) analyses. We examined the correlations of performance in the memory and language domains with indices of grey and white matter integrity. Results indicate significant correlations in multiple gray and white matter ROIs with verbal memory, semantic generation and concept formation. The hippocampus volume and diffusion indices in major language tracts (uncinate and arcuate fasciculi) significantly correlated with all language and memory tests. Relationships between

brain damage and memory and linguistic deficits observed in current research are consistent with clinical observation of verbal and memory deficits in AD and MCI patients.

C61 What does the left prefrontal cortex do for sentence production? Evidence from tDCS *Nazbanou Nozari[1], Jennifer Arnold[2], Sharon Thompson-Schill[1]; [1]University of Pennsylvania, [2]University of North Carolina at Chapel Hill*

Little is known about the role of the left prefrontal cortex (PFC) in sentence production. But we do know that producing a sentence requires suppression of the words already spoken and planning of the words to come. Reducing interference from the past requires biasing competition from an already-spoken word to the immediately-relevant word, and planning the future could entail prioritizing a sub-goal (e.g. temporarily slowing down for optimal planning) over the global goal (i.e. speaking as fluently as possible). We propose that both of these functions are mediated by PFC. We employed Anodal Transcranial Direct Current Stimulation (A-tDCS), previously shown to improve single-word production, to test if PFC's role in sentence production extends to suppressing the past and planning the future. 24 subjects (12 A-tDCS, 12 sham) completed a Moving Objects task: they each produced 134 sentences describing visual events involving one or two geometrical shapes performing one of five actions "moving", "jumping over", "looping around", "wiggling" or "flashing" (e.g. The green circle jumps over the purple trapezoid. The purple trapezoid moves two blocks to the left.). Accuracy data were analyzed using multilevel logistic mixed models. Time data were analyzed using the Mann-Whitney U test, because of the non-normal, and sometimes bimodal, underlying distributions. The A-tDCS group produced significantly fewer sentences that contained an error (14%) than the sham group (23%; $t = 2.04$, $p = .04$). We then performed two sets of analyses to examine whether PFC modulation affects suppression of the past and/or planning of the future. Suppression of the past was measured by comparing perseveratory errors in A-tDCS and sham conditions. Perseveration was defined as erroneous repetition of any word that had been spoken earlier in the same sentence or in the immediately preceding sentence. There were nearly twice as many perseveratory errors in sham (124) compared to A-tDCS (67; $z = -1.875$ $p = 0.06$), showing that A-tDCS improved inhibition of the past. Planning the future was assessed by comparing the number of cases where the subject started describing "jumping over" as "looping around" or vice versa. These two actions are visually identical up to a point, and a premature commitment to speaking before the point of disambiguation can result in an error. The A-tDCS group made significantly fewer errors of this type (anodal = 6%; sham = 13%; $z = 2.019$, $p = 0.04$). Better planning for the A-tDCS group was also indicated by the fact that subjects waited longer before speaking, and then completed the sentence at a faster rate: For 20% of sentences/subject, where the sentence was preceded by a break, display-to-speech-onset times were 1281 vs. 1174 ms for A-tDCS and sham respectively ($p< 0.001$). The sentences following this delay were spoken at a higher rate in the A-tDCS group (median = 2.7 vs. 2.5 words/sec for A-tDCS and sham respectively; $p = 0.008$). In summary, our results show that left PFC supports sentence production by decreasing interference from the past and premature commitments to a future plan.

C62 Gamma responses are larger during picture naming of animals compared to that of non-animals *Eishi Asano[1,2], Katsuaki Kojima[1,2], Erik C Brown[1,2], Naoyuki Matsuzaki[1,2]; [1]Children's Hospital of Michigan, [2]Wayne State University*

Introduction: Event-related gamma-augmentation is considered an excellent summary measure of in situ neuronal activation We determined where and when category-preferential augmentation of gamma activity took place during naming of animal or non-animal pictures. Methods: We studied 41 patients with focal epilepsy who underwent measurement of naming-related gamma-augmentation50-120 Hz during extraoperative electrocorticography. The assigned task consisted of naming of a visually-presented object classified as either 'animal' or 'non-animal'. Results: Within 80 ms following the onset of picture presentation, regardless of stimulus type, gamma-activity in bilateral occipital regions began to be augmented compared to the resting period. Initially in the occipital poles (at 140 ms and after) and subsequently in the lateral, inferior and medial occipital regions (at 320 ms and after), the degree of gamma-augmentation elicited by 'animal naming' became larger (by up to 52%) than that by 'non-animal naming'. Immediately prior to the overt response, left inferior frontal gamma-augmentation became modestly larger during 'animal naming' compared to 'non-animal naming'. Conclusion: Animal category-preferential gamma-augmentation sequentially involved the lower- and higher-order visual areas. Relatively larger occipital gamma-augmentation during 'animal naming'can be attributed to the more attentive analysis of animal stimuli including the face. A specific program of cortical processing to distinguish an animal (or face) from other objects might be initiated in the lower-order visual cortex. Animal-preferential gamma-augmentation in the left inferior frontal region could be attributed to a need for selective semantic retrieval during 'animal naming'.

Language Disorders

C63 Relations between Aging, Memory and Language in Amnesia: Longitudinal Data from Amnesic H.M. on Recall of Phonological, Orthographic and Lexical-semantic Information *Don MacKay[1], Laura Johnson; [1]University of California, Los Angeles*

Does aging impair retrieval of familiar semantic, phonological and orthographic information at the same rate for amnesics and normal older adults? This paper

reviews results of nine longitudinal and cross-sectional experiments conducted from 1983-1999 on relations between aging, memory and language in the famous amnesic H.M. at ages ranging from 57 to 73. Control participants included cerebellar patients and memory-normal adults carefully matched with H.M. for age, IQ, and background. There were five types of tasks: word definition tasks (e.g., What does squander mean?), lexical decision tasks (e.g., Is squander a word?), word reading tasks (e.g., Read this spoken word aloud: SQUANDER), spelling tasks (e.g., Spell this spoken word: "squander"), and the Boston picture naming task (Name the object in this picture). For all five tasks, H.M. exhibited reliable deficits relative to the controls in processing low-frequency (LF) but not high-frequency (HF) information. For example, H.M. misread no more HF words but he misread reliably more LF words than the controls in four experiments. Similarly, on the Boston Naming Test, H.M. did not differ from the controls in naming objects with HF names, but he correctly named reliably fewer objects with LF names, he benefited reliably less often when the experimenter provided target-related phonological cues to forgotten LF names, and he produced reliably more unusual errors than the controls for objects with LF names, e.g., calling a snail a "sideon." Relative to the controls, H.M. also retrieved reliably fewer correct spellings for irregularly-spelled LF words in a two-choice spelling recognition task that controlled for working memory factors. Given these cross-sectional results, three additional studies evaluated effects of aging by comparing H.M.'s deficits in these studies with his performance in earlier studies using similar or identical stimuli. These longitudinal comparisons indicated that H.M.'s deficits for LF but not HF information became progressively worse with aging on from 57 to 73 years of age. Relative to younger controls in the earlier studies, performance of the older became progressively worse with aging for LF but not HF phonological, orthographic and lexical-semantic information acquired decades earlier. However, relative to these normal baselines, H.M. exhibited greater-than-normal age-linked retrograde amnesia, with deficits that became progressively worse relative to the controls from age 57 to 73 for LF but not HF phonological, orthographic and lexical-semantic information. These results comport with interactions between aging and amnesia predicted under binding theory: Internal representations for HF information that were used frequently and recently remained intact with aging, whereas internal representations for LF phonological, orthographic and lexical-semantic information became degraded and unusable due to aging, infrequent and non-recent use. However, normal older adults were able to use their intact hippocampal binding mechanisms to re-learn or re-create defunct internal representations on subsequent encounters with LF information, whereas H.M. could not due to his hippocampal damage. As a consequence, H.M.'s recall of LF phonological, orthographic and lexical-semantic information became progressively worse relative to the controls' as more and more of his internal representations for this information became defunct with aging.

C64 Large-scale neural networks' dynamics in language and recovery from aphasia: Functional connectivity data

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Introduction - Distinctive white matter pathways linking globally-distributed cerebral regions are increasingly documented as supporting language processing. Thus, the alteration of large-scale neural networks may explain the pervasive disorders occurring after stroke's localized lesions, namely aphasia. It is observed that the default-mode network (DMN) main components, which experiment high hemodynamic activity at rest, are somehow engaged in semantic processing and that the disruption of its functional connectivity is associated with cognitive and language disorders in various neuropathologies. A more canonical language network (CLN), linking Broca's and Wernicke's areas through the arcuate fascicle, is also well-known to underlie communicative abilities. These networks' respective contribution to language neurological processing, alteration and recovery are not yet understood. Method - Nine subjects (5 men and 4 women) who have chronic aphasia secondary to a left-hemisphere stroke (between 4 and 25 years post-stroke) are matched with ten control participants (4 men and 6 women). All participants are right-handed native French-speakers. Subjects of the patient group engage in an intensive naming therapy targeting noun and verb production, the Semantic Feature Analysis (SFA). The groups undergo two fMRI sessions, prior- and post-treatment, during picture naming. Functional connectivity data is then processed using spatial Independent Component Analysis (sICA) in Nedica, a program designed to compute integration values in networks and subnetworks of interest: the DMN and the CLN. Integration, as a mean to quantify functional connectivity, correlates the synchronized hemodynamic activity of cerebral regions within a given network which are assumed to exchange information. Results - Localized disruptions in both networks are salient in the subjects. Multiple variables are correlated with post-stroke functional connectivity, namely the neurological lesion size and education level. All participants with chronic aphasia show significant improvement in object and action naming after SFA. While no significant concurrent change is observed in the CLN, the DMN's functional connectivity increases in conjunction with the behavioral improvement, approximating the controls'. Moreover, noun and verb naming exhibit distinctive functional connectivity within the DMN, while the CLN is not sensible to the grammatical class. Still, the integration values of the DMN and the CLN are highly correlated during picture naming. Discussion -

Intensive and targeted interventions by a speech-language pathologist support anomia resolution many years after the vascular lesion's incidence. The neuroplastic mechanisms underlying this form of recovery are hardly sizeable. Given the high complexity of language as a higher-order cognitive function, a network perspective can offer a more comprehensive understanding. As a matter of fact, it is possible to witness inter-networks interactions during language tasks. More importantly, functional connectivity measures of the DMN unveil its contribution to semantic processing and its implication in language recovery concurrent with aphasia therapy. These data give us further insights about the DMN's function during the resting-state, which is likely to encompass a form of ongoing intern speech, characteristic of human beings.

C65 A role for the left temporoparietal cortex in abstract concept representation and semantic relationships

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While great progress has been made in understanding the cognitive and neural representation of concrete concepts, the representation of abstract concepts remains less clear. Some studies have implicated the anterior temporal lobe, while others point to the inferior frontal gyrus, with little consistency between studies. In this study, we conducted a functional connectivity fMRI experiment to identify a network of regions involved in abstract concept knowledge. The results of this experiment were then used to make specific predictions about the deficits of aphasic patients with damage in cortical regions implicated in the abstract network. In Experiment 1 participants were presented with abstract and concrete words, and asked to think deeply about the word's meaning while undergoing an MRI. A psychophysiological interaction (PPI) analysis was carried out on the data, using the left anterior inferior frontral gyrus (aIFG) as a seed region. PPI analysis allowed us to search for task-dependent functionally connected networks by first identifying our psychological predictor (abstract word blocks) and then selecting a physiological predictor (activity in the seed region, the left aIFG). Any regions in the brain that are identified by the interaction of these two terms can be described as functionally connected to a network including the left aIFG during abstract word processing. The connectivity analysis revealed that the left temporoparietal cortex (TPC), including angular gyrus and posterior superior temporal sulcus, was selectively involved in the abstract concept network. An independent concrete network was also identified in the left hemisphere, including the temporal pole and posterior middle temporal gyrus. The function of the TPC in abstract concept representation was further assessed in a neuropsychology study. Previously, the TPC has been implicated in processing thematic semantic relationships (Mirman & Graziano, 2012; Schwartz et al., 2011) and abstract concepts may be particularly dependent on thematic relationships (Crutch & Warrington, 2005). To test the hypothesis that the TPC plays a specific role in abstract semantic knowledge, ten participants with aphasia and lesions restricted to the left TPC were asked to select a spoken target word from an array of four printed words that were either abstract or concrete. The words in each array were either taxonomically related, thematically related, or unrelated to each other. Healthy matched controls performed at ceiling in all conditions. The aphasic participants did not present with a pure deficit for abstract words, which can occur with diverse and nonspecific lesions in the left hemisphere. Instead, aphasic participants made more errors on abstract targets in related arrays than in unrelated arrays, but relatedness had no effect on accuracy for concrete arrays. This interaction of concreteness and semantic relatedness converges with the connectivity-fMRI results in demonstrating that the left TPC plays a unique role in abstract concept representation. Furthermore, the confirmatory results from the aphasic participants supports the notion that connectivity fMRI analyses can provide novel insights about cortical representation of abstract semantic knowledge.

C66 The importance of the ipsi- and contralesional frontal and temporal regions in language recovery in aphasia

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Introduction: While our understanding of the neural basis of language recovery in aphasia has increased tremendously, there is still an ongoing debate regarding the role of the ipsilesional spared tissue and contralesional homologues in facilitating language processing (Fridriksson et al., 2010; Turkeltaub et al., 2011). In this project, we systematically examine the relationship between the degree of spared tissue in the ipsilesional cortex and BOLD signal activation in ipsilesional and contralesional regions of interest in 16 patients with chronic post-stroke aphasia. Methods: Structural ROIs were taken from the AAL atlas and spatially normalized lesion maps were subtracted from them to determine the amount of damaged tissue. Percent signal change was calculated within the resulting ROIs for semantic condition (relative to baseline visual processing condition) during a semantic processing fMRI task using Marsbar. The percentage of spared tissue, (calculated as (Anatomical ROI Volume –Lesion Volume)/(Anatomical ROI Volume)) was lowest for IFG pars opercularis (IFGop) and IFG pars triangularis (IFGtri) and middle temporal gyrus (MTG). Pearson correlations between percentage of spared tissue showed that lesions in IFGop, IFGtri and IFGorb were strongly positively correlated with each other ($p < .01$) but also with Middle Frontal Gyrus (MFG), Superior Frontal Gyrus (SFG) and Angular/Supramarginal gyrus (AG/SMG). Lesions in MTG were not correlated with any other region. Also, correlations between each ipsilesional structural ROI and the percent signal change within each

functional ROI (both ipsilesionally and contralesionally) revealed several significant negative correlations($p < .05$) between: (a) ipsilesional IFGop with contralesional MTG (-0.55), (b) ipsilesional IFGorb and contralesional MTG (-0.569), (c) ipsilesional IFGtri and contralesional IFGop (-0.51), IFGtri (-0.528), SFG (-0.524), MTG (-0.68), and AG/SMG (-0.612)(all contralesional), (d) ipsilesional MFG and ipsilesional MFG (-0.57), (e) ipsilesional SFG and ipsilesional IFGop (-0.53) and MFG (-0.626), (f) ipsilesional MTG and ipsilesional MFG (-0.608) and SFG (-0.822), (g) ipsilesional AG/SMG and ipsilesional IFGorb (-0.573) and contralesional MTG (-0.55) (h) ipsilesional anterior cingulate and ipsilesional IFGorb (-0.567) and MFG (-0.578). Conclusions: We have several interesting observations in this study. 1. Lesion overlap analysis suggests the LIFGtri to be the region of maximal damage across patients with aphasia. Lesions in the LIFG are correlated with ipsilesional regions in MFG, SFG and AG/SMG but not MTG. 2. Damage to LIFGtri is positively correlated with increased signal change in its contralesional homologues, as well as areas within the posterior temporal region (MTG and AG/SMG). 3. LIFGorb and LIFGop are correlated with contralesional MTG activation. 4. Increased activation in contralesional MTG is correlated with the amount of damage in all of the regions damaged in the ipsilesional hemisphere, suggesting that it is a key region for recovery of semantic processing. 5. Lesion in the LMTG is correlated with increased ipsilesional SFG and MFG activation and lesion in the SFG is correlated with increased MFG and IFGorb, and there is no evidence of contralesional increase of activation. These results suggest that as damage to the IFG increases, activation in contralateral regions increases, however, damage to the MTG and SFG results in activation of ipsilesional spared tissue.

C67 Using a Multivariate Multimodal Framework to Define the Neuroanatomic Basis for Confrontation Naming in Frontotemporal Degeneration

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A fundamental challenge to cognitive neuroscience is the identification of large-scale neural networks that subserve performance of complex tasks such as confrontation naming. Here we introduce a novel multivariate approach that links neuroanatomy to confrontation naming in healthy adults and frontotemporal degeneration. First, we create data-driven ROIs that maximally explain variance in the imaging data for both gray matter and white matter. Second, we use a model selection procedure to statistically identify the data-driven ROIs that most strongly relate to confrontation naming. We show that the best model involves a combination of information from both gray and white matter analyses, consistent with contemporary neurobiological models of language. A total of 69 subjects participated in the study. This included 54 patients with a variant of frontotemporal dementia (FTD), including non-fluent primary progressive aphasia (naPPA, n=9), semantic-variant primary progressive aphasia (svPPA, n=12), and behavioral variant (bvFTD, n=33), and 15 age- and education-matched healthy adults. All subjects had T1-and di□usion-weighted structural MRI scans acquired on a 3T Siemens Trio scanner. Most subjects performed cognitive testing at the same time as image acquisition, all subjects had imaging within 6 months of MRI. Confrontation naming was assessed with a 30-item version of the Boston Naming Test. MRI preprocessing was conducted with the PipeDream neuroimaging toolkit http://picsl.upenn.edu/ANTS/pipedream.php, which implements multi-modal spatial normalization pipelines powered by the ANTs toolkit. After determining cortical thickness and diffusion tensors, we defined regions of interest (ROIs) to test for correlations with cognitive performance using Eigenanatomy, computed by the sccan program in ANTs. This is a recent open-source algorithm that parcellates the image space into coherent regions based upon the variation in the subject population. Like Principal Component Analysis (PCA), Eigenanatomy finds a low-dimensional representation of the very high-dimensional data matrix containing all voxel data for all subjects. The decomposition is sparse, unsigned and spatially clustered, resulting in linearly weighted regions of interest that capture variance in the data but are also spatially specific. The weighted average FA or cortical thickness over each component region was used as a predictor of naming in a linear regression framework, and a Bayesian Information Criterion (BIC) was used to estimate the relative goodness of fit and efficiency of a set of candidate models containing up to 8 separate predictors. We found that median naming accuracy was 22/30. The model combining cortical thickness of gray matter and fractional anisotropy of white matter (r2=0.69) was marginally better than the model involving gray matter alone (r2=0.67) and outperformed the model involving only white matter (r2=0.52). The optimal model for naming included 3 predictors, including left inferolateral temporal cortex (p=4x10-7), right dorsolateral prefrontal cortex (p=6.3x10-3), and left inferior longitudinal fasciculus (p=1.2x10-2). Based on this anatomic model, the predicted naming score is highly correlated with actual naming score in each subgroup of participants. These findings show that a multivariate, multimodal imaging framework can identify a large-scale network of cortical and white matter regions that contributes confrontation naming.

C68 Neural Correlates of the Effect of Speech Rate on Lexical Access and Syntactic Dependencies During Sentence Comprehension

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While listening to auditory sentences, neurologically unimpaired individuals demonstrate access to the meaning of lexical items immediately after they are encountered as well as at the gap in filler-gap constructions, including object-extracted relative clauses and overt anaphors (Love et al., 1998; 2008). Individuals with agrammatic Broca's aphasia, in contrast, have evinced a delay in both lexical access and re-access on the order of 300-500 milliseconds (Love et al., 2008; Ferrill et al., 2012; Thompson & Choy, 2009). Slowing the rate of auditory sentence presentation mitigates these delays in the individuals with aphasia yet has an opposite effect on neurologically unimpaired participants, instead disrupting these typical automatic patterns. This fMRI study sought to explore the differing neurological effects that rate of speech input has for individuals with and without language impairments. Participants included four individuals with chronic Broca's aphasia (PWA; 1 female, mean age = 48 years) and fifteen right-handed, native-English-speaking age-matched control participants (AMC, 8 females, mean age = 54 years). Stimuli (as seen in 1a-1c below) consisted of 20 syntactically simple active sentences (ACT, from Ferrill, et al., 2012), 20 sentences containing a pronoun ("him" or "her"; PRON) and 20 matched sentences with a proper noun (e.g. "John"; PROP) in place of the pronoun. 1.a. ACT: The guide carried the student during the utterly exhausting hike to the summit 1.b. PRON: The boxer said that the skier in the hospital had blamed him for the recent injury 1.c. PROP: The boxer said that the skier in the hospital had blamed John for the recent injury In this event-related within-subjects study, all sentences were presented at a regular and slow rate (reduced by 1/3), resulting in 6 conditions (2 (rate) x 3 (sentence type)), broken over 5 blocks totaling approximately 1 hour of scanning time. Consistent with previous findings (Rogalsky et al., 2012), the AMC group demonstrated greater activation of the anterior temporal lobe (ATL) at normal rate of speech compared to slow rate speech input. This general pattern of recruitment held for all three sentence types in the AMC group. Consistent with the literature, the more complex sentence constructions (PRON/PROP) also recruited left inferior frontal gyrus (Broca's area; BA44 and BA45) more for normal than slow rate. This area of the brain has been linked to fast-acting processing (Friederici, 2011). Preliminary analyses of the PWA data revealed that, when an area of activation identified in the AMC group was damaged, neural recruitment was often shifted to the right hemisphere homologue. Interestingly, the effect of rate for the PWA group appeared to be the reverse of that for the AMC group, in that enhanced activation was observed for the slow input rate relative to the normal rate. These patterns are consistent with the effects observed in the behavioral data that reveal a benefit of slowing in real time lexical and syntactic processing in PWA. Further analyses incorporating site and extent of lesion as well as behavioral priming patterns will be discussed.

C69 Involvement of hippocampal subfields in memory performance in semantic variant and logopenic variant primary progressive aphasia *Khaing Win[1,3], John Pluta[2], Paul Yushkevich[2], David Wolk[1,3], Murray Grossman[1,3]; [1]Neuroscience Graduate Group, University of Pennsylvania, [2]Penn Image Computing and Science Lab, University of Pennsylvania, [3]Department of Neurology, Hospital of University of Pennsylvania*

Introduction/Motivation: Language provides an important mean of communication. Primary progressive aphasia (PPA) is a disorder of progressive language decline due to a neurodegenerative condition. Here we focus on semantic variant PPA (svPPA) and logopenic variant PPA (lvPPA). svPPA is characterized by impairment in single-word comprehension and object knowledge, while repetition and speech production are spared. MRI scans of these patients show predominant anterior temporal lobe atrophy. On the other hand, lvPPA is characterized by poor repetition of sentences and phrases, while single-word comprehension and object knowledge are relatively spared. MRI scans on these patients show predominant left posterior perisylvian atrophy. Most research has focused on neocortical atrophy in both types of PPA. Few studies have investigated the role of hippocampal atrophy, although post-mortem studies show hippocampal disease in both conditions and lvPPA is often associated with Alzheimer's disease. It is unclear whether the hippocampal subfields, particularly Cornu Ammonis (CA1) and dentate gyrus (DG), are equally compromised in svPPA and lvPPA. Here, we characterized the involvement of CA1 and DG, and their contribution to semantic and episodic memory performance in both svPPA and lvPPA. Methods: Eleven svPPA patients, eleven lvPPA patients, and twenty-eight control subjects evaluated at the Penn Frontotemporal Degeneration Center underwent high in-plane resolution (0.4x0.4mm) T2-weighted MRI. This sequence allows visualization of the dark band that separates CA from DG. An automatic process based on a multi-atlas template of in vivo 4T MRI scans informed by hippocampal histology was applied to these images. Subsequently, manual corrections on CA1 and DG were performed, and subfield volumes were normalized to whole-brain volume. Analysis of Covariance (ANCOVA) and Tukey's HSD post-hoc test were employed. Pearson correlations were performed between hippocampal subfields and cognitive measures (naming, semantic measures, verbal-memory recall and recognition, visual-memory recall) in svPPA and lvPPA. Results: ANCOVA, covarying for age and disease duration, found a significant difference in CA1 and DG between groups. Post-hoc test showed a varying degree of atrophy between groups ($p<0.001$): greater atrophy of CA1 and DG in svPPA compared to both control and lvPPA, and greater atrophy of CA1 and DG in lvPPA relative to control, but not to svPPA. In svPPA, there was a significant association between left CA1 and, naming ($p<0.01$), semantic measures ($p<0.05$) and verbal-memory recall ($p<0.05$); between right

CA1 ($p<0.01$) and visual-memory recall; and between right DG and visual-memory recall ($p<0.05$). In lvPPA, there was a correlation between right CA1 and verbal-memory recognition ($p<0.05$); between right DG and verbal-memory recognition ($p<0.05$); and between right DG and visual-memory recall ($p<0.05$). Conclusion: Our findings demonstrate greater hippocampal subfield atrophy in svPPA than lvPPA, even though the latter condition is frequently caused by Alzheimer's disease, and selective association between hippocampal subfields and memory measures. This distinct pattern of atrophy in hippocampal subfields may contribute to different language and cognitive profiles of disease in these conditions. Future work will examine the amount of variance that hippocampal subfields and neocortical regions contribute to different forms of memory performance in these patients.

C70 Three Critical Lesion Sites for Persistent Speech Production Deficits After Stroke *Thomas Hope[1], Mohamed Seghier[1], Louise Lim[1], Alex Leff[2], Cathy Price[1]; [1]Wellcome Trust Centre for Neuroimaging, University College London, UK, [2]Institute of Cognitive Neuroscience, University College London, UK*

Introduction. Researchers have struggled to identify structure-function associations for language which are consistent enough to be predictive at the level of individual subjects. Here, we use novel methods to identify regions in which high lesion load is strongly predictive of persistent speech production deficits after stroke (i.e. deficits lasting >5yrs) – both within-sample, and in an independent sample of patients. Methods. We drew our patient samples from the PLORAS database (http://www.ucl.ac.uk/ploras), a large and growing resource which associates stroke patients with high resolution T1-weighted brain images, with demographic data, and with a range of behavioural data, assessed using the Comprehensive Aphasia Test (Swinburn et al., 2004). Extracting lesion images for each patient with an algorithmic process, then sought to identify, in a sample of 80 chronic stroke patients (40 impaired), assessed 5-10yrs post stroke ('the ID-set'), the smallest number of regions which could 'explain' the incidence of the impairment – i.e. regions whose complete destruction by a given patient's lesion might have produced a speech production deficit in that patient. We then assessed how well the resulting regions predicted the incidence of speech production deficits in a second sample of 127 stroke patients, assessed 1-5yrs post stroke ('the Validation-set'). Results. Three critical left hemisphere regions were identified. The first, which explained 28/40 impaired patients in the ID-set, implicated the superior longitudinal fasciculus and underlying the motor cortex. The second, which explained 4/40 patients in the ID-set, implicated the posterior temporo-parietal segment of the same tract. The third, which explained 8/40 patients in the ID-set, implicated the inferior longitudinal fasciculus extending from the temporo-parietal junction to the anterior temporal lobe. The Positive Predictive Value (PPV) of these regions was 95% in the ID-set, and also 95% in the Validation-set (in which 40 patients had >90% damage to any of the three critical regions, and 38/40 were assessed as suffering from a speech production deficit). Our 3-region rule is a significantly better predictor of speech production skills than lesion size alone. Analysis of the 30 patients in the Validation-set whose deficits were not predicted by our 3-region rule suggests that their lesions are predominately located in the frontal lobes. Conclusions. Given access to detailed lesion site information, large patient samples, and appropriate methods, consistent, strongly predictive lesion-deficit associations can be found. Large lesions to the superior or inferior arcuate fasciculus are strongly associated with speech production deficits persisting >5yrs post stroke, while frontal lobe lesions may be associated with more transitory speech production deficits (i.e. lasting more than 1 year, but less than 5 years post stroke). Critical lesion sites for deficits of many other language skills might be found using the approach proposed here. References: Swinburn, K., Howard, D., and Porter, G. (2004). Comprehensive aphasia test CAT. Hove: Psychology Press.

C71 Voxel-based lesion-symptom mapping of naming, fluency and repetition deficits after surgical resection *Stephen M. Wilson[1], Daniel Lam[2], Miranda Babiak[2], Edward F. Chang[2]; [1]University of Arizona, [2]University of California, San Francisco*

The goal of this study was to use voxel-based lesion-symptom mapping (VLSM) to determine the relationship between surgical resections in specific brain regions and any resulting linguistic deficits. While VLSM and voxel-based morphometry have provided important evidence regarding the organization of major language functions in cohorts of patients with stroke and primary progressive aphasia, these methods have not been applied in neurosurgical patients. These patients provide a unique opportunity to study the effects of discrete surgical resections, which are not limited by vascular distribution or patterns of neurodegeneration. 98 patients underwent neurosurgical resections in the language-dominant hemisphere for the treatment of tumor, epilepsy, or vascular malformation. Patients were assessed with the Western Aphasia Battery (WAB) and the Boston Naming Test (BNT) two days after surgery. The primary variables of interest were: (1) a composite naming measure that averaged scores on the BNT and the naming component of the WAB; (2) fluency of spontaneous speech (WAB); (3) repetition of words, phrases and sentences (WAB). The resection cavity and surrounding edema were manually delineated on MRI images acquired after surgery. These images were normalized to MNI space using SPM5 with cost function masking in the region of the lesion, and smoothed. VLSM was carried out to identify regions where tissue damage correlated with behavioral variables. Lesion volume and aphasia quotient were included as covariates. The resulting t maps were thresholded at voxelwise p

< 0.005, then corrected for multiple comparisons by a permutation procedure. Naming deficits were associated with resections to the middle temporal gyrus, inferior temporal gyrus and fusiform gyrus, with the strongest relationship observed in the fusiform gyrus approximately 6 cm posterior to the temporal pole ($p < 0.001$). Fluency deficits were associated with resections to the ventral precentral gyrus and pars opercularis ($p = 0.029$). Repetition deficits were associated with resections to the posterior superior temporal gyrus ($p = 0.067$). The locations identified as most critical for these major linguistic functions are broadly consistent with evidence from other patient groups and methodologies. A significant advantage of this surgical patient population is that presumably little to no reorganization would take place over two days post-surgery, though reorganization prior to the surgery remains a possibility. The locus of naming deficits 6 cm posterior to the temporal pole is noteworthy, since this region was identified despite greatest lesion overlap and power in the temporal pole. Our findings suggest that modern statistical approaches to behavior and imaging in neurosurgical patients offer a novel avenue to the study of aphasia.

C72 Effects of the Metabolic Syndrome on Lexical Retrieval and Sentence Processing in Aging

Dalia Cahana-Amitay[1,3], Avron Spiro[1,2,3], Jason Cohen[5], Emmanuel Ojo[1,3], Jesse Sayers[1,3], Abigail Oveis[1,3], Loraine Obler[1,3,4], Martin Albert[1,3]; [1]Boston University School of Medicine, [2]Boston University School of Public Health, [3]VA Boston Healthcare System, [4]City University of New York, [5]Albert Einstein College of Medicine

Introduction: The metabolic syndrome (MetS) is a constellation of vascular and metabolic risk factors (high levels of glucose, triglycerides, cholesterol, blood pressure, and obesity) associated with development of cardiovascular disease and diabetes, impaired brain structure and function, and increased risk of mortality. MetS is also associated with impaired cognitive function and onset of dementia. The impact of MetS on language performance in aging has not been examined. This study was designed to address this gap by examining the association of the metabolic syndrome with lexical retrieval and sentence processing. Methods: Population: Our sample consisted of 281 English-speaking older adults (aged 55-84; 51% male; mean age 72 years; mean years of education 15), free of stroke and dementia. Participants were screened for neurologic or psychiatric disorder, loss of consciousness, and recent radiation or anesthesia. Procedure: Participants first underwent a health examination, including blood chemistry, and then completed (6-8 hours total) of cognitive and language tests over two sessions within 6 weeks. Defining Metabolic Syndrome MetS: Data from the medical exam were used to define the presence of MetS, based on the harmonized criteria (Alberti et al., 2009). The prevalence of MetS was 41%, comparable to the 36% prevalence reported by Ford et al. (2010) for national US adults aged 20 and older. Language Measures: From the language testing sessions, we selected measures of lexical retrieval (the Boston Naming Test and Action Naming Test) and sentence processing (comprehension of embedded sentences and of sentences with zero, one-, and two-negative markers), scored for both accuracy and reaction time (RT). Results: Regression analyses (adjusting for age, education, and gender) demonstrated that participants with MetS (N=114) had significantly lower accuracy on one of two measures of lexical retrieval (action naming) (95.2% vs. 96.4%, p.<0.012) and on one of the two measures of sentence processing (embedded sentences) (87% vs. 90.4%, p.<0.002). Reaction time, unexpectedly, was slightly faster among those with MetS only on the test of embedded sentences (1586.1 ms vs. 1752.6 ms, p.<.056). Conclusion: Language performance in aging is affected by poor cardiovascular and metabolic health, consistent with previous studies from our lab describing differential patterns of language decline among older adults associated with hypertension and diabetes (Albert et al., 2009; Cahana-Amitay et al., 2012). In particular, we found that accuracy of both lexical retrieval and sentence processing is significantly impaired in persons with MetS. To our surprise, however, we also found reaction time to be slightly faster in this population. We consider this finding to represent a greater speed-accuracy tradeoff in persons with MetS than in the healthy population. We hypothesize that neural networks supporting executive function systems are impaired in persons with MetS, leading to a greater degree of impulsivity and reduced capacity for inhibition.

C73 The relationship between naming treatment outcomes and resting state functional connectivity in post-stroke anomia

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Background: Previous studies investigating the mechanisms underlying treatment in people with aphasia have primarily examined task-based brain activity. However, the use of resting-state fMRI allows for investigation into the connectivity between widely distributed functional networks, and may provide another useful method for examining the neural mechanisms responsible for treatment outcomes. Methods: Eight people with aphasia underwent four weeks of treatment, three sessions per week, which aimed to improve object naming. Sessions alternated between a phonologically-based task and a semantic-based task, with resting-state

fMRI conducted pre- and post-treatment. Brain regions in which the amplitude of low frequency fluctuations (ALFF) correlated with treatment outcomes were used as seeds for functional connectivity (FC) analysis. FC maps were compared from pre- to post-treatment, as well as with a group of twelve healthy older controls. Results: Pre-treatment ALFF in the right middle temporal gyrus (MTG) correlated with greater outcomes for the phonological treatment, with a shift to the left MTG and supramarginal gyrus, as well as the right inferior frontal gyrus, post-treatment. Compared to controls, participants with aphasia showed both normalisation and up-regulation of connectivity within language networks post-treatment, predominantly in the left hemisphere. Conclusions: The results provide preliminary evidence that treatments for naming impairments affect the functional connectivity of language networks, and may aid in understanding the neural mechanisms underlying the rehabilitation of language post-stroke.

Poster Session D

Friday, November 8, 9:50 – 11:50 am, Emerald Ballroom

Auditory Perception, Speech Perception, Audiovisual Integration

D1 McGurk Effect Perceivers Are More Likely to Fixate the Mouth of the Talker *Michael Beauchamp[1], Edgar Walker[2], Demet Gurler[1]; [1]University of Texas Medical School at Houston, [2]Baylor College of Medicine*

The McGurk-MacDonald effect is a powerful illusion that illustrates the importance of visual and auditory information in speech perception. However, there is a high degree of variability in the population. Some people almost always perceive the illusion (strong perceivers, SP), and others hardly ever do (weak perceivers, WP). To better understand the difference between these groups, we used infrared eye tracking to study eye movements as subjects viewed audiovisual speech. Twenty participants (10 male, 10 female, mean age: 25 years old) were tested using nine different audiovisual speech video clips on a monitor placed 60 cm away from them. The video clips consisted of congruent and incongruent McGurk and non-McGurk auditory-visual syllables with a duration of 2 sec. Participants were asked to view the video clip. Following the clip, they reported "what the person in the video was saying" in an open choice format. Monocular eye position was recorded using an EyeLink 1000 video-based eye tracker (SR Research) with a sampling rate of 500 Hz and a spatial resolution of 0.2□ in head-free mode. A 13-point target was used for calibration, with calibration accuracy assessed before presentation of each video. A region of interest (ROI) based data analysis was conducted using Matlab. Three ROIs were created around the left eye, right eye and the mouth of the talker in each video clip. According to their behavioral responses the participants are divided into two categories. SP (n=9) reported the McGurk percept on more than half of the trials (mean 89%, 3% SEM). WP (n=11) reported the McGurk percept on less than half of the trials (mean 32%, 6% SEM). Next, we examined the eye movements made by SP and WP. Across stimuli, strong perceivers spent significantly more time fixating the mouth than did weak perceivers (46% of total fixation time for SP vs. 38% of total fixation time for WP, two sample t-test t 178= -2.3871, p = 0.02). Neuroimaging data demonstrates that brain activity in SP is different than in WP when presented with identical McGurk stimuli. Specifically, the amplitude of blood-oxygen level dependent fMRI responses is greater in the superior temporal sulcus (STS) of SP. The results of the present study suggest a possible explanation for this difference. The STS is known to be strongly responsive to biological motion and like most visual areas, the STS is thought to be retinotopic, with greater representation of the center of the visual field. As SP fixate the mouth, activity in their STS could be evoked by the obligatory mouth movements of the video talker (located at the center of gaze). Conversely, as WP fixate the eyes of the video talker, their STS would receive weaker biological motion input because the talker's eyes (located at the center of gaze) do not necessarily move during speech.

D2 Adjust the expectation of the phonetic form of words according to a talker's voice: A phonological mismatch negativity study *Caicai Zhang[1,2], James Magnuson[3,4], Nicole Landi[3,4], Gang Peng[1,2], William S-Y. Wang[1,2]; [1]Language and Cognition Laboratory, Department of Linguistics and Modern Languages, The Chinese University of Hong Kong, Hong Kong SAR, [2]Language Engineering Laboratory, The Chinese University of Hong Kong, Hong Kong SAR, [3]Department of Psychology, University of Connecticut, U.S.A., [4]Haskins Laboratories, Yale University, U.S.A.*

Despite the tremendous variability between talkers in speech production, human listeners show great success in recognizing words produced by different talkers. The question is, whether listeners store talker-dependent phonetic details in the mental representation of words, and if they do so, whether listeners adjust the expectation of the phonetic form of words immediately according to a talker's voice in online word identification. To probe these questions, two experiments were conducted in Cantonese, a tone language. The acoustic realization – specifically, pitch – of Cantonese words depends on a talker's pitch range. If listeners adjust the expectation of phonetic form of words online, they would expect a word to have a higher pitch when produced by a high-pitch talker than when produced by a low-pitch talker. We investigated this question using the phonological mismatch negativity (PMN) elicited in a visual-word/spoken-sentence matching paradigm. The PMN is a component indexing the violation of expectation of sub-lexical phonological information, which might also include talker-dependent

phonetic details of words. In this paradigm, a visual word was first displayed to elicit the expectation of a target word, followed by the auditory presentation of a sentence produced by talkers with different pitch ranges. The task was to judge whether the final word (i.e. target) in the spoken sentence matches or mismatches the visual word. Listeners could tune to a particular talker's pitch via the context part of the spoken sentence (i.e. words before the final word). If listeners adjust the expectation of pitch height of the target word according to a talker's pitch, the PMN would be elicited when the expected pitch height mismatches the heard pitch height of the spoken word. Moreover, to ensure that listeners adjust the expectation online, the F0 of the context part produced by each talker was raised or lowered, creating the impression that a talker produced the same context with high or low pitch. Given the same visual word, listeners would expect it to have a higher pitch when it is produced by the high-pitch talker, and more so when the F0 of the context was raised than lowered. Results of Experiment 1 show that the PMN is elicited for both high-pitch and low-pitch talkers, supporting that listeners adjust the expected pitch height of words online. Experiment 2 examined the effect of discontinuity in talker gender/identity on the adjustment of expectation. Target words produced by a male talker were embedded in two kinds of preceding contexts, one context produced by the same talker, and the other context from a manipulated female talker. Listeners were less likely to adjust the expectation if they perceived the context to be produced by a female talker (i.e. discontinued talker gender/identity) in behavioral measures. Nevertheless, no difference was found in the PMN. To conclude, our studies show that listeners adjust the expectation of word form according to a talker's voice in online processes as indexed by the PMN. How the adjustment is influenced by the perceived continuity in talker gender/identity warrants more studies.

D3 Phase reset during speech and non-speech discrimination revealed by independent component analysis of event-related EEG

Andrew Bowers[1], Tim Saltuklaroglu[2], Ashley Harkrider[2]; [1]University of Arkansas, Department of Communication Disorders, [2]University of Tennessee, Health Science Center, Department of Audiology and Speech-Pathology

Recent accounts of speech processing have proposed that the auditory system may segment the continuous speech stream by sampling temporal units consistent with the syllable (e.g. entrainment theories). Entrainment accounts predict low-frequency phase reset of ongoing neuronal rhythms at the onset of acoustic speech signals (1-8Hz), with enhancement when top-down predictions (i.e. internal models) match incoming sensory information. During sublexical speech processing tasks, recent neurophysiological theories of speech processing have speculated that that top-down predictions initiated in regions classically involved in speech production may tune neurons in sensory regions to expected sensory features during active attention to syllables. The primary aim of the current study is to investigate the proposed hypothesis that low-frequency phase reset occurs during acoustic processing in the auditory dorsal stream, with enhancements when bottom-up sensory information is sufficient for discrimination relative to when it is significantly reduced via background noise. Thirty-two channel electroencephalography (EEG) to measure ongoing neuronal oscillations in a traditional two-forced choice speech and tone-sweep in noise discrimination task. Sixteen participants were asked to passively listen to or actively indicate whether synthesized consonants or tone-sweeps sounded the same or different at both high and low signal-to-noise ratios (SNRs). Independent component analysis (ICA), within subjects component clustering, and the DIPFIT toolbox in EEGLAB were employed to reduce volume conduction effects and to generate current equivalent dipole estimates (ECD) for each component cluster. A distributed source localization approach known as standardized-low resolution tomography (sLORETA) was also used to assess the statistical significance of results across participants. Results revealed component clusters broadly consistent with the auditory dorsal stream, including bilateral sensorimotor clusters (BA4/6/3), superior temporal clusters (BA42/22), and central midline clusters (BA24;BA6). Compared to passive noise baseline (pFDR<.05), all clusters were associated with low-frequency intertrial coherence (ITCs) commensurate with the onset of auditory stimuli. Paired contrasts using permutation statistics with a correction for multiple comparisons (pFDR<.05) revealed differences in ITC magnitude as a function of stimulus type and SNR. Consistent with the initial hypothesis, for active conditions phase reset occurred earlier in sensorimotor clusters compared to posterior temporal clusters. Correctly identified trials for both syllables and tone-sweeps were associated with significantly higher (pFDR<.05) mean ITCs relative to trials identified at no greater than chance in low SNR conditions. Syllables were associated with left lateralized differences, while tone-sweeps were associated with right lateralized differences. Overall, findings are consistent with entrainment theories predicting low frequency phase reset across regions well known to be involved in speech processing, with enhancements for correct relative to incorrect trials. Further, the finding that sensorimotor phase reset peaked earlier than for posterior temporal clusters is consistent with neurophysiological theories predicting top-down constraints on sensory processing during active attention to syllable discrimination. These findings provide the first evidence that phase reset at low frequencies is significantly related to speech discrimination performance.

D4 Effects of Production Training and Perception Training on Lexical Tone Perception - A behavioral and ERP study *Shuang Lu[1], Eric Holgate[2], Ratree Wayland[1], Edith Kaan[1]; [1]University of Florida, [2]Haskins Laboratories*

Lexical tones are used in many languages (e.g. Mandarin Chinese and Thai) to distinguish lexical meaning and to convey grammatical distinctions (Chao, 1948). Previous research has shown that non-native speakers of tone languages have difficulties in both comprehending and producing lexical tones (e.g. Gandour, 1983; White, 1981). Several behavioral studies found that the perception and production performance improved significantly after short perceptual or production training (e.g. Wang et al., 1999 & 2003). However, very few studies have directly compared the effects of perceptual and production training on tone perception. According to some theories (e.g. The Motor Theory of speech perception, Liberman et al., 1989), training people in the production of sounds may be more effective in increasing discrimination accuracy than perceptual training alone. In order to test the validity of this hypothesis, the current study collected both behavioral and electrophysiological (ERPs) data to examine the effects of a perception-only training and a perception-plus-production training on the intentional and unintentional processing of tones by native English speakers. Stimuli consisted of 9 monosyllables ([pha], [phi], [khɛ], [kho], [tha], [thi], [thɛ], [tho] and [thu]) associated with three linear tones that resemble Mandarin Tone1 (high-level), Tone2 (high-rising), and Tone4 (high-falling). A total of 22 native English speakers were trained and tested over the course of three consecutive days. On the first day, participants' brain waves (ERPs) were recorded using a passive oddball paradigm. During recording, participants watched a silent movie while a stream of standard and occasional deviant syllables was presented. After the ERP recording, participants did a behavioral same/different discrimination task. On the second day, participants received either a perception-only or a perception-plus-production training. The training consisted of a same/different discrimination training. The procedure was the same for both training groups except that the perception-plus-production training required participants to imitate the stimuli, while the perception-only training had participants utter a word unrelated to the stimuli. On the third day, both groups did the same ERP and behavioral tasks as on the first day. In the behavioral tasks, both the perception-only and the perception-plus-production groups improved in tone discrimination accuracy as a result of training. However, the test time × group interaction was not significant, suggesting that the two groups did not differ from each other in the extent of improvement. In the ERP tasks, the MMN was smaller in post-training than in pre-training. Moreover, both groups showed an increased late negativity at the posterior electrodes in the post-training task compared to the pre-training task. In sum, analyses of the behavioral data and ERP components did not show any significantly different effects of training between the perception-only and the perception-plus-production groups, suggesting that the additional production component in the perception-plus-production training did not result in more improvement in tone discrimination at intentional or unintentional levels.

D5 Grey matter volume in SMA predicts individual differences in auditory imagery *Nadine Lavan[1], Cesar Lima[1,2], Andrea Halpern[3], Sam Evans[1], Zarinah Agnew[1], Sophie Scott[1]; [1]Institute of Cognitive Neuroscience, University College London, [2]Faculty of Psychology and Education, University of Porto, [3]Psychology Department, Bucknell University*

Auditory imagery is the ability to imagine sounds in the absence of sensory input. Previous fMRI studies have shown that temporal regions, such as Heschl's gyrus, parietal and frontal regions, such as inferior parietal sulcus (IPS) and dorsolateral prefrontal cortex (DLPC), as well as the supplementary motor area (SMA) are selectively engaged by active auditory imagery tasks (e.g. Herholz, Halpern & Zatorre 2012; Halpern & Zatorre 1999). Evidence suggests that people vary widely in their ability to generate auditory images, but to date there has been no investigation as to whether individual differences in auditory imagery ability are supported by differences in brain structure. In this study, we aimed at establishing the structural correlates auditory imagery. Auditory imagery was assessed using the Bucknell Auditory Imagery Scale (BAIS) (e.g. Halpern & Zatorre 1999; Zatorre & Hapern 2005), a self-report questionnaire providing measures for how vivid the imagery is and how much control can be exerted over the imagery. The high-resolution structural images (MP RAGE) of 56 participants (mean age 47.9, 30 female, 26 male) were acquired at a 1.5T Siemens Avanto scanner using a 32-channel head coil. The structural images were analysed using voxel-based morphometry (VBM) with DARTEL registration in SPM8. Preliminary results of a whole brain analysis of these data show that grey matter volume is positively correlated with the self-reported vividness scores of the BAIS in SMA and the inferior parietal lobule (p less than 0.05 FWE cluster-level corrected). No clusters survived this level of correction for the individuals ability to control auditory imagery. Initial results of a regions of interest analysis within the STG found no evidence for a correlation between grey matter volume and auditory imagery scores. Therefore, although functional brain imaging studies have shown temporal areas are recruited during auditory imagery, we found no evidence for individual differences in auditory imagery ability to be reflected in grey matter volume differences in this region. This was not the case for the SMA. Our results suggest that being able to vividly imagine sounds may not only rely on generating auditory images but also on other factors, such as subvocal rehearsal during the generation of the auditory image to compensate for the lack of sensory input.

D6 Brain dynamics of processing speech sound omissions in predictive and non-predictive contexts *Mathias Scharinger[1], Alexandra Bendixen[2], Antje Strauß[1], Molly Henry[1], Björn Herrmann[1], Jonas Obleser[1]; [1]Max Planck Research Group "Auditory Cognition", Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany, [2]Institute for Psychophysiology of Hearing, University of Oldenburg, Germany*

Speech signals are often compromised by external noise or sluggish articulation. In extreme cases, segments or even whole words are omitted altogether, requiring the detection and potential replacement of missing information. While previous research provided evidence that predictive mechanisms play a crucial role for the processing of speech sound omissions, a precise cortical location of these effects is hitherto lacking. For this reason, the present study examined the effects of word-final missing speech segments in different German sentence contexts. To that end, we contrasted predictive and non-predictive sentence contexts: In the predictive context, sentence-final nouns were the most probable sentence endings, while in the non-predictive context, the same nouns were not the most probable endings, i.e. the sentences could have ended in any other noun. Equally often in both contexts, the sentence-final nouns were either presented as full words, or as a meaningless fragment with omission of word-final consonants, identical for all nouns. This resulted in a 2×2 design with the factors predictability (predictive vs. non-predictive) and omission (omission vs. no-omission). In a 3-T Magnetic Resonance Imaging (MRI) scanner (Bruker Medspec 3000), participants (N=19) listened to a total of 240 sentences (60 from each condition). Sentence stimuli were presented in the silent periods of an Interleaved Silent Steady State (ISSS) volume acquisition protocol. In order to ensure semantic processing of all sentences, after sentence presentation, participants had to rate how well a visually presented probe noun fit into the sentence context. On the whole brain-level, we observed stronger blood oxygenation level dependent (BOLD) responses for omissions than for no-omissions in an extended fronto-parietal network, comprising left premotor cortex, bilateral inferior parietal lobule, bilateral inferior frontal gyrus (BA 45/47), and right precuneus, and also a cluster in the ventral lateral nucleus of right thalamus. Non-predictive sentence contexts elicited stronger BOLD responses than predictive sentence contexts in bilateral middle temporal gyrus (BA 21), while the reverse contrast showed clusters in bilateral auditory areas as well as in left fusiform gyrus. Crucially, the interaction of the factors omission and predictability revealed clusters in left angular gyrus, bilateral middle frontal gyrus (extending into premotor cortex) and left posterior cingulate. These clusters were characterized by stronger activations for omissions than no-omissions in non-predictive sentence contexts, while activations for omissions and no-omissions in predictive sentence contexts did not differ. The results of our study indicate that speech sound omissions modulate neural activity in subcortical (thalamic) and cortical (fronto-parietal) networks, suggesting that omissions already play a role at low levels of the ascending auditory pathway. At higher processing levels, on the other hand, omissions and no-omissions yielded similar neural responses if occurring in a predictive context, reminiscent of electrophysiological results (Bendixen et al., 2009). The activation of premotor cortex in the omission contrast furthermore suggests that omissions disrupt sensorimotor integration, while this effect can be alleviated if omissions occur in predictive contexts. Our findings underline the importance of predictive auditory mechanisms for speech comprehensions, and can be interpreted within current models on the neurobiology of language.

D7 Meta-analytic connectivity modeling (MACM) of anterior vs. posterior superior temporal sulcus *Laura Erickson[1], Josef Rauschecker[1], Peter Turkeltaub[1]; [1]Georgetown University*

Introduction: The superior temporal sulcus (STS) is implicated in many functions, including audiovisual processes (Hein and Knight, 2008). Yet STS functional organization related to auditory and visual streams, including dorsal vs. ventral distinctions is not well understood. Auditory models (Rauschecker and Scott, 2009) predict that posterior STS mainly interacts with dorsal-stream regions, whereas anterior STS mainly interacts with ventral-stream regions. To examine this possibility, we conducted MACM (Zald et al., 2012) analyses that assessed which brain areas consistently coactivated with anterior, middle or posterior STS across studies in BrainMap (brainmap.org). Methods: Regions of interest (ROIs) were created using the lpba40 atlas: left anterior STS (LaSTS), left middle STS (LmSTS), left posterior STS (LpSTS), right anterior STS, right middle STS and right posterior STS. Studies of normal subjects, reporting foci in STS ROIs were obtained from BrainMap (Sleuth). Activation likelihood estimation (ALE) analyses were conducted (GingerALE 2.1). To match sensitivity across ROIs, we equated active voxels across each ALE analysis (min. threshold of FDR q less than 0.05 and cluster threshold > 100 mm3). ALE subtractions isolated connectivity for specific STS regions (e.g., LpSTS – (LaSTS + LmSTS)). Results: 1185 experiments and 14532 subjects were found. In general, areas associated with sensorimotor processing (e.g., parietal and premotor areas) coactivated with LpSTS more often than with other left STS regions. Areas associated more closely with ventral-stream function (e.g., hippocampus) coactivated more often with LaSTS than other left STS regions. There was some dorsal/ventral stream connectivity overlap and other coactivations were present. Some unpredicted patterns were observed (e.g., topographical coactivations with left STS and fusiform gyrus). Coactivation patterns were found for right STS. Conclusions: In general, these findings suggest that left pSTS coactivates mainly with dorsal-stream regions,

whereas aSTS coactivates more with ventral-stream regions. Examining connectivity patterns further may provide insight into STS organization and processing. Hein G, Knight RT (2008) Superior temporal sulcus-It's my area: or is it? J Cogn Neurosci 20:2125-2136. Rauschecker JP, Scott SK (2009) Maps and streams in the auditory cortex: nonhuman primates illuminate human speech processing. Nat Neurosci 12:718-724. Zald DH, McHugo M, Ray KL, Glahn DC, Eickhoff SB, Laird AR (2012) Meta-analytic connectivity modeling reveals differential functional connectivity of the medial and lateral orbitofrontal cortex. Cereb Cortex epub Oct 4 2012.

D8 Functional and structural brain aging and speech perception: new evidence *Pascale Tremblay[1,2], Mylène Bilodeau-Mercure[1,2], Marc Sato[3], Catherine Lortie[1,2], Matthieu Guitton[1,2]; [1]Institut Universitaire en Santé Mentale de Québec, [2]Université Laval, [3]GIPSA-lab, CNRS and Université de Grenoble*

Speech perception difficulties are common amongst elderlies. However, their aetiology is often unclear. Amongst the communication difficulties experienced by elderlies, a decline in the ability to comprehend speech in background noise, for example in the presence of multiple simultaneous talkers, is highly prevalent and disabling. The traditional view that these difficulties are caused primarily by peripheral hearing loss is challenged by new empirical evidence suggesting that brain senescence is also an important contributor to age-related speech perception difficulties. In a recent study, we showed important structural and functional changes in the neural system that underlies speech skills in the absence of behavioural changes (Tremblay, Dick and Small, 2013). Here we present the first multimodal aging study focusing on the ability to perceive speech in challenging situations in relation to both structural (cortical thickness) and functional brain senescence. Following thorough audiometric evaluations (pure tone audiometry, high frequencies audiometry, speech recognition threshold, and distortion product otoacoustic emissions recordings), a group of 11 young healthy right-handed adults (mean age 25.7 ± 3.9 SD; range: 21-32 years; 7 females), and a group of 11 older healthy right-handed adults (mean age 68 ± 4.6; range: 61-74 years; 7 females), underwent magnetic resonance imaging while performing a speech perception task at various intelligibility levels. As expected, age had a detrimental effect on speech perception at all intelligibility levels, even after controlling for hearing sensitivity, which was reflected in lower overall accuracy for the older adults ($F(1,18) = 5.43$, $p = .032$). Using a unique serial mediation analysis framework combining voxel-based and region-of-interest analyses, we show that speech skills in aging are affected both by brain structure (cortical thickness) and brain functioning (change in blood-oxygen level dependent 'BOLD' MRI signal). Moreover, we show that age-related differences in the BOLD signal in regions located outside of the auditory cortex (motor cortex, anterior cingulate gyrus, intraparietal sulcus) affected the relationship of age to speech performance, suggesting that speech difficulties are not primarily related to a decline in general auditory mechanisms. In three cortical areas, we found that structural changes triggered changes in the BOLD signal, and that this series of events had an indirect effect – either beneficial (insula) or detrimental (motor cortex, supratemporal cortex) – on the relationship of age to behaviour. Complementary analyses of subcortical BOLD patterns are currently ongoing. Our results also provide one of the most thorough accounts of the neurobiology of speech perception in aging at the macro-anatomical level. By going beyond traditional approaches that typically focus on a single modality to understand the effect of brain aging on human behaviour we show that the combination of structural and functional measures to study brain aging is key to understand changes in communication-related behaviours.

D9 Tracking of speech rhythm by neuronal oscillations: an MEG study on natural fast speech perception *Hannu Laaksonen[1,2], Karim Jerbi[2], Véronique Boulenger[1]; [1]Laboratoire Dynamique du Langage, CNRS/Université Lyon, France, [2]Lyon Neuroscience Research Center, University Lyon, France*

Introduction Recent work suggests a close correspondence between speech rhythm and cortical oscillations, allowing the brain to parse the acoustic signal into linguistic elements critical for language comprehension. Studies indeed show phase-locking of ongoing theta oscillations in auditory regions to the amplitude envelope of the speech signal. Interestingly, an alignment between oscillatory activity in auditory and premotor regions has further been reported in speech-relevant frequency bands, supporting recent dual-stream models of a functional role of the motor system in speech perception. The goal of this study is to uncover the role of the speech production system in perceptual processes by investigating how articulatory and auditory regions interact during natural speech perception using MEG. Methods Brain activity of 24 normal-hearing participants was recorded using a 275-channel whole-head MEG system. There were three experimental conditions: natural speech produced at a normal rate, natural speech produced at a faster rate and speech artificially time-compressed to match the fast speech rate. The control condition consisted of amplitude-modulated noise without any linguistic content at normal and fast speech rates. Stimuli of the same condition were grouped into blocks of 3 to 5 items that are randomly presented. The task was to detect beep-sounds embedded in random sentences. These trials were excluded from the analysis. Task-related modulations of oscillatory power across multiple frequency bands were computed using routine spectral analysis methods using FieldTrip data analysis package. In addition to computing power modulations, we also estimated the coupling between the speech signal envelope and the MEG signals. Results Our results provide evidence for

an entrainment of neuronal oscillations to the amplitude envelope of the speech signal in a widely distributed cortical network. We found that the coupling to auditory signal was stronger in auditory regions to speech stimuli than to amplitude-modulated noise. In addition, the comparison of the power and coupling results obtained across the 3 speech conditions (natural normal, natural fast and time-compressed speech) shows task-specific modulations of power both in low and higher frequency bands. Our hypothesis that processing faster speech rates is associated with changes in the extent of coupling between the neuronal activity in the auditory and motor cortices and the speech envelope will be tested by phase-locking analysis at lower frequencies (e.g. theta band) between frontal oscillatory activity and the envelope of the acoustic signal. Conclusion Taken together, our findings provide novel insights into the oscillatory dynamics that mediate natural speech perception. Beyond providing further evidence for power modulations in auditory and motor cortices during speech processing, our data suggest that oscillatory brain activity in auditory but also in motor areas displays various degrees of coupling with the speech signal depending on speech rate. We discuss the putative implications of these results on our understanding of the link between processing natural speech and the articulatory changes associated with the production of various speech rates.

D10 Eye position influences on auditory processes measured from within the external ear canal *Kurtis Gruters[1,2], Christopher Shera[4], Jennifer M. Groh[1,2,3]; [1]Center for Cognitive Neuroscience, Duke University, [2]Dept. of Psychology and Neuroscience, Duke University, [3]Dept. of Neurobiology, Duke University, [4]Dept. of Otology & Laryngology and Health Sciences & Technology, Harvard Medical School*

Coordination between vision and hearing is an essential element of language and communication. For example, lip reading can alter perceived phonemes (e.g. the McGurk effect). It is not known where in the brain vision and hearing first begin to interact with each other. In this study, we investigated whether a signature of visual-auditory integration, namely an eye position signal, is evident in the earliest possible stages of the auditory pathway. Eye position is important for visual-auditory integration because the spatial reference frames for vision and hearing are different. The retina provides a map of visual stimulus location defined with respect to the direction of gaze. In contrast, comparison of the sound waves arriving at each ear provides information about sound location with respect to the head. If spatial location is to be used to determine which sights and sounds arise from a common source, information about eye position is necessary to reconcile this discrepancy in how spatial information is defined. Previous research has found that the position of the eyes in their orbits can modulate the firing rates and response patterns of auditory cells in the inferior colliculus (e.g. Groh et al. 2001, Zwiers et al. 2004), primary auditory cortex (Werner-Reiss et al., 2003; Fu et al. 2004), lateral/medial banks of the intraparietal sulcus (e.g. Mullette-Gillman et al., 2005, 2009), and superior colliculus (e.g. Jay and Sparks, 1984, Lee & Groh, 2012). However, it is not clear at what level of the system eye position begins to influence auditory processes. We sought to test this question by determining whether eye position affects the collection of gain control mechanisms that act on auditory signals within the ear itself. We measured sound pressure level in response to brief clicks in the external ear canal of monkeys (n=2) and humans (n=2) as they fixated various locations along the horizontal azimuth. Sound pressure measured in this fashion reflects both oto-acoustic emissions generated by outer hair cells and the action of middle ear muscular reflexes. Both monkeys and one of two humans exhibited statistically significant effects of eye position on the sound pressure level recorded in at least one of their ear canals during a period of time after the stimulus (ANOVA, $p<0.05$) . The time course of the effect varied across subjects. These preliminary results indicate that eye position influences auditory activity even at the very periphery of the auditory system. Regardless of where eye position signals first "enter" the auditory pathway in a neuroanatomical sense, their presence at this early stage of processing suggests that they then have the potential to ramify throughout the system from the periphery and support a variety of interactions between vision and audition, including to facilitate coordinated processing of the visual and auditory elements of communication and language

D11 Perception of synthesized Russian back vowels. *Tatiana Smirnova[1], Nadezhda Andreeva[2]; [1]Skolkovo Institute of Science and Technology, [2]Saint Petersburg State University*

Despite numerous investigations, the question of invariant features for vowels' perception remains open. The most widely accepted vowel perception theory nowadays is that the keys for vowel identification are in the formant pattern, with the first and the second formant considered to be primary. However, analysis of the formant structure only cannot be applied, for example, to vowels with high fundamental frequency (F0). On the other hand, there are data showing the importance of the formant relative amplitude feature for perception of vowels of different languages, but opinions on this subject remain contradictory (Miller, 1953; Aaltonen, 1985; Jacewicz, 2005; Kiefte, 2010). In Saint Petersburg State University under the guidance of prof. Kulikov it was showed that back Russian vowels with fundamental frequency above normal conversational range can be divided into non-overlapping areas on the basis of the relative amplitudes of their frequency components. The aim of our study was to test the significance of this "amplitude" feature in the perception of synthesized Russian back vowels ([u], [o], [a]) with a high F0. A continuum of 22 four-harmonic

stimuli was synthesized (F0=382 Hz, duration of 500 ms, rise and fall time of 40 ms, in which the amplitude of the first two harmonics was varied in decreasing and increasing steps, the other stimuli parameters were kept constant. The identification was carried out in the scheme of three-alternative forced choice (3AFC) and the method of limits (ML) (19 and 29 auditors respectively). The results of these two tests show significance of relative amplitude of harmonic components feature to assess the phonetic quality. Further, using the method of frequency transposition five sets of stimuli were created with different F0 (321, 362, 405, 428 and 454 Hz). Each set was presented with the method of limits (28 auditors). Upon presentation with the method of limits sequence was heard twice: in the direction from the "u" to "a" (direct line) and from "a" to "u" (reverse line). It was found that for all values of F0 studied a series of test stimuli is also divided into three categories, with a shift in the areas of phonemic uncertainty according to F0 value, i.e. phoneme boundary position varies depending on it. Comparison of the results of the present work with those obtained in the works (Andreeva, Kulikov, 2009-2012) shows the proximity of the characteristics of unambiguous stimuli to the patterns of natural speech. Thus, the findings suggest the possibility of identifying Russian back vowels [a], [o], [u] on the basis of the relative amplitude feature. Separately we analyzed the phenomenon of mismatch responses of subjects when listening to the direct and reverse sequences. While on the [o]/[a] boundary the order of presentation seems to have no effect on the assessment, on [u]/[o] boundary the effect of context is present. This fact, together with the lack of a sharp drop of between-category identification allows us to agree with the idea of less categorical perception for vowels than for consonants.

Motor Control, Speech Production, Sensorimotor Integration

D12 Challenging the Role of the Anterior Insula in Motor Speech Production: Further Evidence from Case Studies

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Introduction: Recently, the left insula's role in motor speech production and apraxia of speech (AOS) has been debated (Hillis et al., 2004; Richardson et al., 2012). AOS is a disorder of planning and/or programming motor movements for speech, independent of a language deficit or neuromuscular involvement. Early studies using lesion overlap mapping found that the anterior insula (aIns) was commonly damaged in individuals with AOS (Dronkers, 1996), and spared in those without AOS (Dronkers, 1996; Ogar et al., 2006), concluding that the aIns is responsible for motor speech production. However, more recent findings challenge the insula's role in motor speech production and instead implicate motor and premotor cortex involvement (Josephs et al., 2006; Josephs et al., 2012). In the current study, we present five in-depth case studies that demonstrate the involvement of the left motor and premotor cortices in AOS, and not the aIns. Methods: Five post-stroke individuals (3 female, median age =46; range =41-77) were selected based on structural scans revealing left hemisphere damage either without damage to the insula (n=4; P1, P2, P3, P4) or with isolated damage to the aIns (n=1; P5). Participants were given a battery of speech and language assessments. Each participant's T2-weighted magnetic resonance images were reviewed to interpret behavioral profiles with respect to lesion location. Results: Three participants were classified with mild anomic aphasia (P3, P4, and P5; Western Aphasia Battery-R Aphasia Quotient median = 88.2; range = 77.8-88.6). The remaining two participants (P1 and P2) did not present with aphasia according to WAB-R scores (94.6 and 94.2 respectively). Scores from the Apraxia Battery for Adults-2 and analysis of speech samples, DDK rates, and word/sentence repetition tasks reveal moderate to severe AOS in four participants (P1, P2, P3 and P4). Common areas of damage among those with AOS were left pre-motor and motor areas, with the insula structurally spared. The one participant with isolated damage to the aIns (P5) presented with mildly impaired DDK rates; however, she did not demonstrate characteristics of AOS during increasing word length tasks, word and sentence repetition tasks, spontaneous speech, reading, or automatic speech. Conclusion/Discussion: Findings from each individual's profile challenge the insula's role in motor speech production and AOS. Collectively, these cases provide substantial support for the role of motor and pre-motor damage in AOS. These areas were affected in all four individuals with AOS, while the aIns remained structurally intact. Results from P5 indicate that insula damage is not necessary or sufficient to cause AOS. Continued identification of cases of isolated damage to the left anterior insula or motor and pre-motor cortex will further elucidate the brain areas involved in motor speech production and AOS. Clinical relevance of such findings may eventually aid in treatments that modulate areas responsible for AOS, as current treatments lack strong evidence with support from neuroimaging.

D13 Lesion correlates of quantitative speech measures in left hemisphere stroke

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Adults who survive left hemisphere stroke (LHS) often have difficulty with speech sound production, resulting in reduced speech intelligibility and/or naturalness. Speech problems following stroke may reflect impairments in one or more of the following mechanisms: phonological processing of sounds (i.e. phonemic paraphasia), neuromuscular weakness (i.e. dysarthria) or speech motor programming (i.e. apraxia of speech). Clinical differentiation of these three types of speech sound disorder has been problematic, due to shifting diagnostic

criteria over time and lack of a consistent method for evaluating speech behaviors with respect to these criteria. Ongoing work in our laboratory focuses on the reliable quantification of a wide array of speech behaviors in adults following LHS and identification of natural groupings of characteristics that correspond to the different speech disorder types. The purpose of this study was to determine lesion correlates of quantitative measures of speech production in adults following LHS, using a region-of-interest (ROI) based approach with factor scores based on quantitative speech metrics as behavioral measures. Seventeen left hemisphere stroke survivors were selected from a larger cohort of 47 participants on the basis of availability of clinical brain scans for analysis. Five participants were classified with apraxia of speech, two with borderline AOS, seven with aphasia plus phonemic paraphasia, and three with minimal impairment. Fifteen quantitative measures related to speech sound production, temporal prosody, and speech fluency were obtained from a standard Motor Speech Evaluation. Inter-observer reliability for all metrics was high, with intra-class correlations of 0.90 or higher. In preliminary work with the larger cohort, we used exploratory factor analysis of 15 quantitative speech metrics to identify two factors representing temporal prosody and phonemically salient speech sound production difficulties. Lesions were traced using Mricron and registered to MNI space using Chris Rorden's Clinical Toolbox for SPM8. For lesion-behavior mapping, proportion of damage was determined for eight speech-related ROIs (pars triangularis, pars opercularis, precentral gyrus, insula, postcentral gyrus, superior temporal gyrus, supramarginal gyrus, and angular gyrus). ROI values were entered as independent variables into stepwise multiple regression analyses, with log-transformed values for temporal word prosody (Factor 1) and speech sound errors (Factor 2) serving as dependent variables, and lesion volume as a covariate. Results indicated that greater damage in pars opercularis (PO) was associated with longer durational measures (e.g. syllable, pause length; $p < 0.05$), while damage to the precentral gyrus (PrCG) and pars triangularis (PT) was associated with greater speech sound errors ($p < 0.01$). The relationship between PO and temporal prosody is interesting, as prosodic impairment (e.g. increased duration of pauses and syllables) is one of the key criteria used for diagnosis of apraxia of speech (AOS). This finding is consistent with recent work showing that reduced cerebral blood flow and proportional damage in pars opercularis predicts presence of AOS (Richardson et al., 2012). In future work with a larger cohort, we expect to further clarify the nature of speech sound errors in LHS using factors that delineate speech production errors with greater specificity.

D14 The Superior Precentral Gyrus of the Insula (SPGI) does not selectively support articulation *Evelina Fedorenko[1], Paul Fillmore[2], Kimberly Smith[2], Julius Fridriksson[2]; [1]MIT, [2]University of South Carolina*

Introduction: Broca's (1861) claim that posterior left inferior frontal gyrus (LIFG) is critical for speech production has been challenged on the grounds that it is instead the superior precentral gyrus of the left insula (SPGI) that is causally involved in articulation (e.g., Dronkers, 1996; Bates et al., 2003; Baldo et al., 2011; cf. Hillis et al., 2004). It has further been argued (e.g., Dronkers, 1996) that a) articulation is spatially restricted to SPGI, and b) SPGI is functionally specialized for articulatory coordination. We evaluated these claims in an fMRI study. Methods and results: Twenty participants overtly produced i) complex bisyllabic nonwords (containing consonant clusters), ii) simple bisyllabic nonwords, iii) vowels, iv) non-speech oral movements, and v) breath sequences, in a blocked design. The hypothesis whereby SPGI is selectively engaged in articulation predicts a strong response to the three articulation conditions, with a stronger response to complex nonword production than to simple nonword and vowel production (e.g., Baldo et al., 2011), and a weaker or no response to non-speech oral movements and respiration. We extracted responses to the five conditions from SPGI defined in several different ways. First, we used a group-level anatomical mask for SPGI. Only the non-speech oral movements condition produced a large and statistically robust response in SPGI relative to the fixation baseline ($t>5$, $p<.0001$; see also Bonilha et al., 2006). The other four conditions, including complex nonword production, failed to produce an above-baseline response in this region ($ts<1$). Next, to capitalize on the increased sensitivity and functional resolution of individual-subject analyses (e.g., Nieto-Castanon & Fedorenko, 2012), we intersected SPGI with individual activation maps for the complex > simple articulation contrast or the complex articulation > fixation contrast (taking top 10% of voxels for the relevant contrast within the boundaries of the SPGI mask or within a 10mm-radius sphere drawn around the peak coordinate reported in Dronkers et al., 1996). Across these different ways of defining SPGI, the response was always strongest to the non-speech oral movements condition and weaker (often not above the fixation baseline) for the other four conditions, including the complex nonword production condition. Importantly, the three articulation conditions robustly activated several nearby brain regions in the left frontal lobe (especially in the left precentral gyrus), consistent with prior work (e.g., Bohland & Guenther, 2006; Dhanjal et al., 2008; Grabski et al., 2012; Bouchard et al., 2013). Interestingly, none of these regions showed a functionally specific response to articulation, responding similarly strongly to non-speech oral movements, consistent with these abilities being highly correlated in brain damage (e.g., Kimura & Watson, 1989). Summary and conclusions: 1) SPGI does not appear to be functionally selective for articulation. In fact, it shows a weak or no response during articulation and always a stronger response during non-speech oral movements. 2) A number of other, previously implicated, brain regions

robustly – though not selectively – respond to articulation, with the most prominent response observed in parts of the left precentral gyrus.

D15 Combining psycholinguistic and motor control models of speech production *Grant Walker[1], Gregory Hickok[1]; [1]University of California, Irvine*

Psycholinguistic and motor control models of speech production are traditionally thought to target different levels of representation and therefore require different processing architectures and computational operations. However, a close look reveals much overlap between the two domains, suggesting that an integrated approach should be pursued. A recent attempt at integration has demonstrated at least some level of feasibility (Hickok, 2012). The model uses a psycholinguistically informed hierarchical forward predictive coding architecture, the latter being a prominent feature of motor control approaches. Here, we develop a computational implementation of the model to assess the viability of this approach. We start with a psycholinguistic model that has been successfully used to test theories about the interactive and non-linear properties of lexical access (Schwartz et al., 2006, for details). The model has two adjustable parameters representing the strength of lexical-semantic and lexical-phonological connections respectively. Although the model is simple, its architecture instantiates the statistical properties of observed speech error opportunities. By initializing the parameters to fit data from healthy individuals, the parameters are then reduced to simulate lesions and fit data from patients. In particular, this approach has demonstrated the shared components of picture naming and word repetition. Others have suggested adding an "input phonology" node to the model to allow simulation of non-word repetition and the use of a non-lexical route in word repetition (e.g., Nozari et al., 2010). Our work builds on these suggestions, fully incorporating an "input phonology" layer into the model, by dividing the phonological layer into separate auditory and motor units. The auditory and motor layers are bidirectionally connected to the lemma layer with a fixed weight (0.1 and 0.0001, respectively), and to each other by a lesionable weight (ranging 0.1 to 0.001). As a major point of departure from earlier models, we incorporate auditory representations into the lexical retrieval process: Activation cascades down from the semantic units, and following lexical selection, auditory targets become activated which resonate with potential motor productions. Our theoretical assumption is that aphasia may specifically impair the connections between auditory targets and motor representations. We compared our modified model, SLAM (Semantic Lexical Auditory Motor), to the semantic-phonological (S-P) model described in Schwartz et al. (2006), by fitting data from the same 94 aphasic patients, with a similar mapping procedure. While the mean RMSD results favored the S-P model overall (.022 versus .032), SLAM produced much better fits for a subset of 14 patients. While the S-P model has a tendency to underpredict Mixed errors on average, SLAM tends to underpredict Semantic and overpredict Formal errors on average; the 14 patients with better fits all made relatively low Semantic and high Formal errors. Our preliminary investigations have demonstrated that our augmented model can still account for picture naming reasonably well, and may offer additional theoretical insights for a subset of patients. Furthermore, the model's more fully-specified auditory layer yields the potential to explore the relationships among picture naming, word repetition, and non-word repetition more deeply, which we intend to do in future work.

D16 fMRI evidence for monitoring and inhibition of inappropriate words in speech production. *Samuel J. Hansen[1], Katie L. McMahon[2], Greig I. de Zubicaray[1]; [1]University of Queensland, School of Psychology, [2]University of Queensland, Centre for Advanced Imaging*

How do speakers prevent themselves uttering inappropriate words? To investigate this issue, we employed taboo words as distractors in the picture word interference (PWI) paradigm. According to one account, an early selective attention mechanism filters inappropriate information from entering the production process. Alternatively, speakers might use their comprehension system to monitor the content of an articulatory output buffer, and then block inappropriate words from the production process. We tested neuroanatomically-informed hypotheses based on these two accounts in a functional magnetic resonance imaging (fMRI) experiment. Participants (N=19) named pictures (e.g. CRAB) with superimposed distractors that were either non-taboo (e.g. CRAB-tower), taboo (e.g. CRAB-damn) or phonologically-related taboo (e.g. CRAB-crap) words. Significant interference effects of similar magnitude were observed for taboo and phonologically-related taboo conditions compared to the non-taboo condition. For the taboo > non-taboo contrast, increased BOLD signal was identified in the bilateral premotor cortices (including supplementary and pre-supplementary motor areas), anterior cingulate, and the posterior portions of the middle and superior temporal gyri. Similar regions were observed for the phonologically-related taboo > non-taboo contrast. Overall, the results are consistent with the proposal that inappropriate words enter an articulatory buffer (premotor cortex) as phonologically well-formed responses, with the verbal self-monitor (posterior superior temporal cortex) cueing response inhibition processes in inferior frontal gyrus to remove them from the production process.

D17 Minimal neurofunctional changes associated with high level of verbal fluency performance in aging *Yannick Marsolais[1,2], Yves Joanette[1,3]; [1]Centre de recherche, Institut universitaire de gériatrie de Montréal,*

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Introduction: The preservation of optimal performance in aging has been associated with adaptive changes in patterns of cerebral activations for various cognitive components that tend to decline with age (e.g., Cabeza, 2002). However, only a few studies have investigated this phenomenon in light of expressive language abilities involved in a verbal fluency task, which has been reported to benefit marginally from such neurofunctional reorganization (Meinzer et al., 2009; 2012). The goal of this study was to use functional magnetic resonance imaging (fMRI) to assess overt self-paced semantic and orthographic verbal fluency tasks performed by healthy well-educated young and older adults within a mixed design while attempting to reduce the potential confounding effect of an age-related decline in speed of information processing. Methods: Fourteen young (M = 24.00 years of age, 7 females) and 14 older (M = 63.50 years of age, 8 females), well-educated (M = 16.61 years), right-handed French-speaking adults, with no signs of language, psychiatric or neurological pathology (MMSE > 27) performed a verbal fluency task in a 3T fMRI scanner. They were asked to produce as many words as possible for each of 4 orthographic and 4 semantic criteria, within a limited amount of time (90 s/criteria). The reference task involved repeating the months of the years. The fMRI acquisitions were made within a mixed block and event-related design consisting of a single functional run (1600 s, TR = 2) with prospective motion correction. Preprocessing of the fMRI time-series included temporal realignment, motion correction, DARTEL normalization and smoothing. Results: At the behavioral level, the total average number of correct responses for both age groups was high for the semantic (young = 84.29; older = 78.07) and the orthographic (young = 76.14; older = 81.00) conditions. A 2-way factorial ANOVA revealed that neither the main effect of age (young, older), task (semantic, orthographic), nor the interaction, achieved statistical significance. At the neurofunctional level, whole brain analysis ($p < .05$ FWE corrected, $k \geq 5$) performed using a Task (semantic, orthographic, control) by Age (young, older) flexible factorial ANOVA revealed a significant main effect of task for both designs, but no significant effect of age (assessing using a two-sample t-test) or interaction across the speech conditions, which remained non-significant with more lenient thresholds. Post-hoc analysis contrasting the different tasks revealed a number of significant differential activations in various cortical and subcortical regions, including left-lateralized frontal activation for individual trials and blocs of both verbal fluency conditions compared to the control task (e.g., inferior frontal gyrus, supplementary motor area). Only a few local activity differences were found between age groups using regions of interest analysis. Conclusion: The present results suggest that the preservation of high-level of semantic and orthographic verbal fluency performance in healthy aging is accompanied by minimal neurofunctional changes, thus supporting the notion that the neural bases of some communication abilities tend to be maintained in aging. Such results are discussed in terms of task demands and the Compensation-Related Utilization of Neural Circuits Hypothesis (Reuter-Lorenz & Cappell, 2008).

D18 Brain networks for object naming: Comparison of MEG with hemodynamic imaging and lesion data

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Current models of the brain network that supports object naming implicate temporo-occipital regions, perisylvian language areas, and the anterior temporal lobe (ATL; e.g. Damasio, Tranel, Grabowski, Adolphs, & Damasio, 2004). The purpose of this study was two-fold: First to examine the concurrent validity of magnetoencephalography (MEG) as compared to existing data derived from hemodynamic imaging and lesion studies and, second, to determine patterns of regional interdependencies between activated regions. MEG recordings were obtained from six right-handed young adults performing an overt naming task (animals, fruits-vegetables-plants, objects, and tools) using a whole-head system with 248 axial magnetometers (WH 3600, 4D Neuroimaging). Minimum norm estimates of distributed source currents were calculated in Brainstorm (Tadel, Baillet, Mosher, Pantazis, Leahy, 2011) during the first 400 ms post-stimulus onset (prior to the onset of articulation). A spatiotemporal source-clustering algorithm was applied to identify extended regions of significant activation as compared to the prestimulus baseline for each participant. Cluster center positions were then converted into MNI coordinates. Regional interdependencies were estimated through cross-lag correlation analysis between regional source current time-series. Meta-analysis of data from 13 PET and 8 fMRI studies (n=302) providing 533 activation foci for rest vs. naming contrasts were performed in the BrainMap database (www.BrainMap.org). Consistently across participants activation loci were found in medial occipital cortex, inferior occipitotemporal regions (BA 19/37), the posterior portion of the superior and middle temporal gyri, the anterior, middle-inferior temporal lobe, motor cortex, and the inferior and middle frontal gyri (BA 45, 46, 47). Meta-analytic data revealed hemodynamic activation foci in most of these regions with the exception of ATL, a region that appears to be indispensable to naming purportedly through its role in the storage of semantic information (Lambon Ralph & Patterson, 2008). Results are discussed in relation to the sensitivity of neuromagnetic and hemodynamic measures for capturing the spatiotemporal outline of the brain network involved in object recognition, semantic access, and name retrieval and production.

D19 Beta EEG activities reflect a close relationship between language comprehension and motor function

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During the last decade, it has been shown that different aspects of language processing are correlated with frequency specific brain oscillations. Frequencies in the beta range (13-30 Hz) seem to be particularly important with respect to cognitive and linguistic manipulations during language processing (Weiss and Mueller, 2012). Concerning the role beta frequencies play in motor processing and sensorimotor integration we assume that beta activities may reflect the close relationship between language comprehension and motor functions – one of the core claims of current theories on embodied cognition. If a special role of the sensorimotor system exists for meaning constitution in language processing, then the beta band is a good candidate to indicate activation of such motor-related simulations. Results on beta oscillations accompanying semantic word processing and the processing of action verbs might support this hypothesis. A decrease in beta power consistently reflects activation of the motor system in action-oriented studies for the performance of either action execution or observation (e.g., Babiloni et al., 2002). In addition, beta changes at premotor and motor regions have also been found during language tasks without the involvement of a motoric component. For instance, van Elk et al. (2010) found a beta decrease at premotor regions during the processing of action verbs, which was interpreted as reflecting the retrieval and integration of action semantic information. Similarly, both a beta power decrease and coherence increase at central electrodes during processing of auditorily presented action versus non-action verbs have been shown. These findings propose a distinction between subgroups of verbs based on sensorimotor features. Although the current knowledge on the beta's role in language processing is quiet complex and findings are still contradictory, beta oscillations seem to reflect the involvement of the sensorimotor system in language processing. References Babiloni, C., Babiloni, F., Carducci, F., Cincotti, F., Cocozza, G., Del Percio, C., Moretti, D. V. & Rossini, P. M. (2002). Human cortical electroencephalography (EEG) rhythms during the observation of simple aimless movements: a high-resolution EEG study. Neuroimage 17, 559-572. van Elk, M., van Schie, H. T., Zwaan, R. A. & Bekkering, H. (2010). The functional role of motor activation in language processing: motor cortical oscillations support lexical-semantic retrieval. Neuroimage 50, 665-677. Weiss, S. & Mueller, H.M. (2012). "Too many betas do not spoil the broth": The role of beta brain oscillations in language processing. Front Psychol 3, 201.

Orthographic Processing, Writing, Spelling

D20 Examining the effects of lexical quality on masked form priming effects using event-related potentials

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In form priming by briefly exposed primes, inhibition results from an orthographic prime for a target word from a large orthographic neighborhood (high N). However, Andrews and Hersch (2010) found that only good spellers (high lexical quality) and not poor spellers (low lexical quality) showed this inhibition effect. To assess the time course of this inhibition effect and its dependence on individual differences in lexical quality, we carried out an ERP study with adults varying in vocabulary and spelling knowledge. Primes were presented for ~60ms preceding word targets that were from either high N (wull-WALL) or low N neighborhoods (elho-ECHO). PCA identified three temporal components that correspond to the N170, P3b, and P600. Individual differences were visible for the N170 amplitude, which is thought to reflect broad pre-lexical activation based on the orthographic input. For poor spellers, low N targets elicited larger N170s than high N targets, whereas the reverse was true for good spellers. In participants with smaller vocabularies, unrelated primes preceding high N targets elicited larger N170s than form primes, whereas the pattern was reversed for participants with large vocabularies. The later occurring P3b appears to reflect a word selection process, in which a word is uniquely distinguished from orthographically related strings (the prime as well as any lexical neighbors). For this component, higher lexical quality was negatively associated with priming by a related form, while lower lexical quality was positively associated with priming from a related form. These data suggest that for high lexical quality participants, lexical activation is facilitated by sublexical overlap between the prime and the target, and lexical selection is quickly achieved through inhibition of competing lexical candidates. Participants with low lexical quality show less sublexical activation and thus less need to inhibit lexical competitors. These data suggest that the behavioral findings concerning the effects of lexical quality on high N inhibition stem from lexicon-wide activation from the earliest stages of word identification rather than later stages of lexical inhibition and selection. However, the differences in the P3b suggest that there is a stage in processing where the facilitative effects of a related prime (regardless of N) are restricted to participants with low lexical quality. We tentatively interpret this to reflect a late selection process that continues to be facilitated by orthographic overlap (priming) for low lexical quality participants but inhibited by orthographic overlap for high lexical quality participants. At a more general level, the results suggest that temporal information obtained through

ERPs can help localize the rapid interdependent phases of lexical decisions and suggest how individual differences in word knowledge play a role.

D21 Building a Better Network: artificial orthographies and the serial decoding scaffold *Elliot Collins[1], Michelle Moore[2,1], Corrine Durisko[1], Julie Fiez[1]; [1]University of Pittsburgh, [2]West Virginia University*

Readers of alphabetic writing systems can use learned grapheme-phoneme correspondences to "decode" the spoken form of printed words. Decoding is a highly effortful process for beginning readers that becomes automatic with practice. The neural substrates that scaffold skilled reading have received relatively little attention, in part, because of difficulties associated with longitudinal fMRI studies in children. Here, we explore reading acquisition in adults using artificial orthographies. Thirty-six right-handed native English-speaking participants (15 males, M Age=20.5) completed a two-week training program in which they were pseudo-randomly assigned to learn one of three alphabetic artificial orthographies of English (AOEs). Each AOE consisted of graphemes made from faces, houses, or Korean characters. Participants then underwent fMRI scanning while passively viewing AOE stimuli and non-orthographic patterns in a block design experiment. fMRI data were collected on a 3-Tesla head only Siemens Allegra magnet using a single-shot echo-planar imaging pulse sequence (TR/TE/FOV/Flip angle = 2000ms, 25ms, 200mm, 70 degrees). A T2-weighted anatomical scan was also taken. Prior to analysis, data were corrected for motion, scanner drift, normalized to a global mean, spatially smoothed (8mm FWHM), and transformed into Talairach space using NIS/AIR/AFNI. Using NIS, we completed separate ANOVAs on each AOE group at an uncorrected voxel-wise significance threshold of p=0.005 and contiguity threshold of 5 voxels. To isolate brain regions associated with decoding, we created a map of overlap across all AOE F-maps using AFNI. We then drew spheres (r=7.5mm) on the center of mass of overlap from AOEs and examined their overlap with spherical regions-of-interest drawn from two sources: regions associated with reading degraded and inverted stimuli (Cohen et al. 2008, Durisko et al. 2011) and those positively correlated with left fusiform during resting state (Vogel et al. 2011). These studies were selected because the findings of the work were discussed in terms of a fronto-parietal attentional network that might support effortful decoding. A behavioral analysis of single word naming showed that reading time increases with increasing word length, suggesting that our beginning readers employed a serial decoding strategy. The AOE F-maps showed 16 regions in which clusters overlapped by a minimum of 10 voxels. Four of these regions also overlapped with the spheres drawn from the literature: left and right posterior parietal cortex, left precentral gyrus, and the left fusiform gyrus. Converging lines of evidence from different neuroimaging paradigms suggest that brain regions associated with serial attention and speech production subserve an effortful, serial decoding process. The set of identified regions may together form a network that scaffolds automatic orthographic-phonological access by regions located within the left occipitotemporal cortex. In the future, these results may also inform the significant comorbidity of developmental reading and attention related disorders.

D22 Focus on the word: Early effects of repetition are modulated by readers' goals. *Giulia Christine Pancani[1], Joseph Hopfinger[1], Peter Gordon[1]; [1]The University of North Carolina at Chapel Hill*

Lexical repetition can facilitate the processing of words presented in lists or in sentences; this facilitation can be observed with behavioral and neurophysiological measures, and can occur for both clearly visible and masked primes. When targets immediately follow their primes, effects of repetition appear on both early (N250) and late (N400) event-related potential (ERP) components, but appear only on late components when the target is separated from the prime (Misra & Holcomb, 2003; Ledoux et al. 2007). The N250 has been interpreted as reflecting prelexical ortho-phonological processes that underlie word recognition (Holcomb & Grainger, 2006), as well as early lexical-semantic processing (Duñabeitia et al., 2009); its attenuation by repetition priming indicates that subsequent presentations of a word require less processing at these early stages. Priming effects on the N250 can be eliminated when there is separation between the target and prime. This may be because processing of the form of intervening words resets the state of activation in recognition units thereby eliminating the basis for early facilitation. Processing a visible prime may cause the target to be perceived as a separate event, again leading to the resetting of activation in prelexical processing units. Although these explanations may account for data from masked-priming studies, they are inconsistent with evidence from sentence-reading studies where eye-movement data show that early processes of word recognition are facilitated by lexical repetition even when a number of clearly visible words intervene between the prime and the target. Alternatively, repetition effects on early ERP components may appear because the single-word recognition tasks used in masked-priming experiments produce much greater focus on the word form than typically occurs when reading words with the goal of understanding the sentence in which they appear. The present study tests this alternative account by integrating the masked repetition-priming technique with sentence reading using Rapid Serial Visual Presentation (RSVP). In Experiment 1a participants read sentences in RSVP and answered True/False comprehension questions. Embedded in each sentence were two target words which were primed by either the same word (e.g., SHOWER-shower) or a different word (e.g., CIGAR-shower); non-critical words were primed by a random string of letters. Primes were presented for 30ms, followed by a 20 ms blank screen. Targets appeared for 300ms, followed by a 200ms

blank screen. Experiment 1b featured the same conditions and timing but the target words were presented in a word list and participants performed a lexical decision task on non-word fillers. Results for targets embedded in sentences show a repetition effect that is marginal on the N250 [F(1,16)= 4.84, p=.043] and a strong on the N400 [F(1,16)= 9.72, p=.007] whereas a strong effect of repetition is present for both components (N250: [F(1,16)= 15.7, p=.001] ; N400: F(1,16)= 18.31, p=.001]) for targets in a word list. This pattern of results suggests that while the first processing stages of words benefits from immediate masked repetition priming in sentences, the benefit is more robust when words are presented out of context, perhaps because of a heightened focus on the word form.

D23 The Visual Word Form Area May Not be Specific to Words: Evidence from Functional Neuroimaging and Response Time Measures

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INTRODUCTION: i) Neuroimaging: Using functional magnetic resonance imaging (fMRI), researchers have begun to examine the overlap between word and picture identification processes, which has led to a debate regarding the neuroanatomical locations of each process. On one hand, Dehaene and Cohen (2011) argued that words activate a visual word form area (VWFA) in the ventral visual processing stream. On the other hand, Price (2012) argued that word and picture identification share this region. However, these studies did not control for the degree of ventral-lexical involvement in reading. As such, the present experiment controls for the degree of lexical involvement in reading by using exception words (EXC; e.g., comb, which must be read lexically given its inconsistent spelling to sound mappings) and regular words (REG; e.g., coin, which can be read either lexically or sublexically), and their corresponding pictures. By identifying the VWFA in each participant via their EXC word reading, we can determine if identifying the corresponding pictures shares activation within this region. ii) Behavioural: Previous research on word and picture identification has almost solely relied on onset reaction time (RT). However, given that identification processes are still ongoing after the initiation of a vocal response, exploring response duration (RD) in addition to RT opens a wider window into the underlying cognitive processes. Earlier research has shown that the more lexically an item is processed, the shorter the RD (Gould et al., 2012, 2013). As such, given that pictures and EXC words must be identified lexically as "whole-words", and if picture identification invokes orthographic processing, EXC words and pictures should show shorter RDs than REG words and pictures. METHOD: For the neuroimaging localization, we examined fMRI BOLD activation using a multi-subject ROI analysis to separate the shared cortical functions from those that are unique to pictures or words. For the behavioural data, participants' vocal responses were recorded in the MRI and manually analyzed for onset and offset of each response. RESULTS: The fMRI results revealed that significant activation was shared by both EXC words (which must be processed lexically) and their corresponding pictures, and thus supports the notion that word and picture identification share activation in the putative VWFA. The RT results replicated larger behavioural studies (Gould et al., 2012, 2013) showing that words are named faster than pictures, and that EXC pictures are named faster than REG pictures. The RD effects showed that REG words produced longer RDs than EXC words, and this effect approached significance for pictures. These results suggest that pictures activate their corresponding orthographic representations, and that RD is shorter for items that are identified lexically as "whole-words". CONCLUSIONS: Our neuroimaging results suggest that the region referred to as VWFA may also be involved in picture identification, and not solely involved in the orthographic representation of words. Our behavioural results demonstrate that identification processes are occurring after response initiation, and that items processed more lexically elicit shorter RDs. We extend a model of basic reading processes to include interactions with the picture processing system.

Language Development, Plasticity, Multilingualism

D24 Do Structurally Asymmetrical Regions of Language-Relevant Cortex Differ in Gyrification?

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Leftward asymmetries for language function are well documented in several frontal, temporal, and parietal regions. It is less clear whether structural asymmetries are observed in these same regions. For example, leftward asymmetry of the planum temporale is well established, yet findings for Broca's Area are much more variable. Advances in surface-based methods allow us to examine in greater detail which cortical features may underlie structural asymmetries. We previously reported reliable leftward asymmetries in cortical surface area, but not thickness, in several perisylvian regions (Chiarello et al., 2013). Here we investigate whether there are also asymmetries in local gyrification in these and additional language-relevant regions. Increased areal folding is thought to reflect either greater white matter tension produced by local connectivity (Van Essen, 1997), or increased differential tangential expansion (Ronan et al., 2013), during neurodevelopment. If such processes occur to differing extents across hemispheres, we would expect asymmetries in gyrification in language-relevant regions. Left and right cortical surface area, and a local gyrification index (Schaer et al., 2008), were computed for the following FreeSurfer parcellations in a sample of 200 healthy young adults: anterior insula, pars opercularis, pars triangularis, Heschl's gyrus, planum temporale, supramarginal gyrus,

angular gyrus, and middle temporal gyrus. The gyrification index is a ratio, within a given region, of the total cortical surface area against unburied cortex. Asymmetries for each parcellation were calculated by subtracting the right measure from the left and dividing by the average, yielding a positive laterality index (LI) for leftward asymmetries. Surface area was reliably leftward asymmetrical in the anterior insula (LI = +.09), pars triangularis (+.04), pars opercularis (+.13), Heschl's gyrus (+.29), planum temporale (+.18), and supramarginal gyrus (+.09). Reliable rightward surface area asymmetries obtained in the middle temporal gyrus (LI = -.05) and angular gyrus (-.17). Local gyrification was reliably leftward in the pars triangularis (LI = +.013), supramarginal gyrus (+.018), and middle temporal gyrus (+.037), and reliably rightward in the pars opercularis (-.014) and planum temporale (-.014). No gyrification asymmetry was found for anterior insula, Heschl's gyrus, or angular gyrus. Since gyrification asymmetries, even when statistically significant, were substantially smaller than surface area asymmetries, we examined these indices for all other FreeSurfer parcellations. Local gyrification asymmetries were much smaller across the cortex (range +.05 to -.07) than were surface area asymmetries (range +.32 to - .39), and gyrification and surface area asymmetries were uncorrelated (r = .05). We conclude: (1) All perisylvian language-relevant regions demonstrated robust left hemisphere asymmetries for surface area. In contrast, adjacent regions often associated with semantic processing (angular gyrus, middle temporal gyrus) had greater right hemisphere surface area. (2) Asymmetries were also observed for local gyrification in some regions, although of substantially smaller magnitude than for surface area asymmetries. (3) No overall relationship between the degree and direction of surface area and gyrification asymmetries was detected. Within language relevant cortex, it appears that factors determining the growth/pruning of surface area play a much greater role in generating asymmetries than do factors promoting the degree of local folding.

D25 Word Inversion Reveals Native Language Influences on Lexical Organization in a Second Language

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Studies in bilingual populations show that the structure of their native language (L1) influences second language (L2) processing. The present study extends previous findings by investigating the orthographic representation and phonological processing of English in two proficient bilingual groups who have similar visuo-spatial complexity in their native scripts (Korean vs. Chinese), but who differ in the design principles of their L1 background (respectively, alphabetic vs. non-alphabetic). We hypothesized that disrupting a holistic approach to word naming would reveal differences in phonological assembly skills, attributable to the transfer of L1 reading approaches to L2. Along with a native English-speaking control group, the Chinese-English (CE) and Korean-English (KE) bilinguals completed a battery of reading and phonological skill assessments. Despite equivalent comprehension scores, the groups displayed skill profiles consistent with their L1 backgrounds. In a speeded word-naming task, all groups exhibited effects of word frequency and consistency on response times. The word reading performance of the CE as compared to KE bilinguals was more disrupted when items were presented in an inverted (upside-down) orientation. Additionally, when naming inverted (upside-down) words, the benefit of consistency was eliminated in CE bilinguals. These findings suggest that sublexical information is less available to CE than KE bilinguals during L2 processing, possibly because of the CE group's bias towards holistic reading procedures that transfer from L1 to L2 reading. Results also point towards the utility of a word inversion manipulation in revealing differences in lexical organization that are normally masked by high levels of linguistic proficiency.

D26 Differential electrophysiological effects of L1 word processing as a function of pre-exposure to L2 wordforms

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Background: Our lab has been exploring a second language (L2) vocabulary acquisition strategy that is based on the pre-exposure of L2 wordforms prior to any associative learning; i.e. learners are exposed to L2 wordforms before any learning of meaning takes place. Lexical pre-exposure is hypothesized to strengthen the L2 wordform representations of the lexicon during L2 vocabulary acquisition, facilitating subsequent acquisition. Here we explore how this strategy affects first language (L1) word processing. Objective: The Revised Hierarchical Model (RHM) of bilingual word processing proposes that L2 vocabulary acquisition is lexically mediated by the pre-existing L1 system. Given this relationship, it's no surprise that previous research has shown learning an L2 vocabulary to be accompanied by electrophysiological changes in L1 processing as well (Yum, 2013). The present study investigated the ERP changes in L1 translation equivalents of newly acquired L2 words. Importantly, we sought to find any differences in L1 processing as a function of pre-exposure of L2 vocabulary items; specifically, is there any change in L1 word processing brought on by lexical pre-exposure of L2 wordforms? Methods: Thirteen native English speakers who were enrolled in an Introductory Spanish class took part in this longitudinal ERP study. Using a within-subject design, half of the L2 words to be learned during the course was lexically pre-exposed prior to any learning of meaning as part of our L2 learning strategy while the remaining half was learned traditionally in class without any lab interference. During lexical pre-exposure, participants attended to the orthographic and phonological representations of L2 wordforms in an N-back task prior to learning the meaning of the words in class. Following

learning, ERPs were collected to both types of L2 words (pre-exposed or not) as well as to both types of their L1 translation equivalents in a semantic categorization task across two sessions. Results: In our Spanish learners, L1 translation equivalents of pre-exposed L2 words showed reduced N400 amplitudes compared to those whose L2 translations had not been pre-exposed. This N400 effect was larger one month following L2 learning and pre-exposure, indicating that shifts in the interaction between the L1 lexical representations and the concept store are ongoing and occur even after explicit learning has been completed. Similarly, pre-exposed L2 words elicited smaller N400s than non-pre-exposed L2 words. Conclusion: Our results indicate that introducing participants to L2 wordforms prior to the learning of meaning in class induces a change in processing of both L2 words and their L1 translation equivalents. Moreover, the attenuated N400 observed in L1 words whose L2 translations were pre-exposed suggests a facilitation of lexico-semantic mapping during word processing. According to the RHM, this is likely due to top down influences: concepts that are more easily accessed for L2 lexical items due to the pre-exposure paradigm, as shown by their smaller N400s, are similarly more easily accessed for their L1 translation equivalents. These results provide some evidence that lexical pre-exposure to an L2 vocabulary could have advantageous effects on future bilingual processing.

D27 Implicit sublexical access to the first language: An ERP study on Chinese-English bilinguals *Jin Xue[1], Jie Yang[2]; [1]School of English Language, Literature and Culture and Center for Language and Cognition, Beijing International Studies University, China, [2]Department of Neurology, University of California, Irvine*

It has been reported that bilinguals implicitly access to their native language. However, it is unclear the extent to which they retrieve the mental representations. Whether the sublexical information of the native language is active during second-language comprehension is open for discussion. In the present study, we use event-related brain potentials to demonstrate implicit access to the sublexical information of the first language when bilinguals read words exclusively in their second language. We collected behavioral and electrophysiological data in 28 Chinese–English bilinguals who acquired English after mean age of 8.35 (SD = 2.7) (late intermediate bilinguals). According to the self evaluation on the 10-point scale, language proficiency is M = 7.70, SD= 1.21 for Chinese, and M = 6.36, SD= 0.95 for English). Two separate blocks were run for Chinese word pairs and English word pairs, respectively. Chinese–English bilinguals were required to decide whether words presented in pairs were related in meaning or not. Implicit to the participants, for Chinese word pairs, half of the word pairs shared a character component (or a radical), for instance, 蓝(blue)-监(monitor); for English word pairs, half are not related in meaning but shared a radical component when translated into Chinese, for instance, bell（铃）-now（今）. It was found that for the hidden factor modulated the brain potential for Chinese word pair, which was more obvious in radical repetition. The same modulation patterns was also found for English word pairs, establishing English words were automatically and unconsciously translated into Chinese. Critically, the present study extended previous studies by showing that the sublexical information of the native language was activated in second language reading. This work was supported by a grant from Humanities and Social Sciences project of the Ministry of Education of P.R.C. (10YJCZH194) and a grant from National Social Science Foundation of China (12CYY027). Corresponding author: J. Xue (xuejin@bisu.edu.cn) & J. Yang (jiey7@uci.edu)

D28 Does phonology influence word learning in a visually unfamiliar L2? A training study with ERP *Yen Na Yum[1,2], Katherine J. Midgley[1,3], Jonathan Grainger[4], Phillip J. Holcomb[1,3]; [1]Tufts University, [2]University of Hong Kong, [3]San Diego State University, [4]CNRS & Aix-Marseille University*

Does phonological information facilitate reading acquisition in initial second language (L2) learners of a phonologically opaque language? The role of phonology in learning to visually identify Chinese words was investigated in this 5-week laboratory training study. During training, two groups of initially naïve learners of Chinese were randomly assigned to learn Chinese words through visual presentation only (Visual) or using both visual and auditory presentation (Auditory). A variety of tasks including repetition detection, lexical decision, translation recognition, and verbal translation were used to behaviorally assess orthographic processing and semantic access as a function of learning. For both groups of learners, orthographic knowledge and orthographic to semantics links were quickly acquired. Behavioral data in the translation tasks showed that Visual learners initially performed better than Auditory learners, but that in later sessions the pattern reversed. We suggest that the early difference in learning trajectory reflects the heavier learning load for the auditory group who had to acquire both phonological and orthographic knowledge about their new L2 vocabulary. This effect reversed later in the course of learning once a threshold of orthographic knowledge was reached, after which the combination of both orthographic and phonological knowledge enhanced word learning. Before and subsequent to learning, ERPs were recorded to learned L2 items to track the neural changes that occur at the beginning of L2 vocabulary learning. A go/no-go semantic categorization task was used assess ERP correlates of learning. Chinese words were only presented visually to create equal testing conditions for both groups. Despite an absence of behavioral differences in the semantic categorization task, we observed different patterns of ERP changes between Visual and Auditory learners. There was a greater reduction of the P2 component as a function of learning in the Visual group

compared to the Auditory group, which we interpreted as reflecting development of more efficient orthographic processing. In the N400 window, both groups exhibited an increase in negativity with larger amplitudes and earlier onsets of the N400 as a function of learning. Importantly, these N400 changes had a different distribution between Visual and Auditory learners, with Visual learners showing the largest change in the fronto-central region in the right hemisphere and Auditory learners showing the greatest effect at central sites. This finding suggested that semantic processing was influenced by the presence of phonological information during acquisition. These results showed that L2 learning is at least partially dependent on learning contexts.

D29 Learning to read shapes the orthography consistency effect in Chinese spoken word recognition *Yu-Lin Tzeng[1], Wen-Fan Chen[2], Chun-Hsien Hsu[2], Jie-Li Tsai[3], Chia-Ying Lee[1,2]; [1]Institute of Neuroscience, National Yang-Ming University, Taiwan, [2]Institute of Linguistics, Academia Sinica, Taiwan, [3]Department of Psychology, National Chengchi University, Taiwan*

Previous studies have shown that literacy affects the spoken word recognition. Most of the supporting evidences come from orthographic consistency effect in the metaphonological tasks. The orthographic consistency was defined as whether words had rimes that can be spelled in multiple ways. Ziegler (1998) have observed that the rhyming judgments are easier for orthographically consistent words than for orthographically inconsistent words. Ziegler et al. (2007) suggested that this effect substantially reflects the acquisition of literacy skills. However, when and how the orthographic consistency effect emerges along learning to read is still in debate. Chen et al. (2012) have differentiated two types of orthographic consistency effects in Chinese adults' spoken word recognition with semantic category judgment and rhyme judgment tasks. One is the homophones density (HD) (which is defined as the number of characters sharing exactly the same pronunciation, including tonal differences) in the late positivity component with central parietal distribution. The other one is the phonology-to-orthography mapping consistency (P-O consistency) (which is defined as whether a set of homophones can be subdivided into subgroups based on their phonetic radical) on N400 distributing over the frontal-central scalp. By using the same experimental design, the present study aims to examine whether the orthographic consistency effect varied as a function of reading ability. Children from 3rd to 6th grades were divided into two groups according to their vocabulary size accessed by the Chinese Character Recognition Test. Each group has 16 children (high reading ability: 6 girls and 10 boys; low reading ability: 9 girls and 7 boys). Participants were asked to perform a rhyme judgment task. There were 90 monosyllabic Chinese words which were divided into three conditions based on their homophone density and P-O consistency as follows: (1) low HD and high P-O consistency (low HD/ high P-O); (2) high HD and high P-O consistency (high HD/ high P-O); (3) high HD and low P-O consistency (high HD/ low P-O). Another 90 monosyllabic words were selected as the probes, and each critical stimulus was paired with a probe. In the task, participants would hear a critical stimulus and then a probe, and they were asked to indicate whether the critical stimulus was rhymed with the probe. The ERP data to the critical stimuli showed the homophone density effect on N400, but no P-O consistency effect, in children with low reading ability. That is, the low HD/ high P-O condition revealed more negative N400 than the high HD/ high P-O condition did. On the other hand, children with high reading ability showed P-O consistency effect on N400, in which the high HD/ low P-O condition revealed more negative N400 than the high HD/high P-O condition did. These results suggested that the orthographic information were processed in different manners between high and low ability children. Although the homophone density effect in spoken word recognition has presented in less experience readers, the sublexical orthographic effect could only be found in more advanced readers. These findings imply that learning to read may restructure the phonological representations.

D30 Modulation of temporal cortical and striatal activity during recognition of novel words learnt with the dopamine precursor levodopa *Alicia Rawlings[1], Katie McMahon[2], Anna MacDonald[1], Emma Finch[3], Peter Silburn[1], Pradeep Nathan[4], David Copland[1,3]; [1]Centre for Clinical Research, University of Queensland, Herston, Australia, [2]Centre for Advanced Imaging, University of Queensland, St. Lucia, Australia, [3]School of Health and Rehabilitation Science, University of Queensland, St. Lucia, Australia, [4]Department of Psychiatry, Cambridge University, UK*

Background: Levodopa, a dopamine precursor, has been shown to improve new word learning in healthy adults. However the neural and cognitive mechanisms underlying this effect remain unclear. This study aimed to investigate this effect using a double-blind, placebo-controlled drug study in young healthy adults. Participants learnt new names for familiar objects over a four-day period, followed by a functional magnetic resonance imaging (fMRI) task examining recognition of newly learnt words. Methods: 33 (17 female) healthy young adults were randomly assigned to one of two drug arms. Participants received a tablet (Madopar 125mg or placebo) prior to daily training sessions in a novel explicit word learning paradigm over four consecutive days. Participants learnt new auditory names (legal nonwords) for 50 commonly-known familiar objects. After completion of the four training sessions, recall and recognition of the newly-learnt words was tested while event-related fMRI data was acquired with blood oxygen level-dependent (BOLD) contrast at 4 Tesla. All image processing and analysis was conducted in SPM8. Results: Region-of-interest analysis (using p less than .05

corrected) showed that while performing the new word recognition task, participants who had taken levodopa exhibited increased activity in the left striatum and left hippocampus as compared to participants who had taken a placebo. Additionally, participants in the levodopa group exhibited less activity in left superior and middle temporal gyri compared to participants in the placebo group. Conclusions: The results suggest that levodopa may modify learning of new words through increased recruitment of the left striatum and hippocampus, two primary targets of dopaminergic signalling that are strongly implicated in learning and memory. The decreased temporal cortex activity observed for the levodopa group suggests more efficient retrieval of recently acquired word representations. This research contributes to our understanding of the role of dopamine in language learning and could assist with the development of novel pharmacological treatments for language disorders such as post-stroke aphasia.

D31 Neural language processing in adolescent first-language learners: Longitudinal case studies in American Sign Language *Naja Ferjan Ramirez[1], Matthew Leonard[2], Christina Torres[1], Eric Halgren[1], Rachel Mayberry[1]; [1]University of California, San Diego, [2]University of California, San Francisco*

One of the most challenging questions in brain development is whether the predisposition of left hemisphere, fronto-temporal areas for language has a limited developmental window during which language stimulation is necessary. The relationship between brain growth and language experience is difficult to separate because all hearing children experience language from birth. However, among the deaf population are individuals who have been cut off from language until adolescence; they do not have meaningful access to spoken language and have not been exposed to any kind of sign language (Mayberry, 2010). The present study is a longitudinal analysis of word processing in two deaf adolescents (cases) who had no language until age 14 when then became fully immersed in ASL (Ferjan Ramirez et al, 2013). Their unique language backgrounds allow us to ask if the neural processing of word meaning changes over time once language is first experienced in adolescence. Using anatomically constrained magnetoencephalography (aMEG) (Dale et al, 2000), we studied the cases' neural responses to ASL signs after 2 and 3 years of ASL experience (Time 1; Ferjan Ramirez et al, in press), and again 15 months later (Time 2). All stimuli were part of the cases' vocabularies (op. cit.), and were presented as videos immediately following a picture that either matched ("cat-cat") or did not match ("cat-ball") the sign. Twelve deaf native signers and 11 hearing L2 learners of ASL were controls. At T1 the cases' responses to signs were radically different from those of the controls (op. cit.). While both control groups exhibited semantic priming effects in a left-lateralized perisylvian network, the cases engaged the right superior parietal, anterior occipital, and dorsolateral prefrontal areas. Some semantic effects in the left superior temporal cortex were observed, but these were increased rather than decreased by semantic priming. We asked whether the cases' brain responses to words become focal to the left perysilvan network with longer language experience, as they do in typically developing children (Mills et al, 2005). If neural plasticity is lost after childhood, the expected outcome would be no change. Alternatively, if some plasticity is preserved, the cases' neural processing of words would be more typical at T2. Our results support the second hypothesis. The cases' performance accuracy increased 3 to 4% and RT increased 11 to 30% from T1 to T2, suggesting improved familiarity with ASL words. Although many of their neural responses still show a non-canonical polarity, they now localize to the left perisylvian and frontal areas. The leftward asymmetry is particularly strong for the signs to which they responded with fast RTs; responses to signs with slow RTs still localize to the right hemisphere. These results show that a leftward brain asymmetry for lexico-semantic processing is emerging specifically in response to language learning in these two adolescent L1 learners. These results suggest that the adolescent brain remains partly sensitive to language input after an absence of language learning in childhood and that it exhibits both typical and atypical neural responses to newly learned words.

D32 Neural processing of written language in deaf readers: An event-related potential analysis *Alison S. Mehravari[1], Lee Osterhout[1]; [1]University of Washington*

A majority of deaf students leave high school reading at or below a fourth grade level, but some deaf individuals do become highly proficient readers. There is disagreement about the causes of this reading difficulty, and by association, disagreement about the effectiveness of different strategies for teaching reading to deaf children. The goal of this project was to use real-time measures of neural language processing to better assess what leads to successful reading in deaf adults, especially those from different language backgrounds. Two groups of participants took part in this study: 1) adults who became severely or profoundly deaf before two years of age, and 2) age-matched normal hearing adults. Event-related potentials (ERPs) were recorded while participants read: a) sentences that were either well-formed or contained a subject-verb agreement, meaning, or combined agreement-meaning error, and b) pairs of words that were either unrelated or related in meaning, phonology, orthography, or both phonology and orthography. Standardized reading comprehension skill was measured in all participants. Deaf participants displayed both quantitatively and qualitatively different ERP responses to sentence violations than did normal hearing participants. On an individual subject level, some ERP responses varied as a function of the deaf participantsâ□□ language backgrounds. These data begin

to suggest what patterns of neural language processing may be associated with better reading proficiency in deaf individuals.

Lexical Semantics

D33 Object-specific coding in human perirhinal cortex is modulated by semantic confusability

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Our ability to apply meaning to the world around us and name the objects we see is underpinned by a multitude of sensory and cognitive processes. In order to name an object we must first decode the visual input and extract the meaning of the specific object; a process which rests upon the ventral visual pathway. However, although object representations within the ventral visual pathway must be sufficiently rich and complex to support the recognition of individual objects, little is known about how specific objects are represented with most previous work focusing on semantic categories. Here, we sought to address this fundamental issue by testing what kind of object information is reflected in fMRI activation patterns evoked by single objects. Sixteen participants performed an picture naming task during fMRI, where 131 different objects were repeated 6 times. We used a form of multivariate pattern analysis, representational similarity analysis (RSA; Kriegeskorte et al 1998), to compare the similarity of activation patterns for the 131 objects to the predicted similarity defined for 19 different visual, categorical and object-specific semantic measures. A whole-brain searchlight analysis was used to determine where in the brain the activation patterns matched those of our model predictions. Consistent with previous studies, our results show a gradient of informational specificity along the ventral stream from representations of visual properties of the image in early visual cortex, to distributed categorical representations in the posterior ventral visual pathway. A key finding showed that object-specific semantic information is represented in the perirhinal cortex. After establishing the perirhinal cortex codes object-specific information, we sought to determine how these representations might be differentially important for different objects. To achieve this we calculated a measure of the semantic confusability of each object, hypothesizing that highly confusable objects will be more dependent on perirhinal representations. We found that activation levels in the perirhinal cortex were parametrically related to semantic confusability, showing that the perirhinal not only represents object-specific information but is also increasingly activated when fine-grained object-specific information is required. These findings point to a key role for the perirhinal cortex in representing and processing object-specific semantic information that becomes more critical for highly confusable objects. Our findings extend current distributed models by showing coarse dissociations between objects in posterior ventral cortex, and fine-grained distinctions between objects supported by anterior medial temporal lobes, including the perirhinal cortex, which serve to integrate complex object information in order to support lexical and phonological processes involved in naming.

D34 Semantic Word Processing Recruits Cortical Areas Involved in the Integration of Sensory-Motor Information

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The "embodied cognition" approach to semantics proposes that word meanings that are highly associated with particular sensory-motor features are stored in cortical areas involved in the perception of those features. In a previous study we showed that different sensory-motor attributes of word meaning engage distinct regions of sensory, motor, and association cortex, coinciding with or overlapping areas typically involved in the perception of the respective attributes. In the present study, we re-analyzed that data set with the goal of identifying cortical areas specifically involved in the integration of different types of sensory-motor information during lexical processing. Participants were 20 healthy, right-handed, native speakers of English. They were required to decide whether a word shown on the screen refers to something that can be experienced through the senses (semantic decision) and respond as quickly as possible by pressing one of two keys. The stimuli consisted of 900 words and 300 matched pseudo-words. All words had been previously rated by a separate group of 342 participants on 5 sensory-motor attributes: sound, color, shape, motion, and manipulation. Ratings were on a 0-6 scale. Stimuli were presented in pseudo-random order in a fast event-related design. We collected 10 runs of 196 volumes each on a 3T GE MRI scanner. Individual time courses were analyzed with a Generalized Least Squares regression model. To create a regressor that was sensitive to the integration of different sensorimotor attributes, we combined the five sensory-motor ratings into a single composite score and converted it to z-scores. The z-transformed RT for each trial was also included as a nuisance regressor. We normalized the individual beta maps into standard space and performed a random-effects analysis to test the significance of the regression parameters at each voxel. Accuracy in the task was .84 for words and .96 for pseudo-words. Activation maps were thresholded at a combined alpha of .0005 at the voxel level and .01 at the cluster level (> 20 voxels). The combined sensory-motor attributes regressor modulated multimodal integration areas in the bilateral parahippocampal (PHG), supramarginal (SMG), angular (AG), and posterior cingulate (PC) gyrus, as well as bilateral hippocampus. The PHG integrates visual information processed in different areas of the ventral stream (such as shape and color) for visual object recognition. The SMG is a convergence zone for motor and somatosensory information, involved in

action planning and action recognition. The PC is likely to integrate auditory, visual and somatosensory information (as it was modulated by both the shape and sound ratings in our previous analysis), and the AG has been presumed to be a high-level convergence zone for several sensory-motor processing streams. We propose that activation in the hippocampus, PC and retrosplenial cortex reflects encoding in episodic memory. There were also unexpected activations in some early visual areas, such as the lingual gyrus, and small areas in the pre- and postcentral gyri. Our results show that areas previously implicated in sensory-motor integration are involved in semantic word processing, supporting the notion of embodied "convergence zones" in semantic representation.

D35 Cued word-retrieval as a nonhomogeneous Poisson process: Evidence from inter-response intervals in semantic cued-word recall tasks

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Category-cued word retrieval has been understood as the outcome of two processes, the identification of semantic clusters by cues, and activation of lexical-semantic entries within each cluster (Troyer & Moscovitch, 2006). Recently, Meyer et al. (2012) examined the distributions of inter-response time intervals (IRI) in a category fluency test. They argued that the distribution of within-cluster IRIs supported a race model, as they followed a Weibull distribution. However, the distinction between within- and between-cluster IRIs was not made on the basis of semantic relatedness of words. In the current study, we addressed two methodological issues (definition and classification of IRIs) in their study, to determine what retrieval mechanism(s) are consistent with the observed IRI distributions. We tested 394 healthy adults on two category fluency tests (animal names and supermarket items) for 1 minute each. All verbal responses were digitally recorded. We employed the two definitions of IRI that have been used: (1) between the onsets of consecutively named words (e.g., Meyer et al., 2012) and (2) between offset of the first and the onset of the second words (e.g., Pickett et al., 2009). The IRIs of two words were classified as being within- or between cluster based on semantic/associative relatedness according to Ledoux et al.'s (2009) scoring system, independently of IRI measurements. With the onset/onset definition of IRI as in Meyer et al. (2012), virtually all of the within- and between-cluster IRI distributions of the two category conditions could not be fit well by Weibull, gamma, or exponential distributions (Kolmogorov-Smirnov tests). But with the offset/onset definition, the within- and between-cluster IRI distributions showed ever-decreasing patterns and were fit well by exponential, Weibull, or a mixture model of two exponential distributions. Furthermore, when the offset-onset within-cluster IRIs were divided into their relative locations in the 1 min production time (i.e., early and late clusters), exponential distributions provided good fits with greater means for the later cluster IRIs than for the early ones. This observation is consistent with the concatenation of multiple Poisson processes (i.e., nonhomogeneous Poisson process). The race model supported by a Weibull distribution of within-cluster IRIs implies that the search of concepts initiated by a cue within a cluster resets whenever a concept is found. A different model is that activation continues without resetting until all available concepts are exhausted and new clusters are sought, a mechanism that can be best characterized by spreading semantic activation. In race model terms, the race is not over until all entries are retrieved. This explanation is supported by the good fits of exponential distributions to within-cluster IRIs, which are consistent with a nonhomogeneous Poisson process for entire cued word retrieval. In addition, within- and between-cluster IRI distributions were not qualitatively different, suggesting that word retrieval processes in two situations are in fact similar; different only in parameters. Lastly, although it requires further validation, the offset/onset definition of IRI seemed to provide better estimates of true IRIs than the onset/onset definition does, given their fits to the expected stochastic process for cued-word retrieval.

D36 The role of the inferior parietal lobule for integrating meanings with orthographic similarity

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Functional magnetic resonance imaging (fMRI) was used to examine the neural correlates of semantic judgments to Chinese characters in adults. Previous research has demonstrated that character pairs with stronger association show greater activation in inferior parietal lobule (BA 39), indicating that this region is critical for integrating meanings between characters at the lexical level. Based on the direct mapping between orthography and semantics at the sublexical level in Chinese, we further explored the contribution of the semantic radical to semantic judgments. In this study, orthographic similarity was defined as characters having the same orthographic component (i.e. semantic radicals). Two semantic judgment tasks were used: visual-similar (i.e. shared a semantic radical) versus visual-dissimilar (i.e. did not share a semantic radical) character pairs. By the systematic manipulation of semantic association and semantic radical, this study aimed to explore the interaction of lexical and sublexical semantic information to semantic judgments. Participants were asked to decide if character pairs were related in meaning that were arranged in a continuous variable according to association strength. This parametric manipulation allowed for a more precise examination of the role of the left inferior parietal lobule (BA 39) in processing meaning. The results showed that stronger association pairs produced greater activation in the inferior parietal lobule in the visually similar task than the visually dissimilar task, demonstrating that similar orthography facilitates the detection of overlapping semantic features between

characters. Our findings suggest a combinatorial semantic processing that combines semantic features and captures similarity structures to define conceptual categories.

D37 Study of the human retrosplenial cortex during auditory and visual naming through grouped electro-corticography and cortical stimulation mapping *Cihan Kadipasaoglu[1], Tom Pieters[1], Vatche Baboyan[1], Christopher Conner[1], Nitin Tandon[1]; [1]Vivian Smith Dept. Neurosurgery, UT Houston*

The retrosplenial cortex (RSC) is considered to play a role primarily in spatial navigation, although recent evidence has implicated it in autobiographical and episodic memory retrieval, imagination, and planning. Unfortunately, its location has made study of the human RSC difficult. Evidence for functional specificity has been primarily derived from lesional analyses, which are rare and rarely unique to the RSC, and fMRI studies, which suffer from a lack of specificity. Patients undergoing subdural electrode (SDE) implantation, in preparation for surgical treatment of pharmacologically resistant epilepsy, present a unique opportunity to perform direct electrophysiological studies from the cortical surface in regions such as the RSC. SDEs provide the ability to study cognitive functions using high-fidelity recording techniques such as electro-corticography (ECoG) as well as disruptive techniques such cortical stimulation mapping (CSM). We investigated RSC activity using ECoG (n=24, left hemisphere, mid gamma range: 60 to 120 Hz) recorded during category-specific visual naming tasks (faces, places, animals, tools), as well as using CSM (n=51, left hemisphere, 3 to 10 mA) performed during repetition, auditory, and visual object naming tasks. We applied novel methods to spatially transform subject data and accurately represent ECoG and CSM on individual 3D cortical models, generated from high-resolution anatomical MRIs. Individual datasets were normalized to a common surface (N27) using surface-based co-registration to correct for cortical variability across patients. Grouped ECoG analysis was performed using a mixed-effects multi-level analysis (MEMA) to compare percent power change across patients following stimulus onset (50 to 700 ms), compared to baseline (-850 to -200 ms). Grouped CSM analysis was performed by modeling cortical depolarization from direct current spread, computing the point probabilities of linguistic function presence for the entire cortical region per subject, and then using a t-test to compute subject z-scores in common space. Grouped ECoG result yielded regions with significant percent power changes during category-specific naming ($p=.05$, corrected). Grouped CSM results yielded positive language sites by identifying significant disruptions of naming ($p<.001$, corrected). Multiple comparisons were controlled for by using familywise error rate (ECoG) or false detection rate (FDR) corrections. Significant RSC activity was identified in the grouped ECoG analysis during face, place, and animal naming, but not tool naming. Significant disruption of language by RSC stimulation occurred in auditory naming during CSM, but not visual or repetition naming. Our results demonstrate that the RSC is involved in semantic tasks such as auditory, face, place, and animal naming. The grouped electrophysiological results from large cohorts of patients undergoing CSM and ECoG provide direct specific evidence, which improves our understanding of the involvement of the RSC in cognitive functions. Further, the generation of statistically valid, topologically accurate, surface-based population maps of electrocorticographic and cortical stimulation data provides the opportunity to improve patient clinical outcomes, as well as enhance our understanding of cognitive function through meaningful multi-modal comparisons.

D38 Spatial Arrangement of Vertically Related Word Pairs affects the N400 Component *Cyrille Magne[1], Tyler Hubbard[1], William Langston[1]; [1]Middle Tennessee State University*

Several recent theories of cognition proposed that embodied experiences play an important role in language processing. In line with this view, several previous behavioral studies have shown that readers judge more quickly the semantic relatedness of word pairs sharing a spatial relationship (e.g., Attic and Basement) when they are presented vertically in their expected arrangement (e.g., "attic" above "basement") than when presented in their reverse spatial arrangement or horizontally. Embodied accounts of this effect propose that readers rely on perceptual simulations of the words pairs to make their decision. However, an alternative account suggests that this spatial relationship is encoded linguistically in the frequency of word order so that items that are higher are more frequently cited first. The present series of experiments directly seeks to compare the embodied vs word effect accounts. In two experiments, EEG was recorded in 32 participants while performing a semantic judgment task on pairs of words. In both experiments, stimuli consisted of 64 semantically related and 64 semantically unrelated word pairs. All of the related word pairs shared a vertical spatial relationship (e.g., Attic-Basement). In experiment 1, the two words of each pair were presented simultaneously in a vertical arrangement. Half the related pairs were presented in an iconic arrangement (e.g., Attic on top of Basement) while the other half were presented in a reverse-iconic arrangement (e.g., Basement on top of Attic). In experiment 2, word pairs were presented one word at a time in the middle of a screen. The order of presentation was manipulated so that the top item appeared first in half the pairs (e.g., Attic - Basement), or last in the other half (Basement - Attic). Results showed that unrelated word pairs elicited significantly larger N400 component than related word pairs in both experiments. In contrast, the N400 elicited by related word pairs was modulated by the spatial configuration of their presentation. In Experiment 1, related word pairs presented in a reverse iconic arrangement were associated with both higher error rates and larger

N400 components than related word pairs presented in an iconic configuration. Analysis of the estimated EEG sources revealed significant differences between iconic and non-iconic related pairs in a right fronto-parietal network between 300 and 600 ms. In Experiment 2, these effects were not present when the words were presented in succession in the center of the screen. Overall, these results suggest that perceptual simulations affect semantic processing, and primarily involve a visuo-spatial attentional network in the right hemisphere. The next step will be to utilize source analysis to compare the underlying neural generators of the N400s elicited by reverse iconic word pairs vs unrelated word pairs.

D39 Recovery from Anomia Following Semantic Feature Analysis: Therapy-Induced Neuroplasticity Relies upon a Circuit Involving Motor and Language Processing Areas

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Stroke remains a major health problem whose consequences can be devastating. Approximately 30% of stroke survivors are left with persistent language impairments. Aphasia is a language deficit that results in communication disabilities and reduced social participation which may in turn lead to isolation and depression. Anomia is the most frequent and pervasive aphasic symptom across aphasia types. Recovery from aphasia depends upon adaptive brain plasticity which is the brain's potential to regain function. Aphasia therapy may contribute to trigger this potential; however, our understanding of the links between neuroplasticity and aphasia therapy remain limited. Aphasia recovery is considered to rely upon two different mechanisms: functional reactivation with the recruitment of perilesional classical language areas, or functional reorganization which involves alternative networks of non-classical language areas, either in ipsilateral areas or in contralateral non-damaged right hemisphere (RH) areas. Number of studies provides evidence for the fact that, whether relying upon functional reorganization, functional reactivation, or combination of both, specific mechanisms underlie this recuperation, and these mechanisms can be enhanced by language therapies. The advent of neuroimaging techniques allows us to deepen our knowledge of these neuroplasticity mechanisms. Previous work by our lab (Marcotte et al., 2012), reported neurofunctional changes associated with recovery from anomia following Semantic Feature Analysis (SFA) in a group of chronic participants with moderate to severe chronic anomia, providing evidence of therapy-induced neuroplasticity in chronic aphasia. This paper discusses the activation patterns reported in Marcotte et al. study (2012), in light of anatomical and neurofunctional evidence linking motor and language processing in healthy adults. A group of nine participants with aphasia (PWA) and moderate to severe chronic anomia, recovered the ability to name nouns following SFA (for more details, please refer to Marcotte et al., 2012). Data analysis showed a positive correlation between a successful outcome following SFA and the significant activation of the left precentral gyrus (PCG: BA4/6), both before and after therapy. Moreover, a significant activation of the left inferior parietal lobule (LIPL) was observed concurrently with naming recovery following SFA. The LIPL and the LPCG, classically known to be part of speech production processing network, have been shown to be involved in semantic processing as well. In fact, the LIPL is considered to be a multimodal associative area, receiving auditory, visual and somatosensory inputs. The LPCG comprising the primary motor cortex (BA4) and premotor cortex (BA6), may play a role in semantic processing, and contribute to motor semantic system encoding of word-related motor features. Moreover, from an integration perspective, the evidence from DTI studies show that an indirect pathway transits between Broca's and Wernicke's areas through the LIPL , via the arcuate fasciculus the LPCG being a relay station for this fibers. Thus, the neurofunctional pattern observed following recovery with SFA suggests that the semantic nature of this therapy favored a specific recruitment reflecting the importance of sensorimotor information supported by the LPCG, and transmodal binding of this information by the LIPL.

Discourse, Combinatorial Semantics

D40 Semantic illusions reveal cross-linguistic differences in auditory sentence processing: Evidence from EEG and fMRI.

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The processing of sentence meaning is influenced by predictions generated via the contextual environment. Expectations can facilitate comprehension but also increase susceptibility to semantic illusions such as the famous „Moses Illusion" [1]. Recently, an English ERP study [2] showed that detected borderline anomalies (i.e., sentences in which the semantically incongruous word has a close fit to the global context) elicit a late positivity only, whereas classic, easy-to-detect semantic violations engender an N400-late positivity pattern. Given systematic cross-linguistic differences in the electrophysiological response to semantic reversal anomalies [3], we conducted four event-related studies using EEG and fMRI to test whether the processing of borderline anomalies differs in English and German. The experimental design was identical across the studies, asking participants to listen to context-target sentence pairs of both anomaly types and their non-anomalous controls and to make a binary plausibility judgement. While the English ERP study (n=18) replicated previous results, the German study (n=22) found a biphasic N400-late positivity response for detected anomalies of both types compared to their non-anomalous counterparts. The results of the fMRI experiments

showed the opposite pattern. For German (n=18), group analysis of the BOLD response to anomalous sentences elicited diverging activation depending on anomaly type. Compared to non-anomalous sentences, easy anomalies showed higher bilateral activation in the superior temporal lobe (transverse temporal sulcus, planum temporale and superior temporal gyrus) and inferior parietal lobule (supramarginal and angular gyrus), while detected borderline anomalies only revealed higher activation in the inferior parietal lobule and anterior insula. In English (n=21), the activation patterns for the same contrasts showed less variation. Here, detected borderline and easy anomalies elicited higher activation in the left prefrontal cortex including pars orbitalis/triangularis/opercularis of the inferior frontal gyrus than non-anomalous sentences. In contrast to German, this comparison did not reveal higher activation for detected anomalies in temporal and inferior parietal regions. The ERP results speak in favour of an account explaining the absence/presence of the N400 by language-specific weighting of top-down and bottom-up factors that influence semantic processing. Crucially, the absence of an N400 in English can be explained by a strong top-down impact of predictions based on word order information. This causes a temporary blindness and delayed detection of the anomaly reflected by the late positivity. This is in line with the fMRI results since activation in the prefrontal cortex has been associated with both the P600 and domain-general cognitive control processes [4-6]. In German, a more thorough analysis of bottom-up information leads to an earlier detection of the anomaly and to higher activation in temporal and inferior parietal regions. [1] Erickson, T.D., & Mattson, M.E. (1981). J Verb Learn Verb Behav, 20. [2] Sanford, A.J. et al. (2011). J Cog Neurosci, 23. [3] Bornkessel-Schlesewsky, I. et al. (2011). Brain Lang, 117. [4] Stowe, L. et al. (2005). Lingua, 115. [5] Thompson-Schill, S.L. et al. (1997). PNAS, 94. [6] van de Meerendonk, N. et al. (2011). NeuroImage, 54.

D41 Predictability and Plausibility in Sentence Comprehension: An ERP Study

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Many models of language processing suggest that people predict not only general semantic content of discourse, but also specific semantic and lexical features of upcoming words in sentences [1]. Thornhill and Van Petten (2012) showed that the N400 is sensitive to the conceptual match between a word and the meaning built up by the context, while the frontal positivity that often follows is sensitive to whether the word matches the specific lexical item suggested by the prior context. Here we tested whether the frontal positivity is modulated by the eliciting word's plausibility, or whether implausible sentence completions elicit a parietal positivity [2]. ERPs were recorded from 16 healthy adults as they read 145 high- and 145 low- constraint sentence frames ending with either the best completion from an off-line sentence completion task, or three types of unexpected endings. These included related endings, plausible completions that were similar in meaning to the best completion; unrelated endings, plausible completions of the sentence frame that were unrelated to the best completion; and implausible completions. Example stimuli: High constraint: Gary doesn't think a husband should cheat on his… Best Completion: wife./Related: spouse./Unrelated: taxes./Implausible: cement. Low constraint: The final score of the game was… Best Completion: tied./Related: even./Unrelated: posted./Implausible: quilted. Sentence frames and final words were arranged so that each participant saw at least 35 different sentences in each condition with no repetition of sentence frames or sentence-final words. Across participants, each sentence frame was paired in equal frequency with the Best Completion, Related, Unrelated, and Implausible endings. Experimental manipulations affected the amplitude of ERPs measured 300-500ms (N400) as well as the late positivity measured 500-800ms post-word onset. The N400 results confirmed previous findings that N400 amplitude is sensitive both to cloze probability and semantic relatedness [3]. In order of increasing N400 amplitude (i.e. the least negative appears first) were high constraint Best Completions, low constraint Best Completions, high and low constraint Related, high constraint Unrelated, low constraint Unrelated, and high and low constraint Implausible sentence completions. For both high and low constraint sentences, best completions elicited less positive ERPs over frontal electrodes 500-800ms post-onset than all low-cloze completions, replicating the finding that unexpected sentence final words elicit larger frontal positivities than do the best completions [2]. For high constraint sentence frames, the amplitude of the frontal positivity was similar for Related, Unrelated and Implausible endings. For low constraint sentence frames, there were no differences in the overall amplitude of the late positivity elicited by the Related, Unrelated and Implausible low cloze endings, but analysis suggested subtle topographic differences between the positivity elicited by the Unrelated endings compared to both the Related and Implausible endings, as the latter two patterned together. These results suggest that a similar cognitive process may be elicited by all types of failed lexical predictions, but there may be modulation of this mechanism or additional processing elicited by different types of failed predictions. [1]Van Berkum et al., 2005 [2] Thornhill & VanPetten, 2012 [3]Kutas & Federmeier, 2011

D42 The role of left anterior temporal lobe in semantic integration: Evidence from Event-Related Optical Signals

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The neural basis of integrative processes in language comprehension has attracted much attention in psycholinguistic research. Both left inferior frontal gyrus (LIFG) and left anterior temporal lobe (LATL) have typically been associated with such integrative processes.

Activation in LIFG has often been reported by previous imaging studies on language processing, especially in fMRI studies. However, the function of LATL in language comprehension is still not clear, partly because LATL is located near the air-filled cavities, where fMRI signals are easily distorted. In a recent study (Huang et al., in press), we used the Event-Related Optical Signal (EROS) technique (Gratton et al., 1995) that is of both high temporal (less than 100ms) and spatial resolution (5-10mm) to examine the dynamics of brain activation in these regions for semantic integration in sentence reading. We found that LATL was more strongly activated during approximately 200 to 300 ms when comparing the highly expected sentences with the unexpected ones. We proposed that LATL may be related to the relatively "rapid" and transient integration, through which participants constructed coherent sentence representations. The present study used the EROS technique to verify our hypothesis about the integrative role of LATL in semantic processing with a simple composition paradigm (Bemis and Pylkkänen, 2011). Twelve subjects read 450 pairs of lexical items presented one item at a time, comprehended the items in each pair, then made a lexical decision to the second item in each pair (i.e., the target). The EROS responses were recorded and time-locked to the target. Each target was preceded by a word that could be integrated with the target to form a meaningful phrase (i.e., the congruent condition), a word that could not form a meaningful phrase with the target (i.e., the incongruent condition), or a meaningless nonword consisting of randomly combined strokes (i.e., the control condition). Another 300 lexical pairs, in which the second item was always a nonword, were used as fillers to balance the number of positive and negative responses. The EROS data revealed that at around 200-300ms, relative to that in the control condition, the activation of LATL in both the congruent and the incongruent conditions were significantly stronger, while the congruent condition had a significantly greater activation than the incongruent one. In contrast, comparing with the congruent condition, the incongruent condition evoked a stronger activation in LIFG in the N400 time window. Thus, the activation in LATL differed from that in LIFG not only in the time window (LATL: around 200-300 ms vs. LIFG: N400) but also in the pattern of activation (LATL: congruent > incongruent; LIFG: incongruent >congruent), suggesting that LATL and LIFG may reflect two different brain pathways for semantic processing. Specifically, LATL may reflect a relatively rapid and automatic integration process, whereas LIFG reflect an enduring integration, by which readers try to reconstruct a coherent representation for the incongruent phrases.

D43 Pre-Activation of Semantic Features in Spoken Discourse *Megan A. Boudewyn[1], Debra L. Long[1], Tamara Y. Swaab[1]; [1]University of California, Davis*

Introduction Recent evidence suggests that comprehenders pre-activate grammatical and phonological features of specific lexical items when context is moderately to highly constraining (van Berkum et al., 2005; Wicha et al., 2004; Delong, Urbach & Kutas, 2005; Szewczyk & Schriefers, 2013). However, it is currently unknown whether comprehenders are able to pre-activate semantic features of upcoming words. The present study examined this question by comparing event-related potentials to feature-words that were consistent or not with a predictable upcoming noun (e.g., "giant" or "small" in a story in which "panda" is predictable). If comprehenders pre-activate semantic features of highly predictable upcoming words, the results should show a difference in N400 amplitude between Discourse-Consistent (smaller amplitude) and Discourse-Inconsistent (larger amplitude) features. Methods Participants (n=16) listened to two-sentence passages that were constructed such that a particular noun was highly expected, given the overall story context, midway through the second sentence. Critically, at this point in the story, the highly predictable noun was replaced by a prediction-consistent semantic-feature word of that noun (Discourse-Consistent Feature) or a prediction-inconsistent feature-word that was instead consistent with another, unexpected noun (Discourse-Inconsistent Feature). For example, given a story context such as "Wendy heard that the zoo had acquired a new animal that was shipped all the way from China. She patiently waited in the long line to see the ___", the noun "panda" was highly expected, whereas the noun "koala" was not. In this example, the Discourse-Consistent Feature continuation was "giant", whereas the Discourse-Inconsistent Feature continuation was "small". Importantly, neither the Discourse-Consistent nor the Discourse-Inconsistent features were expected in the stories at that point. ERPs were time-locked to critical feature words (giant/small) and nouns (panda/koala). Results Results showed that N400 amplitudes were significantly reduced for Discourse-Consistent features compared to Discourse-Inconsistent features (p less than 0.001). At the subsequently presented noun, results showed a main effect of Discourse-Expectedness: the N400 to the discourse-expected nouns was significantly reduced relative to the discourse-unexpected nouns (p less than 0.001). There was also a significant Feature-Consistency by Discourse-Expectedness interaction (p less than 0.05), such that the N400 amplitude to nouns that were unexpected at the discourse-level (koala) was reduced when they were preceded by a consistent local cue (small), as compared to when they were preceded by an inconsistent local cue (giant). Conclusion These results suggest that listeners routinely pre-activate specific semantic features of nouns that are predictable given the discourse context. This is consistent with recent proposals suggesting that underspecified predictions, such as pre-activation of semantic features, might be routinely made during language comprehension (Van Petten & Luka, 2012; Szewczyk & Schriefers, 2013; Kuperberg, in press; see also Pickering & Garrod, 2007 for a production-based account of both fully-specified and under-specified predictions).

D44 Sentence processing reflected in oscillatory and event-related brain activity *Nietzsche Lam[1,2], Annika Hultén[1,2], Julia Uddén[1,2], Jan-Mathijs Schoffelen[1,2], Peter Hagoort[1,2]; [1]Max Planck Institute for Psycholinguistics, Nijmegen, The Netherlands, [2]Radboud University Nijmegen, Donders Institute for Brain, Cognition and Behaviour, Donders Centre for Cognitive Neuroimaging, Nijmegen, The Netherlands*

The Memory, Unification and Control Model (MUC) of sentence processing (Hagoort, 2005, 2013) proposes that contextual constraints help the integration of the lexical and semantic characteristics of the current word into the unfolding sentence representation. In this model word retrieval is thought to take place in the left posterior temporal region, while unifying words into a meaningful sentence requires the contribution of the left frontal cortex. Here, we evaluate whether brain activity, quantified in terms of oscillations and event-related brain responses, can be related to the MUC model. Specifically, we ask if the computations underlying word retrieval and unification vary in the degree in which they are time and phase-locked with respect to the onset of the stimuli. We measured 84 participants during MEG while they read 120 sentences and 120 word lists, which were visually presented word-by-word. We created word lists by scrambling the sentences. The conditions were counterbalanced across participants so that no subject saw both the sentence and its word list counterpart. We analysed the data from -0.2 to 1.0s, around the onset of each word. Thus, our main comparison was between single words in a sentence context and single words in a word list context. In the oscillatory domain we focused on the 16Hz (beta) frequency band. We computed source models with minimum norm estimates and beamforming for the event-related responses and oscillations, respectively. In the analysis of the evoked responses, activation proceeded over time from bilateral occipital to left dominated occipito-temporal, left temporal and frontal regions. In the oscillatory domain, sources were more bilateral, and additionally found in the parietal cortices. When comparing the words in sentence to the same ones in word lists we found that the amplitudes of evoked activity in the left temporal and frontal cortices were significantly higher in the sentence context (between 0.2 and 0.6 s after word onset). The oscillatory signal showed a significant decrease in power for the words in a sentence relative to words in the word lists in these very same regions. Conversely, within a fronto-parietal network we found a significant bilateral increase in power for words in sentences. As a function of word order in sentences, we also found a parametric increase in beta power in left superior temporal gyrus, but a parametric decrease in bilateral occipital and parietal regions. The present data suggests that while there are partial overlaps in areas found activated in the analyses of the event-related and oscillatory responses, there are also non-overlapping areas that suggest the involvement of functionally different networks. Further investigation is required to explain the functional differences between event-related and oscillatory responses in a complex cognitive task such as sentence processing.

D45 A tale of two hubs: a multi-voxel similarity analysis of semantic composition types in left anterior temporal lobe and angular gyrus *Christine Boylan[1], John C. Trueswell[1], Sharon L. Thompson-Schill[1]; [1]University of Pennsylvania*

The left anterior temporal lobe (LATL) and left angular gyrus (LAG) have been dubbed "semantic hubs" due to their reliable involvement in multi-modal semantic processing and conceptual combination. However, it is unclear which aspects of semantic composition each area subserves. Work on adjective-noun pairs demonstrates the LATL is sensitive to "feature-based" combinatorics, whereby meaning is derived by combining concepts' features (Baron et al., 2012; Bemis & Pylkkänen, 2011). LAG, on the other hand, has been implicated in tracking event structure and thematic relations between concepts (Graves et al., 2010). One prediction emerging from these studies is that LATL subserves "feature-based" combination of predicates with other predicates, formalized as Predicate Modification (PM), while LAG is more sensitive to "function-based" thematic relations of the sort that arise when a predicate is combined with its arguments (formally Functional Application (FA)) (Heim & Kratzer, 1998). However, it is unknown whether LAG might be sensitive to Functional Application in general, which derives meaning for both verb and non-verb phrases (e.g. prepositional phrases), or to the valency of verbs in particular (Thompson et al., 2007). In an fMRI study, adult English speakers [N=8] read word pairs, whose composition involved either FA or PM and whose head was either a verb or not. We compared +verb_FA compositions like "cooks food" with both (1) –verb_FA (no verb) compositions like "with food" and (2) +verb_PM compositions like "cooks daily" (where "daily" modifies "cooks" and there is no application of an argument). We predicted that LATL would be more sensitive to composition type (FA vs. PM) than LAG; i.e. that the +verb_FA pattern would be more similar to the –verb_FA pattern in LATL than in LAG. We also predicted that LAG would be sensitive to a different dimension of composition than FA-vs.-PM, namely thematic relations of event-denoting verbs, and thus to the presence/absence of a verb. Under this hypothesis, the +verb_FA activity pattern would predict the +verb_PM in LAG but not LATL. We assessed the similarity of fMRI patterns evoked by these stimuli; e.g., how similar are the multi-voxel patterns evoked by "cooks food" and "with food" in different regions? For a given ROI, we looked at the correlations within 36 sets of {+verb_FA, -verb_FA, +verb_PM}, where +verb_FA and –verb_FA had the same noun object and +verb_FA and +verb_PM had the same verb. For each subject, a voxel pattern for the +verb_FA condition

was correlated against both +verb_PM and –verb_FA patterns. The resulting similarity matrix allowed us to compare composition profiles between LATL and LAG. We found that +verb_FA was a significant predictor only of –verb_FA in LATL (permutation test, $p < 0.05$), while +verb_FA was marginally predictive of +verb_PM in the LAG. Crucially, the +verb_FA-+verb_PM correlation was significantly greater in LAG than in LATL across subjects ($t(7)=4.17$, $p<0.01$), and the -verb_FA-+verb_FA correlation was significantly greater in LATL than in LAG ($t(7)=5.37$, $p<0.01$). This suggests LAG is more sensitive to verb structure similarity than composition type, while LATL captures similarity of composition type regardless of whether a verb is present.

D46 Conceptual combination vs. numeral quantification in the left anterior temporal lobe: MEG evidence from production and comprehension

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INTRODUCTION: The left anterior temporal lobe (LATL) has risen as a leading candidate for a brain locus of composition in language; yet the computational details of its function are unknown. Although most literature discusses it as a combinatory region in very general terms (e.g., Hickok & Poeppel, 2007), it has also been argued to index the more specific function of conceptual combination (Baron & Osherson, 2011), which in the classic use of this term (e.g., Hampton, 1997) mainly pertains to the combination of open class words with obvious conceptual contributions. We aimed to distinguish between these two possibilities by contrasting plural nouns in contexts where they were either preceded by a color modifier ("red cups"), eliciting conceptual combination, or by a number word ("two cups"), eliciting numeral quantification but no conceptual combination. This contrast was chosen as it works well both for comprehension and production: a display of two red cups can be named as "two cups" or "red cups" depending on the task instruction. MEG activity was recorded either during the comprehension of these phrases or during their planning for production, prior to motion artifacts. DESIGN: In production we kept the first uttered word constant across combinatory and non-combinatory stimuli whereas in the comprehension design the target noun was kept constant. In production all conditions needed to involve the same number of words to keep reaction times parallel. In comprehension, this was less crucial and since finding a natural non-combinatory two-word utterance involving a plural as a second word proved difficult, only one-word controls were used. Consequently, the non-combinatory controls of the production design were two-word color and number lists, elicited by displays of colored patches and dots (in dice-like arrangement), respectively, whereas the control of the comprehension design was the plural noun preceded by a consonant string. The comprehension phrases were followed by pictorial displays that either matched or mismatched the phrase. PRODUCTION (current N=7): Number-Phrase: "two cups"; Color-Phrase: "red cups"; Number-List: "two,one"; Color-List: "red,white" COMPREHENSION (current N=5): Number-Phrase: two cups; Color-Phrase: red cups One-word: qwj cups; RESULTS: Production: A 2x2 cluster-based permutation test (Maris & Oostenveld, 2007) on LATL activity revealed an interaction between Word-Type (Color vs. Number) and Composition (Phrase vs. List) at 126-236ms ($p<.05$). Pair-wise comparisons showed this effect was driven by an increase for Color phrases ("red cups") compared to list controls ("red,white"; $p<.05$); the Number phrases ("two cups") did not elicit increased activity compared to their list control ("two,one"). Comprehension: Pairwise cluster-based permutation tests of the phrasal conditions compared to the one-word control showed an increase for Color phrases at 167-283ms ($p<.05$) but no increase for Number phrases. CONCLUSION: Our results show that although the LATL is sensitive to conceptual combination of color adjectives and object-denoting nouns ("red cups"), this effect does not extend to numeral quantification ("two cups"), suggesting that the LATL may be specifically involved in conceptual combination. A qualitatively similar data pattern was found in comprehension and production, supporting models where combinatory mechanisms are shared between these processes.

Syntax, Morphology

D47 Individual Performance on the Raven Matrices Predicts Brain Responses to Visual Word Category Violation

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1. Introduction: Interpretations of e[arly] L[eft] A[nterior] N[egativities] to W[ord] C[ategory] V[iolations] such as "The man admired Don's *of sketch the landscape" as obligatory, language/syntax-specific processes of phrase structure generation (e.g., Friederici, 2002), have clashed with counterevidence and arguments prompting their revision (Steinhauer & Drury, 2012). First, a number of visual studies point out that these components may index low-level visual responses to mismatching word forms instead of language-specific eLANs (e.g., Dikker et al., 2009; Kim & Gilley, 2013). Second, there is evidence that WCVs can elicit semantics-related N400s instead of eLANs (van den Brink & Hagoort, 2006; Zhang et al., 2013), downplaying the claim that a sentence's syntactic structure is a temporal requisite to its semantic analysis. Taken together, these findings suggest that the cortical mechanisms of visual processing may play a more important role in visual WCV studies than previously assumed. However, the specific role of visual processing in detecting the formal and semantic aspects of WCV

remains elusive. An interesting strategy in understanding this role is to focus on the possible neural correlates of participants' strength and weaknesses in visual processing during language comprehension (Kraemer et al., 2009). 2. Methods: Inspired by the above-mentioned findings as well as the literature on "individual differences" in language processing, we further investigated the role of vision in the detection of the formal and semantic correlates of WCVs by examining the relationship between participants' performance on the Raven's test of visual processing (Raven et al., 1998) and their ERP responses to written WCVs in a "balanced paradigm" (see point 3 below) to avoid methodological shortcomings identified in earlier studies (e.g., "contextual effects", "spill-over" etc.; see Steinhauer & Drury, 2012). We reasoned that if early (0..200 ms) brain responses to WCV were to be conceived of as sensory visual components (i.e., N100) instead of eLANs, these components may be more prominent in high Raven performers relative to low Raven performers in response to visual WCV. Another prediction was that if visual processing could somehow be linked with the semantic aspects of linguistic analysis, similar correlates between component amplitude and Raven performance may also affect the N400 (200..400 ms). 3. Examples of stimuli: a. He chose the rabbit to adopt for his kids; b. He chose the *adopt to rabbit for his kids; c. He chose to adopt the rabbit for his kids; d. He chose to *rabbit the adopt for his kids. 4. Results and Discussion: Increased N100s and N400s to WCV were found in high- relative to low-Raven performers, suggesting not only that visual processing is implicated in the formal *and* semantic aspects of WCV detection, but also that this phenomenon depends in great part on individual participants' strengths and weaknesses in visual processing. These findings provide a potential basis for reworking current neurocognitive models of sentence comprehension, taking individual differences in cognitive style into account. Possible connections with other domains of cognitive neurosciences such as "mental imagery" and developmental neuroscience (Bourguignon et al., 2012) will be discussed.

D48 Dimensions of argument structure complexity: Evidence from fMRI *Jennifer Mack[1], Aya Meltzer-Asscher[2], Elena Barbieri[1], Ellen Fitzmorris[1], Cynthia K. Thompson[1]; [1]Northwestern University, [2]Tel Aviv University*

Introduction. Verbs vary with respect to multiple dimensions of argument structure complexity: the number of arguments (transitive verbs, e.g. cut, are more complex than intransitive verbs, e.g., wink), the mapping between thematic roles and syntactic positions (unaccusative verbs, e.g., fall, which take theme subjects (noncanonical), are more complex than unergative verbs, e.g., wink, which take agentive subjects (canonical)), and the number of syntactic frames (alternating verbs, e.g., break, are more complex than non-alternating verbs, e.g., fall). Previous research has found effects of argument number in left posterior temporal and inferior parietal regions (Ben-Shachar et al., 2003; Den Ouden et al., 2009; Thompson et al., 2007, 2010), whereas left frontal as well as posterior perisylvian regions have been associated with processing unaccusative (Shetreet et al., 2010) and alternating verbs (Meltzer-Asscher et al., 2012; Shetreet et al., 2007). However, the contributions of these regions to argument structure processing are not yet clear. Methods. 29 healthy, right-handed adults (M age = 40, range = 19-74), all native English speakers, performed lexical decisions on visually-presented pseudoverbs (e.g., to ventire) and verbs from four argument structure classes: unergative (e.g., to wink), unaccusative (e.g., to fall), transitive (e.g., to cut), and alternating (e.g., to break). The design was event-related with 1500 ms stimulus presentation, 500 ms ISI, and jittered null events (0-20 sec). Scanning took place on a Siemens TIM Trio 3T scanner. Behavioral (RT) analysis was performed using mixed-effects regression in R. fMRI data analysis was performed in SPM8 with group analyses thresholded at a p-value of 0.001 (voxel-level, uncorrected), with cluster-level FWE correction (p-value 0.05). Imageability and participant age were included as predictors in both behavioral and fMRI analyses. Results. Behavioral results: Verb class significantly predicted RT, with unaccusative verbs eliciting longer RTs than the three other verb classes. Imageability was also a significant predictor of RT (longer RTs for less imageable words), as was participant age (longer RTs for older participants). FMRI results: Transitive verbs elicited greater activation in the left posterior middle temporal gyrus (MTG) relative to verbs with one argument (unergative + unaccusative) (peak MNI coordinates: [-50 -70 10], 1640 mm3, p = 0.032). The left posterior inferior frontal gyrus (IFG) exhibited greater activation for unaccusative verbs as compared to verbs with agentive subjects (unergative + transitive) ([-46 2 28], 2896 mm3, p = 0.005). No significant activation was found for alternating verbs as compared to verbs with one syntactic frame (unergative + unaccusative + transitive). Conclusions. Consistent with previous studies, complexity in terms of argument number was supported by the left posterior MTG, supporting previous research suggesting that this region is associated with storage and retrieval of argument structure representations (Thompson and Meltzer-Asscher, in press). Greater activation for unaccusative verbs in the left IFG may reflect noncanonical thematic mapping (Hirotani et al., 2011) and/or syntactic movement (Hirotani et al., 2011; Shetreet et al., 2010). In contrast with previous studies, the number of syntactic grids did not elicit differential activation, perhaps due to the inclusion of different verb classes between studies.

D49 Morpho-syntax and the aging brain: An ERP study of sentence comprehension in older adult Spanish speakers *Alondra Chaire[1], Viridiana Estrada[1], Nicole Wicha[1,2]; [1]The University of Texas at San Antonio, [2]The University of Texas Health Science Center - San Antonio*

Normal aging comes with increased knowledge, as well as qualitative and quantitative changes in cognitive processes. Previous work with English monolinguals has shown that event-related potential (ERP) measures of sentence comprehension decrease in amplitude (N400), or change in distribution (P600) with age. However, little is known about the electrophysiological correlates of aging with regard to other languages, especially those with richer morpho-syntax than English. In this study we measured ERPs in native speakers of Spanish while they read sentences in Spanish and measured 2 ERP components related to sentence comprehension, the N400 – reflecting meaning-level processes, and the P600 – reflecting brain processes sensitive to syntactic information. Our aims were: 1) to identify age-related differences in sentence comprehension between younger and older Spanish speakers, specifically for grammatical gender agreement, and 2) to determine how syntax and semantics interact in the healthy aging brain. Methods. Younger adult (18 – 35 years of age) and older adult (55 + years of age) native speakers of Spanish were matched based on education level and verbal fluency. Participants read sentences in Spanish one word at a time (300ms duration; 200ms ISI). A target article–noun pair in each sentence was manipulated to create four conditions: gender match and semantically congruous (control sentence), gender mismatch and semantically congruous, gender match and semantically incongruous, and double violations - gender mismatch and semantically incongruous (e.g., "Es increíble que una oruga se pueda convertir en una/un mariposa/tortuga tan hermosa." Translation: It is incredible that a caterpillar can turn into a[fem]/a[masc] butterfly[fem]/turtle[fem] so beautiful.) ERPs were measured from the onset of the target noun. Results and Conclusion. Older adults showed a similar pattern of effects compared to previous findings in young adults (Wicha, Moreno and Kutas, 2004). In older Spanish speakers, semantic violations elicited larger N400 amplitude and larger late positive amplitude compared to control sentences. Gender agreement violations elicited a negativity over left anterior electrodes followed by an increase in late positive amplitude compared to control sentences. Double violations elicited a boosting of the N400 effect over frontal and prefrontal electrodes compared to semantic violations alone, indicating that gender and semantics interact early in processing. Finally, the amplitude of the P600 did not differ between the 3 violation conditions, reflecting a significant cost in reprocessing errors in older adults regardless of the type of violation. The differences in processing grammatical gender and the interaction between gender and semantics between younger and older adults appear to be primarily quantitative and not qualitative in nature. These findings will be discussed in light of models of sentence comprehension and aging.

D50 Sentence Processing: Reflexives vs Syntactic Movement. An ERP Study *Ruben Torres Agustin[1,2], Mario A. Rodriguez Camacho[2], Juan F. Silva Pereyra[2], Yaneth Rodriguez Agudelo[1], Amanda G. Jaimes Bautista[1,2], Martha Alejandra Gomez Lopez[2]; [1]National Institute of Neurology and Neurosurgery, Mexico, [2]National Autonomous University of Mexico*

Under the base of experiments with normal subjects and patients during syntax comprehension tasks, it has been proposed that object relative clauses whit syntactic movement are more difficult to process than reflexive clauses. To test that proposal, this study focused on the analysis of the N400 (associated to semantic processing) and the P600 (associated to the syntactic processing) ERPs of 20 Mexican-Spanish speakers while performing a sentence comprehension task. The task consisted of 160 sentences to be discriminated. Subjects were faced with sentences like: "La gallina vio a la señora que preparó el guisado" (distance 0 / no movement), object relative clauses with syntactic movement "La señora a la que miró la gallina preparó el guisado" (distance 1). Reflexive sentences "El campesino al que vio el caballo se quemó la mano" 50% of the sentences ended with a semantic incongruity "La señora miró a la gallina que preparó el guisado" / "El campesino miró al caballo que se quemó la mano" . EEG recording was performed while the subjects were asked to differentiate the congruity/incongruity, the ability to differentiate the incongruity was obtained by the N400 component, also studied the P600 and LAN waves of Event-Related Potentials. No differences were found between the two types of sentences without movement or distance (object relative/reflexive) in the number of correct answers. Differences were found between the two types of sentences with syntactic movement or distance (object relative/reflexive) in the number of correct answers. There were also differences between two types of sentences with syntactic movement or distance in the reaction times, the object relative clauses with syntactic movement had longer times. Regarding the difference in average amplitudes for the N400, were found no differences between conditions, but a trend to higher latency in "distance 1/semantic incongruity"; respecting to P600 and LAN components, there were no differences in latency, but amplitude differences were found in the "distance 1 conditions" . This results suggest that indeed, object relative clauses with syntactic movement are harder to process than reflexive sentences.

D51 ERP responses to portioning and sorting in Icelandic: contrasting coercion with silent syntax *Drew Trotter[1], Matthew Whelpton[2], Þórhalla Guðmundsdóttir Beck[2], Curt Anderson[1], Joan Maling[3], Alan Beretta[1]; [1]Michigan State University, [2]University of Iceland, [3]Brandeis University*

INTRODUCTION In Icelandic, sorts and portions readings of mass nouns are distinguishable by determiner-noun agreement. (1) annað kaffi another_(neut.) coffee_(neut.) (Sorts interpretation) (2) annan kaffi another_(masc.) coffee_(neut.) (Portion interpretation) In (1), the meaning of 'kaffi' is coerced to countable sorts. In (2), 'annað' agrees with an unexpressed nominal 'bolli' (cup_(masc.) which is built into the syntactic representation, the Extra Syntax contributing to a countable portions interpretation (Wiese & Maling, 2005). We compared Coercion, Extra Syntax and Neutral conditions following a common sentence frame, Determiner-Noun1-Noun2: Coercion: another_ (fem.) sauce_(fem.) bowl_(fem.) Neutral: another_(fem.) doll_(fem.) pram_(fem.) Extra Syntax: another-(fem.) rum_ (neut.) bottle_(fem.) Using fillers to set up an expectation the sentences would end at N1, we predicted distinct ERP profiles for each condition at N1. Expected commitments made at N1 must be reversed at N2 unevenly across conditions: Coercion: N1: mass-count coercion; assume N1 is head-N N2: revise coercion, and head-N to N2 Neutral : N1: assume N1 is head-N N2: revise head-N to N2 Extra Syntax: N1: gender mismatch; build unexpressed-N into syntax; assume it is head-N N2: unexpressed-N now expressed; no revision METHODS 18 native speakers of Icelandic read 35 sentences per condition (and 280 fillers with a single noun in object position.) Frequencies and word-lengths were controlled. Pretests (cloze, plausibility, portion-sorts rating) established stimuli were as intended. Sentences were presented RSVP (SOA 600ms) in 8 blocks; randomized for each subject. 32 electrodes. 256Hz sampling rate; filter 0.01 to 40Hz. Linked mastoids as reference. RESULTS N1: Mean ERP amplitude calculated for each condition and ROI during 350-450 and 500-700ms windows. 350-450ms: main effect of ROI [$F(6,102) = 5.37$, $p = 0.0069$], no main effect for condition [$F(2,34) = 0.31$, $p = 0.70$]. ROI x Condition interaction [$F(12, 204) = 4.71$, $p = 0.0013$]. Extra Syntax more negative than Coercion or Neutral at two anterior ROIs. 500-700ms: main effect for ROI, [$F(6,102) = 4.91$, $p = 0.015$] and for Condition, [$F(2,34) = 4.75$, $p = 0.015$]. Interaction ROI x Condition, [$F(12,204) = 7.92$, $p = 0.00001$]. Extra Syntax more positive than Coercion and Neutral at four centroparietal/posterior ROIs. N2: 350-550ms: main effect for ROI [$F(6,102) = 7.48$, $p = 0.005$], no main effect for condition [$F(2,34) = 2.45$, $p = 0.13$]. Interaction of ROI x Condition [$F(12,204) = 5.21$, $p = 0.007$]. Coercion and Neutral more negative than Extra Syntax at two anterior ROIs. DISCUSSION At N1, no effect was observed for Coercion, but clear effects were found for Extra Syntax: an early anterior negativity followed by a late centroparietal positivity. Like others (Koester et al., 2004), we interpret the early negativity as an index of the (legitimate) gender mismatch, and the late positivity as a P600, often associated with reanalysis, but here slightly extended in range to build the unexpressed syntax. At N2, we view the increased negativity of Coercion and Neutral as indicative of revising the commitment of head noun from N1 to N2; relative to Extra Syntax which has no work remaining.

Control, Selection, Working Memory

D52 Graded specialisation for words and pictures in prefrontal cortex: An fMRI investigation of semantic and linguistic control across tasks and modalities

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The contribution of left inferior frontal gyrus (IFG) to linguistic control is well-established in the context of phonological and verbal semantic judgements, but there is a paucity of research investigating the neural basis of semantic control processes in other modalities. This study used fMRI to observe graded functional specialisation within IFG for phonological, verbal semantic and picture semantic tasks which varied in their difficulty (indexed by RT). We observed changing effects of task and modality across posterior to anterior IFG: while some sites responded to control demands irrespective of task and modality (mid-LIFG, BA45), the engagement of semantic and linguistic control regions was also influenced by the nature of the input. Posterior parts of left IFG (BA44) responded to difficulty across all tasks yet showed greater activation for phonological than semantic decisions and for pictures relative to words. Anterior left IFG (BA47) did not show this stronger response to phonological decisions, yet showed greater activation for verbal than picture semantic tasks, in sharp contrast to the multimodal response in BA45: this is consistent with the view that anterior IFG contributes to more abstract forms of control. There were also important differences between the left and right hemispheres: posterior parts of right IFG showed more activation for pictures than words. The right IFG response to easy verbal tasks was not above baseline, yet this site was recruited for more difficult verbal tasks, confirming that linguistic and semantic control processes are bilateral.

D53 Cerebral organization of verbal associations: Is prior semantic representation important?

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The aim of this study was to clarify how the degree of semantic loading on verbal material, presented as a simple paired associate learning paradigm, alters the pattern of neuronal recruitment within and between the cerebral hemispheres. Participants were 21 healthy, English-speaking, and tertiary educated volunteers (10 male; 1 left handed). Mean age was 29.9 years (SD 7.88 years; range 18-48 years). The study received approval from the Austin Health Human Research Ethics Committee, and was conducted in accordance with the ethical standards specified in the 1964 Declaration of Helsinki.

Sixty word pairs, 30 category-exemplar, or semantically related, and 30 arbitrarily conjoined, or semantically distant word pairs, were visually presented across six cycles of encoding, retrieval and rest. Participants were instructed to remember the word pairs for later testing. Each word pair was presented once only for 3 seconds. Each encoding block was immediately followed by a retrieval block, during which the first word of each pair was presented, and subjects were asked to recall the associated word orally. Verbal responses were used to identify correct trials within each encoding block (i.e. successfully encoded word pairs). During the rest phase, participants viewed four digit number pairs passively. fMRI data acquired during the encoding and rest blocks are reported in this presentation. Relative to rest, encoding of arbitrary pairs activated a large area of left prefrontal cortex. Significant activity was also seen in the left superior parietal lobule. The reverse contrast revealed a large cluster of significant deactivation in the posterior cingulate region. Successful encoding of arbitrary pairs was related to BOLD signal change in a number of left hemisphere sites that included middle frontal and premotor cortex, posterior hippocampus, uncus, and temporal pole. In the right hemisphere successful encoding was significantly correlated with BOLD signal change in the right anterior hippocampus and temporal pole. Arbitrary word pairs produced left greater than right activation at a whole brain level, and when the region of interest was restricted to the mesial temporal area. By contrast, successful encoding of semantic pairs engaged both hemispheres, with prominent bilateral hippocampal activation, as well as activity in left inferolateral frontal cortex, and right secondary visual cortex. Relative to arbitrary pairs, semantic pairs produced greater activation in the right hemisphere. Semantic loading in the context of a common associative paradigm exerts a substantial influence on the lateral and intratemporal distribution of task-related activity. Associative encoding when the probability of previous semantic representation is low, recruits cortical systems usually linked with top-down executive and goal-oriented attention. This mechanism is not engaged in semantic associative encoding, consistent with the facilitatory effects of prior representation.

D54 Narrowing in on what's relevant: Perturbing Wernicke's area perturbs task-relevant representations

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Compare the category of BIRDS, members of which cohere on many features (feathers, two-legs, etc.) to the category GREEN THINGS, which depends on isolating a single diagnostic dimension. Previous research has shown that labeling facilitates the latter type of categorization, arguably because it supports selective representation of task-relevant features. We used transcranial direct current stimulation (tDCS) to test whether modulation of cortical activity in Wernicke's area—associated with labeling, particularly comprehension of word meaning—affects selective representation of task-relevant information and abstraction over irrelevant information. Previous work in our lab showed tDCS over Wernicke's area affects labeling: down-regulating activity decreases speed, up-regulating increases. Thus, depending on polarity of the current, tDCS allows us to up- or down-regulate the labeling process while keeping behavioral task demands constant, enabling us to assess whether perturbing activity in a region involved in labeling affects the process by which task-relevant representations are activated. Experiment 1. Participants completed two tasks—a picture-word verification task and a flanker task (without tDCS). We were interested in the correlation between performance in these tasks—both designed to measure selective representation of task-relevant information—to assess whether individuals who could best focus on category-relevant features were also the best at selectively focusing on the target in the flanker task. In the verification task, participants saw pictures varying in category dimensionality from high (e.g., dog) to low (e.g. carrot), heard a label, and responded whether the label matched the picture. Proportionately faster responses on low-dimensional compared to high-dimensional trials would indicate better selective focus on category-relevant information. Our version of the flanker task had a varying delay between presentation of flankers and target; the variable of interest was the extent to which increasing delay eliminated differences in speed in valid relative to invalid (conflict) trials. Smaller changes induced by delay would indicate better selective focus on target and ignoring of flankers. Flanker performance predicted verification performance: those benefiting most from flanker delay were fastest on high-dimensional category trials (suggesting generally diffuse attention to relevant and irrelevant stimuli/properties). We next examined whether this correlation between selective representation in flanker and verification tasks meant common neural pathways related to language were involved. Would tDCS-induced differences mimic individual differences found in Experiment 1? Experiment 2. Participants completed the verification task while receiving anodal (up-regulating) or cathodal (down-regulating) tDCS over Wernicke's area. We found that relative to anodal tDCS, cathodal tDCS increased speed on high-dimensional trials—which call for a more diffuse high-dimensional representation across features. This suggests neural activity associated with labeling normally helps highlight category-relevant information. Experiment 3. Participants completed the flanker task while receiving the same tDCS as in Experiment 2. We found cathodal tDCS increased delay-induced changes in speed relative to anodal tDCS, indicating more diffuse focus across flankers and target. This suggests neural activity associated with labeling helps highlight task-relevant information—even in a nonverbal flanker task, Together, our results suggest perturbing a

cortical region associated with labeling affects ability to form task-relevant representations in both verbal and nonverbal contexts.

D55 A common neural basis for syntactic and non-syntactic conflict-control *Nina S. Hsu[1,2,3], Susanne M. Jaeggi[2,3,4], Jared M. Novick[1,2]; [1]Center for Advanced Study of Language, University of Maryland, College Park, [2]Program in Neuroscience and Cognitive Science, University of Maryland, College Park, [3]Department of Psychology, University of Maryland, College Park, [4]School of Education, University of California, Irvine*

Language and memory tasks both involve cognitive control, the ability to flexibly adjust behavior to resolve information-conflict. When parsing sentences, cognitive control enables the revision of initial misinterpretations[1]; when remembering items, cognitive control facilitates target selection despite familiar-but-irrelevant memoranda[2]. Do these conflict-control procedures share neurobiological underpinnings? Neuropsychological and neuroimaging evidence suggests so: patients with cognitive control deficits within memory fail to recover from parsing misanalysis[3], and healthy subjects completing Stroop-conflict trials and a syntactic ambiguity task show co-localized LIFG activity[4]. Yet, it remains unclear whether multivariate analyses of neuroimaging data could complement traditional univariate findings within a study, providing convergent evidence for a domain-general theory of cognitive control. We used fMRI to investigate the commonality of conflict-control mechanisms across ostensibly different memory and language tasks. We hypothesized that cognitive control tasks commonly recruit regions within left inferior frontal gyrus (LIFG) regardless of differences in task goals and stimulus characteristics. Twenty participants completed four tasks while undergoing fMRI. In Stroop, participants indicated the ink color of color-terms while ignoring word meaning; we included conflict, non-conflict and neutral trials. In the recent-probes task, participants indicated whether a letter-probe was among a memory set. Occasionally, the item was recent and familiar, but not among the current set, thus creating conflict relative to non-recent trials also eliciting a "no" response. In the 3-back memory task, subjects viewed single words sequentially, indicating if the current one matched the word three trials ago. We included recently-presented but incorrect lures in nearby positions, (i.e. 2- and 4-back), creating conflict between familiar yet irrelevant memoranda. Finally, participants read garden-path sentences (e.g., "While the thief hid the jewelry that was elegant sparkled brightly") to assess syntactic conflict-control versus a comma-disambiguation condition ("While the thief hid,…"). For each task, we compared the conflict condition to its baseline. Preliminary ROI analyses (N=15) revealed distinct but overlapping brain activity across all tasks within LIFG (Stroop: t=1.99, p=0.07; 3-back: t=3.58, p=0.003; Recent-probes: t=1.54, p=0.15; Parsing: t=3.43, p=0.004); other regions did not show cross-task overlap (e.g., in V1, Stroop: t=0.96, p>0.3; N-back: t=0.18, p>0.8; Recent-probes: t=1.00, p>0.3; Parsing: t=-0.53, p>0.6). This suggests that common LIFG regions may selectively mediate cognitive control in language and memory. To extend the univariate co-localization approach, we employed multi-voxel pattern analysis to examine whether conflict detection elicits a common brain state reflected by cross-task pattern similarity that a machine classifier can reliably identify (going beyond information obtained with univariate analyses). Preliminary data suggest above-chance classification in LIFG within-task (37% classification accuracy for Stroop conditions; chance=33%). We are currently testing whether a classifier trained on conflict in one task can accurately classify conflict in the three other tasks, despite superficial differences. This result would suggest common mind and brain states associated with conflict, consistent with a domain-general theory of cognitive control that can inform neurobiological theories of language processing. [1] Novick et al. (2005). CABN. 5, 263–281[2] Jonides & Nee (2006) Neuroscience 139, 181–193. [3] Novick et al. (2009) Cogn. Neuropsychol. 26, 527–567 [4] January et al. (2009) JOCN. 21, 2434–2444.

D56 Attention for speaking: domain-general control from the anterior cingulate cortex in spoken word production *Vitoria Piai[1,2], Ardi Roelofs[1], Daniel Acheson[1,3], Atsuko Takashima[1,4]; [1]Radboud University Nijmegen, Donders Institute for Brain, Cognition and Behaviour, The Netherlands, [2]International Max Planck Research School for Language Sciences, Nijmegen, The Netherlands, [3]Neurobiology of Language Department, Max Planck Institute for Psycholinguistics, Nijmegen, The Netherlands, [4]Radboud University Nijmegen, Behavioural Science Institute, The Netherlands*

Until recently, it was commonly believed that most psychological processes underlying speaking happen rather automatically. Accumulating evidence suggests, however, that some degree of attentional control is required to regulate and monitor processes underlying speaking. Attentional control refers to the regulatory and monitoring processes that ensure that our actions are in accordance with our goals. For example, when planning a word or a multi-word utterance, speakers need to prevent interference from concurrent information in the environment. The object that one wants to refer to may have more than one name, in which case top-down regulation is needed to resolve the conflict between alternative responses. Attention is also needed for self-monitoring, through which speakers assess whether planning and performance are consistent with intent. In the past few years, significant progress has been made in delineating the neural substrates of the core language processes underlying speaking through the use of tasks such as picture naming, word generation, and word/pseudoword reading. Despite this progress, the neural substrates associated with the processes of regulating

and monitoring language production have remained relatively underspecified. We conducted an fMRI study examining the neural substrates related to performance in three attention-demanding tasks varying in the amount of linguistic processing: vocal picture naming while ignoring distractors (picture-word interference, PWI); vocal colour naming while ignoring distractors (Stroop); and manual object discrimination while ignoring spatial position (Simon task). All three tasks had congruent and incongruent stimuli, while PWI and Stroop also had neutral stimuli. For example, for the PWI task, the picture of a dog was paired with the distractor word 'cat' (incongruent), 'dog' (congruent), or 'pen' (neutral). For the Stroop task, the red ink was used for presenting the word 'blue' (incongruent), the word 'red' (congruent), or the word 'dream' (neutral). Analyses focusing on common activation across tasks identified a portion of the dorsal anterior cingulate cortex that was active in incongruent trials for all three tasks, suggesting that this region subserves a domain-general attentional control function. In the language tasks, this area showed increased activity for incongruent relative to congruent stimuli, consistent with the involvement of domain-general mechanisms of attentional control in word production. Language-specific activity was observed in the anterior-superior temporal gyrus. Activity increased for neutral PWI stimuli (picture and word did not share the same semantic category) relative to incongruent (categorically related) and congruent PWI stimuli. This finding is consistent with the involvement of language-specific areas in word production, possibly related to retrieval of lexical-semantic information from memory. The current results thus suggest that in addition to engaging language-specific areas for core linguistic processes, speaking also engages the anterior cingulate cortex, a region that is likely implementing domain-general attentional control.

D57 Inter-regional dynamics within the left inferior frontal convolution during lexical selection *Christopher Conner[1], Nitin Tandon[1]; [1]University of Texas, Houston*

Neuroimaging studies of the left inferior frontal gyrus (LIFG) during language has led to its division into distinct sub-regions: pars opercularis (POp), pars triangularis (PT), pars orbitalis (POr), and primary motor cortex (M1). However, an understanding of how these regions operate in concert with each other to select and produce the appropriate response is unknown. We performed electrocorticography (ECoG) in 27 left hemisphere dominant patients to evaluate the dynamics of LIFG during visual naming. Subjects overtly named pictures of nouns, verbs or scrambled images during ECoG recording. Subdural electrodes (SDEs) were localized in LIFG using individual anatomy. Data were filtered into the gamma band (70-110Hz) and Hilbert transformed to obtain the power envelope. Amplitude envelope correlations were calculated between each region to assess functional connectivity. Directionality was estimated by using time-lagged correlations. Attractor state dynamics were modeled using k-means clustering of information flow between all LIFG subregions regions. Similar connectivity patterns were clustered in time and visualized in phase space using principal components. The onset of naming led to a dramatic decrease in gamma power in POr below baseline 250ms after stimulus onset and preceded concurrent activation of PT, POp and M1. Between 300-600ms, negative correlation from POr to PT and from POr to POp was noted during both noun and verb generation. Around 400ms, connectivity increased bi-directionally between POp and M1 until articulation, after which, M1 became negatively correlated with PT, suggestive of a stop signal. Verb naming resulted in a distinct unique positive correlation between POr and M1. During language, parallel, bi-directional processes occure in serial fashion. POr initializes this state through negative modulation of POp and PT. Later, descending signals from M1 are involved in semantic retrieval and termination of lexical processing. This study conclusively rejects rigid, rostro-caudal hierarchy and yields deep insights into frontal lobe function.

D58 Verbal Motor Imagery in Children with Cerebral Palsy: an fMRI study *Y. C. Chang[1], F. P. Yang[1], Y. W. Wang[1], C. L. Chen[2]; [1]National Tsing Hua University, Hsinchu, Taiwan, [2]Chang Gung Memorial Hospital, Linkao, Taiwan*

Cerebral palsy (CP) refers to a group of disorders related to movement and posture that are attributed to disturbances occurring in the developing fetal or infant brain. Significant physical limitations in all four limbs are likely to be associated with damage or abnormal engagement of the sensory-motor cortex, consistent with fMRI evidence of smaller activation magnitudes and spatial extents found in primary and secondary somatosensory cortices. Research has also shown that motor-imagery tasks can be used to study cortical motor control in CP patients because shared motor representations can give rise to a functional equivalence in intending, imagining, observing, and performing an action. The present study is focused on the differences of effects on motor imagery induced by verbal stimulation between CP patients and age-matched controls. 11 patients and 10 healthy, age-matched controls were examined using fMRI and asked to follow verbal instructions on the screen: (1). using the dominant index finger to press a button, 2. imagining themselves pressing a button or walking, and 3. imagining another person pressing a button or walking. Healthy controls revealed greater activations in frontal and temporal regions than patients during the button-pressing and imagining walking tasks. The results suggest that CP patientsâ□□ deprivation of physiological experience relates with imagery effects induced by linguistic stimuli, and results in hypoactivation in motor-related regions. Lastly, differences in functional

activations between healthy controls and CP patients can potentially be a bio-marker for prognosis and index for efficacy of imagery-based rehabilitation.

D59 Altered activation of the right TPJ during spatial attention tasks in migraineurs, and relationships between attentional cuing effects and lexical reading performance. *Marla Mickleborough[1], Layla Gould[1], Chelsea Ekstrand[1], Katherine Anton[1], Paul Babyn[1], Ron Borowsky[1]; [1]University of Saskatchewan*

INTRODUCTION: Migraine is a primary headache disorder which is strongly associated with heightened sensitivity to visual stimuli, even between headache attacks. Recently, evidence is building to suggest that these abnormalities may be in part due to abnormal spatial-attentional processing. Specifically, migraineurs do not show the normal suppression of cortical responses to visual events outside their zone of attentional focus, and have heightened reflexive visual-spatial orienting to sudden-onset peripheral events. Evidence suggests that spatial attention and word recognition do not operate independently. Indeed, poorer visual spatial attention performance has been linked to poorer reading performance. Given this interactive relationship between attention and reading, the purpose of this research was to use functional magnetic resonance imaging (fMRI) to explore attention in a clinical migraine group and correlate behavioral performance in these spatial cueing tasks to reading performance. METHODS: To address these issues we tested migraineurs (n=10) and non-migraine controls (n=10) during two canonical spatial orienting tasks, as we measured BOLD response using fMRI. In the attentional tasks, participants maintained fixation on a central location while on each trial being cued (either via a central arrow cue or a peripheral box flash) to orient their visual attention to either the left or right side of visual space. A target letter of "A" or "H" was then briefly presented in either the cued or uncued location, and the participant was to say "A" or "H" aloud. Behavioral reaction times (RTs) and response durations (RDs) were recorded for the attention task. In addition, these scores were compared to participant RTs and RDs in response to a reading task. Letterstrings were designed to specifically activate the ventral-lexical stream, which specializes in the reading of familiar words (ie. exception words such as "yacht"), vs. the dorsal-sublexical stream, which specializes in phonetic decoding of novel letterstrings (ie. pseudohomophomes such as "yawt"). RESULTS: Our fMRI analyses focused on the known bilateral frontoparietal cortical network of attention. In particular, the right temporal-parietal junction (RTPJ) has been suggested to provide a circuit-breaking reorientation to unattended but highly salient and behaviorally relevant sensory events. Given migraineurs lack of suppression of unattended events, we hypothesized the RTPJ would show abnormal activation in migraineurs. Indeed, we found that controls had greater activation in the RTPJ than migraineurs. In addition, we found significant correlations between attention and reading performance, supporting previous work that suggests the interactive relationship of attention and reading. CONCLUSION: We found that migraineurs have less activation than controls in the RTPJ -- an area linked to assessing the behavioural relevance of unattended stimuli and reorienting attention to unattended but highly salient sensory events. This fits well with previous studies which suggest that migraineurs have abnormalities in the suppression of unattended events. In addition, our data support previous studies that suggest an interactive relationship between attention and reading.

D60 Neural correlates of phonological sequencing *Malathi Thothathiri[1], Michelle Rattinger[1]; [1]George Washington University*

Left lateral frontal cortex is associated with both language and cognitive control. Recent studies have examined the role of control functions (e.g., selection) in language processing. We previously reported that patients with left frontal lesions, specifically to BA 44/6 extending dorsally to BA 44/6/9, are impaired in "selection for position" or flexibly sequencing words [1]. A subsequent study found that these patients were impaired specifically in sequencing phonological (cf. semantic) representations [2]. The current study uses fMRI to further elucidate the neural basis of phonological sequencing. Eleven healthy, right-handed, English-speaking adults participated. In each trial, they saw 4 stimuli and pressed corresponding buttons. Stimuli were either syllables or words, and presented concurrently or consecutively, resulting in 4 experimental conditions (concurrent-syllable, consecutive-syllable, etc.). Each participant completed two runs (1 syllable, 1 word). Each run contained 2 blocks each of the experimental conditions and a baseline task. The concurrent condition involves sequencing i.e., planning responses to multiple stimuli at the same time. It is expected to engender interference and require selection relative to the consecutive condition. We predicted that regions that support automatic phonological sequencing would show greater activation for concurrent than consecutive conditions across stimulus types, and that regions that support controlled phonological sequencing would show an interaction, with greater concurrent > consecutive activation for syllables (phonological) than words (semantic-phonological). Our analyses focused on anterior and posterior regions of interest (ROIs) on the dorsal language pathway, which has been associated with phonological processing. Three ROIs (BA 6, 40, 44) were defined as 6 mm spheres around previously reported coordinates [3]. Two others were defined using the BA 44 and BA 6 Juelich maps: BA 44/6/9 (dorsal), BA 44/6 (ventral). Behaviorally, participants slowed down for the first item and sped up for subsequent items during the concurrent relative to the consecutive condition, consistent with concurrent planning of multiple responses in the former case. The interference score [2] was significantly greater than zero for words and marginal for syllables. The two scores did not differ. Percent signal change in BA 44/6

and BA 44/6/9 showed a significant interaction: concurrent > consecutive for syllables but not words. In contrast, BA 40 showed a significant effect of task: concurrent > consecutive, but no interaction. No significant effects were found in BA 44 and BA 6. These results show that anterior and posterior dorsal pathway regions are involved in controlled and automatic phonological sequencing respectively. The findings converge remarkably with our neuropsychological results. Here, BA 44/6 and BA 44/6/9 - but not BA 44 and BA 6 - showed an activation pattern that reflects controlled phonological sequencing. In the previous study [2], frontal patients with additional damage to these specific regions were impaired specifically in sequencing phonological representations. Together, results suggest that the prefrontal-premotor junction plays an important role in controlled phonological sequencing, which is important for speech and other language functions. [1] Thothathiri et al. (2010), Brain and Language. [2] Thothathiri et al. (2012), Neuropsychologia. [3] Gold & Buckner (2005), Cerebral Cortex.

D61 Brain mapping in verbal and spatial thinking *Olga Martynova[1], Galina Portnova[1], Larisa Mayorova[1,2], Svetlana Kuptsova[1,2], Oxana Fedina[2], Alexey Petrushevsky[2], Alexey Ivanitsky[1]; [1]Institute of Higher Nervous Activity and Neurophysiology of Russian Academy of Science, [2]Centre of Speech Pathology and Neurorehabilitation, Moscow*

For the last decades such non-invasive techniques as fMRI and MEG/EEG localised the key structures of speech system in the human brain, while more complex cognitive language functions dealing with abstract verbal meanings remain a subject of discussion. The goal of this study was to compare the topography of the active cortical areas and subcortical structures of verbal thinking, which mainly operates with verbal signs, with brain structures of nonverbal spatial thinking, which requires orientation in real and imaginary space. 18 right-handed healthy voluntaries (11 males, mean age 30,7) participated in the study. Four types of tasks were presented: two experimental tasks - verbal (anagram from 5 letters) and spatial (search for a piece to complement a square), and two types of control tasks (written words and a spatial task, where all the pieces are identical). 575 T2*weighted images were acquired at 1.5 T scanner with BOLD contrast (TR 3000 ms) after T1*weighted anatomical image for all subjects. The fMRI-data analysis was performed by SPM8 including co-registration, motion correction and normalization to MNI space. General linear model was used to determine differences in activations between different conditions: verbal or spatial versus control tasks. At the group level an evaluation of the brain activity was carried out using one sample t-test. Voxel activation threshold corresponded pFWEcorr was less than 0,05 adjusted for multiple comparisons, z less than 3.09. The cluster threshold of activation was determined at puncorr less than 0.05, the minimum cluster threshold (FWEc) was 100 voxels. The verbal thinking demonstrated BOLD activation in the superior parietal cortex, the inferior frontal gyri predominantly in the left hemisphere and Broca's area. The right middle frontal gyrus, the superior parietal cortex, the left precentral gyrus and thalamus were activated in solving the spatial tasks. For occipital region an activation of the visual field 18 (according to Brodmann's classification) was more explicit in solving the spatial tasks, the solution of anagrams followed by an activation of the field 19 associated with higher levels of visual processing. The cerebellum was active bilaterally in both tasks with predominance in the spatial thinking. In solving the verbal tasks the greater volume of activation was observed in the left hemisphere involving Broca's area while the brain activation during spatial thinking was less lateralized than during verbal thinking. The obtained fMRI data indicate that verbal and spatial types of solving tasks are provided by an activation of narrow specific sets of brain structures and can be separated in the brain topography. This research was supported by the grant of Russian Foundation for Basic Research 13-04-01916.

D62 Go/no-go vs yes/no tasks in psycholinguistic research: ERP correlates of inhibitory control *Marta Vergara-Martínez[1], Manuel Perea[1], Pablo Gómez[2]; [1]ERI-Lectura Universitat de València, [2]DePaul University Chicago*

Go/no-go tasks (i.e., only respond X when the stimuli matches the criteria, and refrain to respond if it does not) are becoming increasingly common in cognitive neuroscience and psycholinguistic research relative to yes/no task (i.e., respond X when the stimuli matches the criteria, and respond Y if it does not). Comparatively, the simple-choice procedure provides more accurate response patterns than the two-choice procedure, a reason why many researchers prefer the go/no-go to the yes/no task. The explanation for this superiority is still a matter of debate. Interestingly, earlier mathematical modeling had shown that the two task procedures involve the same core processes, suggesting that the difference may take place in ancillary task-dependent processes like response execution (Gómez, Ratcliff & Perea, 2007). However recent modeling work with the lexical decision task suggests that the story may be more complex, so that the perceptual decision making module might feed back into the word recognition module (Gómez & Perea, 2012). To shed more light on this issue, we used online measurements of brain activity (ERPs) to further explore how these two experimental procedures impact the core processing of stimuli. More specifically, if there is no impact of the task on the core processes, we shall expect late ERP effects of task in the time course of lexical decision processes. However, if the impact of task is on the core processes, we shall expect earlier ERP effects. Participants' responses (both behavioral and EEG) were recorded in a lexical decision experiment that included a yes/no vs. go/no-go within-subject manipulation with word-frequency as a lexical factor. Words and nonwords were (visually) presented in two consecutive blocks (yes/no and go/no-go; the order was

counterbalanced across subjects). Our aim was to analyze how the task modulated the word frequency effect. In line with previous evidence, behavioral results revealed an interaction of task and frequency: the frequency effect (faster responses for high compared to low frequency words) was larger in the go/no-go compared to the yes/no task. Accuracy analysis revealed more accurate responses in the go/no-go compared to the yes/no task. The ERP data was analyzed in 4 different time-windows: 180-260ms (N2), 260-360ms (P3), 360-480ms (N4a) and 480-570ms (N4b). The results revealed different time-course and size of the frequency effect in each task: while it was apparent and larger in the four epochs in the go/no-go task, the yes/no task revealed smaller frequency effects (starting in the second epoch). Altogether, this pattern of results (early modulation of task on the time-course of frequency effect) supports the hypothesis of feedback from decision making into word recognition stages. Our interpretation of the results is focused on the functional meaning of the N2-P3 component, which is related to executive control mechanisms (inhibition and conflict detection).

Language Disorders

D63 Damage to the anterior arcuate fasciculus predicts non-fluent speech production in aphasia

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Non-fluent aphasia implies a relatively straightforward neurological condition characterized by limited speech output. However, it is an umbrella term for different underlying impairments affecting speech production. Several studies have sought the critical lesion location that gives rise to non-fluent aphasia. The results have been mixed but typically implicate anterior cortical regions such as Broca's area, the left anterior insula, and deep white matter regions. To provide a clearer picture of cortical damage in non-fluent aphasia, the current study examined brain damage that negatively influences speech fluency in patients with aphasia. It controlled for some basic speech and language comprehension factors in order to better isolate the contribution of different mechanisms to fluency, or its lack. Cortical damage was related to overall speech fluency, as estimated by clinical judgments using the Western Aphasia Battery's (WAB; Kerstez, 1982) speech fluency scale. Other factors that were controlled for included: rudimentary auditory language comprehension (WAB), diadochokinetic rate from the Apraxia Battery for Adults (ABA-2, Dabul, 2000), and executive functioning (scores on a matrix reasoning test; WAIS-III, Wechsler, 1997) in 64 patients with chronic left hemisphere stroke. Unlike much work using lesion-symptom mapping (c.f. Bates et al., 2003) which uses binary lesion masks, we relied on a method pioneered by Tyler and colleagues (2005), in which image intensity is directly correlated with behavioral scores. This relies on the assumption that in T1-weighted MRI, damaged tissue usually appears darker than the surrounding tissue. Inter-individual variability in intensity was addressed by converting raw values to Z-scores. Manually demarcated lesions were used to improve spatial normalization. Whole-brain regression analyses were then performed on the Z-scored T1 images for each voxel in the brain, and multiple comparisons were corrected for using permutation thresholding. Stepwise linear regressions were also conducted using mean intensity values from a priori regions of interest (ROI's), including brain areas typically implicated in speech and language processing. The ROI analysis revealed that non-fluency in aphasia is first predicted by damage to the anterior segment of the left arcuate fasciculus; an improved prediction model also included the left uncinate fasciculus, a white matter tract connecting the middle and anterior temporal lobe with frontal lobe regions, including pars triangularis. Models that controlled for diadochokinetic rate, picture-word recognition, or executive functioning also revealed a strong relationship between anterior segment involvement and speech fluency. Whole brain analyses corroborated the findings from the ROI analyses. An additional exploratory analysis revealed that involvement of the uncinate fasciculus adjudicated between Broca's and global aphasia, the two most common kinds of non-fluent aphasia. In summary, the current results suggest that the anterior segment of the left arcuate fasciculus, a white matter tract that lies deep to posterior portions of Broca's area and the sensory-motor cortex, is a robust predictor of impaired speech fluency in aphasic patients, even when motor speech, lexical processing, and executive functioning are included as co-factors. Simply put, damage to those regions results in non-fluent aphasic speech; when they are undamaged, fluent aphasias result.

D64 Speech-related brain activity in stuttering and cluttering: similarities and differences

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Stuttering and cluttering are disorders affecting the flow of speech. People who stutter (PWS) typically know what they want to say but produce speech that is characterized by repetitions and prolongations of speech sounds and silences. The speech of people who clutter (PWC) is disorganized or rapid or both, and is thought to reflect a problem in both planning and executing speech. PWS show structural and functional abnormalities in the speech and motor system relative to controls (CON). The neural correlates of cluttering are unknown, however. Here, we explored brain activity during overt picture description and sentence reading using sparse-sampling functional MRI (3T, 32 axial slices 4 mm 3, TR=9s (7s delay), TE=30ms) in 17 PWS (aged 19 – 54 yrs, 4 females), 17 PWC (aged 20 - 55 yrs, 4 females), and 17 CON (aged 19 – 53 yrs, 4 females). Group comparisons of PWS and PWC against CON were made for each condition relative to a silent baseline. These group difference maps were thresholded at $p < .01$, with

an arbitrary extent threshold of 30 voxels (uncorrected). In general, overt speech production during both conditions showed a pattern of overactivity in PWC relative to CON and underactvity in PWS. Specifically, in both conditions, PWC had greater activity than CON in ventral premotor cortex bilaterally, pre-supplementary motor area and right superior temporal suclus, whereas PWS had less activity than CON in right pars opercularis, parietal operculum and angular gyrus. In addition, during picture description only and in comparison with CON, PWC showed greater activity in right ventral striatum, whereas PWS had greater activity in ventral premotor cortex bilaterally and pre-supplementary area; both PWC and PWS showed less activity in the anterior lobe of the cerebellum bilaterally relative to controls. During the sentence reading condition only, PWC had less activity relative to CON in left pars orbitalis while PWS showed less activity than CON in the middle frontal gyrus, angular gyrus and caudate nucleus bilaterally and the left pars opercularis and pars orbitalis. In summary, both PWC and PWS showed abnormally high activity in the ventral premotor cortex bilaterally and pre-supplementary motor area and reduced activity in the anterior cerebellum during picture description. Notable differences between the groups were also seen; the ventral striatum was overactive in PWC whereas in PWS the dorsal striatum was underactive. Our results support the idea that these two fluency disorders share a common underlying pathology but each has additional neural abnormalities. Such differences most likely reflect the specific deficits in execution and planning of speech that separately characterise these two disorders.

D65 White matter tracts sustaining speech in primary progressive aphasia *Maria Luisa Mandelli[1], Eduardo Caverzasi[2], Richard J Benney[1], Bagrat Amirbekian[2,3], Maya L Henry[1], Miranda Babiak[1], Nikolas Block[1], Christa Watson[1], Bruce L Miller[1], Roland G Henry[2,3], Maria Luisa Gorno-Tempini[1]; [1]Memory and Aging Center University of California, San Francisco, [2]University of California, San Francisco, [3]Graduate Group in Bioengineering, University of California, Berkeley*

Introduction: Speech production deficits and atrophy in related left frontal gray matter regions are the characteristic features of the non-fluent/agrammatic variant of primary progressive aphasia (nfvPPA). However, early differential diagnosis from other forms of progressive aphasia such as logopenic (lvPPA) and semantic variant (svPPA) is often difficult. In nfvPPA, gray matter (GM) damage is found in fluency-related regions in the left inferior frontal, supplementary motor and basal ganglia regions. NfvPPA is most often caused by frontal-temporal lobar degeneration (FTLD)-tau pathology with typical tau inclusions in white matter (WM). Therefore, changes in WM tracts connecting the regions involved in speech production could provide an early marker for differential diagnosis. However, WM tracts within the frontal speech production network have seldom been mapped in healthy subjects and have never been investigated in PPA. Methods: We used residual bootstrap q-ball probabilistic tractography on high angular resolution diffusion imaging (HARDI) data to reconstruct the WM pathways that connect the frontal cortical and subcortical network underpinning speech production in healthy brains. The tractography results were then used to define WM pathways of interest for a novel assessment of motor-speech tract alterations across the three PPA variants and controls using classical Diffusion-Tensor-Imaging derived WM metrics. We also performed a correlation analysis between the WM metrics of these tracts and the patients' cognitive performance including a composite score of speech production. Results: In line with our hypothesis, we demonstrated WM alterations across all of the motor speech tracts in nfvPPA relative to controls, but not in the other two variants. Moreover, we demonstrate specific correlations between WM metrics obtained from the speech production tracts and the composite score of speech production, confirming their functional role in speech. Conclusion: We provide the first demonstration that WM changes in the frontal speech production network are specific to the non-fluent variant of PPA. Our findings offer a potential biomarker for differential diagnosis and for longitudinal assessment of nfvPPA in clinical trials.

D66 The effect of music therapy for a person with nonfluent aphasia: a neurobiological perspective *Joslyn Fisch[1], Julie Massa[1], Daniela Toron[1], Erin White[1], Megan Dewing[1], Anita Gadberry[1], Vijayachandra Ramachandra[1]; [1]Marywood University*

The purpose of this presentation is twofold. First, to review the literature on the neurobiology of language and music. Second, to discuss the effect of music therapy (MT) for a person with nonfluent aphasia. Recent evidence emerging from neuroimaging studies suggests common neural substrates serving both language and music. Therefore, people with aphasia may benefit tremendously from MT. Melody Intonation Therapy (MIT), which makes use of melody and rhythm, has been one of the most popular therapy techniques for improving speech in people with aphasia. Neuroimaging data related to MIT have been promising. Recently, a diffuse tensor imaging (DTI) study showed increase in volume and number of arcuate fasciculus fibers in the right hemisphere of 6 patients who underwent intensive MIT therapy. Although MIT has been the most widely tested therapy technique, there are other types of procedures that effectively utilize music for improving spoken language in people with aphasia. It is important for clinicians and researchers to carry out research on the efficacy of other methods. Recently, a MT technique that employed singing familiar songs, breathing into single-syllable sounds, musically assisted speech, dynamically cued singing, rhythmic speech cueing, oral motor exercises, and vocal intonation has been successful in enhancing speech in people with aphasia (Tomaino, 2012). The current study tested this method with RJ who has nonfluent aphasia. RJ is a 69-year-old right-handed man

with a high school education. In August 2011, he suffered an acute ischemic stroke. A brain CT scan showed a large chronic left middle cerebral artery infarct. There was no acute focal mass or hemorrhage. Following the stroke, RJ suffered paralysis of the entire right- side. He was unable to walk, speak, and also had hearing deficits. The results of the Psycholinguistic Assessments of Language Processing in Aphasia (PALPA) indicated that he suffered from a nonfluent type of aphasia. Neuroimaging studies have shown that people with large left hemisphere lesions may show activation of the right homologous language regions. Since RJ had a large left hemisphere lesion, we thought he might benefit from MT, which may facilitate speech recovery by reorganizing neural structures in the right hemisphere. In the present study, a protocol similar to the one established by Tomaino (2012) was used to treat RJ. The therapy mainly focused on singing familiar songs, breathing exercises with vowel production, speaking to the rhythm of drumbeats, and sentence completion within songs. At the completion of seventeen forty-five minute sessions, RJ was able to independently produce a few simple 3-4 sentences, prolong vowels on exhalation, and sing a few familiar songs along with the therapist. He, however, had difficulty producing complex sentences. RJ was also able to joke during the sessions, and maintain simple conversations with the therapist. A post-therapy administration of Profile of Mood States revealed significant decrease in anger and depression. Overall, we saw some functional improvement in RJ's language skills after only a few sessions of MT. We will discuss these results from a neurobiological perspective.

D67 tDCS alters lateralization of reading-related activity in a case of pure alexia *Elizabeth H. Lacey[1,2], Xiong Jiang[1], Sarah F. Snider[1], Rhonda B. Friedman[1], Peter E. Turkeltaub[1,2]; [1]Georgetown University, [2]MedStar National Rehabilitation Hospital*

Introduction: There is evidence that transcranial direct current stimulation (tDCS) can improve oral language recovery after brain injury, but it is not clear how this occurs, whether the effect generalizes to untrained items, or whether written language deficits could also be remediated. The current case study of a person with pure alexia (NHL) begins to investigate these questions. We hypothesized that tDCS would accelerate practice-related increases in reading speed and reduce NHL's word-length effect, and that this would be accompanied by a more left-lateralized pattern of BOLD activity during a reading task. We hypothesized that this would be especially apparent in the visual word form area (VWFA), which is often involved in lesions causing pure alexia. Case and Methods: NHL is a 70-year-old right-handed retired executive with mild pure alexia resulting from a traumatic brain injury to the left occipital lobe and right frontal lobe in 2005. His reading is accurate but slow, with a word length effect. We measured oral text reading speed before and after five consecutive days of treatment with tDCS followed ten days later by five days of sham treatment. NHL read aloud 4 passages with feedback during tDCS, and 4 matched passages during sham treatment. Oral reading times of these paragraphs were tested at the beginning of each treatment day. tDCS was administered at 2mA for 20 minutes, with the anode over left posterior temporal lobe and the cathode over the right, based on a prior study demonstrating reduced reading times in healthy subjects using a similar configuration (Turkeltaub et al., 2012). Generalization was assessed before and after the course of tDCS on single words ranging in length from 3-9 letters, and on untrained passages matched to training passages. Before and after real tDCS, NHL covertly read 3-8 letter words in the scanner. Behavioral Results: Reading times decreased on practiced paragraphs during both real and sham tDCS ($F(4,24)=18.125$, $P<.001$). Reading times on training paragraphs (as a percentage of pre-tDCS reading times) were shorter during the week of tDCS treatment compared to sham ($F(1,6)=10.743$, $P=.017$). The length effect decreased after tDCS (Length x Time $F(2,172)=4.942$, $P=.008$; Pre-tDCS: 208 ms/letter, 1 day post-tDCS: 147 ms/letter). fMRI Results: Before tDCS, there was more activation in the right hemisphere homolog (RHH) than the VWFA during the word reading task, whereas after tDCS, the pattern switched so that the VWFA was more active than its RHH ($p<0.001$). Moreover, the VWFA showed a pattern of increasing activation with increasing word length that was not apparent before tDCS. Conclusions: This case study suggests that tDCS can be effective for treating alexia and that the treatment effects may generalize. The fMRI data suggest that this could be due to increased activation in left hemisphere language areas crucial to reading. Further research is needed to better understand the therapeutic effects of tDCS and its neural underpinnings. References: Turkeltaub, P.E., Benson, J., Hamilton, R.H., Datta, A., Bikson, M., & Coslett, H.B. (2012). Left lateralizing transcranial direct current stimulation improves reading efficiency. Brain Stimulation, 5(3), 201-207.

D68 Brain routes for reading in adults with and without autism *Rachel Moseley[1], Friedemann Pulvermuller[2], Yury Shtyrov[3,4]; [1]MRC Cognition and Brain Sciences Unit, Cambridge, UK, [2]Brain Language Laboratory, Free University, Berlin, Germany, [3]Centre for Functionally Integrative Neuroscience, Aarhus University, Denmark, [4]Centre for Languages and Literature, Lund University, Sweden*

INTRODUCTION: Reading utilises two neural pathways: the first (lexical) route visually mapping whole words to their lexical entry to retrieve meaning, the second (nonlexical) mechanically decoding words via general grapheme-phoneme conversion rules of the given language in order to construct its pronunciation. Whilst neurotypical readers typically employ the direct lexical route for reading familiar regular words, a pattern of poor reading comprehension plus precocity at mechanically 'sounding out' words ('hyperlexia') suggests the same

may not be true of readers with autism spectrum disorders (ASD), who may utilise different pathways and who often seem to lack a 'default' semantic processing mode. In this study, We attempted to compare visual word processing of short, simple words between participants with an ASD and age- and IQ-matched controls. METHODS: MEG and EEG recordings were taken as participants passively read single words. Following preprocessing of combined MEG/EEG data, we explored the neuronal generators underlying electrophysiological and neuromagnetic activity with source analysis using high-resolution structural MRI scans from each participant. Results were confirmed in both an anatomically-defined and data-driven regions of interest (ROI) approach. RESULTS: The physiological data revealed preferential recruitment of temporal areas associated with the lexical route in control subjects. Though showing less activation than controls in temporal areas, ASD participants showed no preferential use of either route, but additional recruitment of the nonlexical route associated with a dorsal stream of activation in parietal areas and BA 44. Greater activation of this dorsal route in ASD occurred throughout the epoch, from 70ms after word presentation to 450ms. In addition, analysis of semantic differences between experimental words revealed many category-specific semantic differences in the control group that were lacking in the ASD group, particularly in the earliest time-windows. CONCLUSIONS: In contrast to controls who preferentially employed the lexical route, people with ASD appear to automatically decode even familiar words, showing recruitment of additional pathways and theoretical consistency with hyperlexia, a tendency to mechanically phonologically-decode language whilst, in previous literature. The lack of automatic category-specific differences between words with different meanings in the ASD group supports the suggestion that whilst semantic processing in autism may not be globally impaired, semantic information may not be automatically activated without explicit instruction.

D69 Functional and Structural Connectivity across Levels of Language in Children with Dysgraphia *Todd Richards[1], Thomas Grabowski[1], Katie Askren[1], Peter Boord[1], Kevin Yagle[1], Zoe Mestre[1], Frederick Reitz[1], Olivia Welker[1], Desiree Gulliford[1], Liza Young[1], Elliot Collins[1], Virginia Berninger[1]; [1]University of Washington*

Specific Aims: We analyzed functional connectivity patterns among brain regions across levels of written language. The focus is on transcription skills (handwriting and spelling) and translation of cognition into language through strategic preplanning for children with dysgraphia (impaired handwriting and/or spelling); but analyses for control and contrast groups will also be presented. Methods: Six middle-school children were scanned on a Philips 3T Achieva scanner with both functional connectivity and diffusion tensor imaging (DTI). As part of this project, we developed and published an article about a device for recording handwriting during an fMRI task. Each participant completed four tasks in this order: (a) resting state default network--no experimenter-defined task, (b) handwriting, (c) spelling, and (d) planning for composing on experimenter-provided topic. The composition was written outside the scanner after imaging. The response requirement for handwriting and spelling was the same--to write one letter—that either came after the visually displayed letter in the alphabet for handwriting task (sublexical) or that fit in the blank in letter series to spell a real word (lexical). The DTI findings for the language-related fiber tracts were previously reported at the Organization for Human Brain Mapping Annual Meeting 2013 (poster 1505). This presentation will focus on functional connectivity maps generated for seeds in supramarginal gyrus (MNI: -52,-32,34mm) and an occipital-temporal region (MNI: -50,-60,-16mm), based on a meta analysis of fMRI writing studies (Purcell et al 2011). Regions of interest (ROI) were formed from a 15mm sphere centered at each seed, within which the fMRI time-series were averaged. The averaged time-series at each ROI was correlated with every voxel throughout the brain to produce functional connectivity correlation maps, which were converted to z-statistics using the Fisher transformation. Results: Common and unique brain regions in group maps showed connectivity to each seed region for the four writing tasks. For the supramarginal seed, connectivity was found for 29 regions for handwriting, 28 regions for spelling, 18 regions for planning, and 31 regions for resting-state scans. Connectivity to 14 regions was shared across all four writing tasks. Seven connections were unique to handwriting compared to spelling; six were unique to spelling compared to handwriting. Two connections unique for strategic planning compared to resting-state and fifteen connections unique for resting-state compared to strategic planning were identified. For the occipital-temporal seed, of nineteen connections for handwriting, four were unique compared to spelling, and eleven of twenty-six connections for spelling were unique compared to handwriting. Two of the twenty connections for planning were unique compared to resting-state, for which seven of the twenty-eight connections were unique compared to planning. Frequently observed connectivity across seed points and tasks included several cortical regions (including cingulate and precuneus), cerebellar regions, hippocampus, and subcortical regions (thalamus, striatum and sometimes brain stem). Conclusions: Both common and unique functional (and structural) connections for transcription (handwriting and spelling) and translation (resting-state and preplanning) may be important in understanding writing in children with specific learning disabilities.

D70 Functional reorganization of orthographic networks subsequent to neural injury *Jeremy Purcell[1], Brenda Rapp[1]; [1]Johns Hopkins University, Baltimore, MD*

Recent work has identified a network of regions consistently associated with spelling including the left ventral occipitotemporal (VOT) cortex, inferior frontal gyrus, superior temporal gyrus, and intraparietal sulcus (Purcell et al., 2011). When part of this functional network is damaged due to brain injury, how does the network reorganize? In this research we examined an individual, DPT, who underwent a resection within the left VOT cortex and who demonstrated persistent deficits in word spelling. We investigated whether damage to left VOT cortex led to functional reorganization as measured with an fMRI spelling task. In order to compare DPT's spelling activation pattern to that of a group of control participants we carried out a novel three-stage Individual Probabilistic Peak Comparison (IPPC) analysis. This analysis compares the activation patterns in a single individual to those obtained in a set of non-impaired control participants, taking into account measurement uncertainty and variability across participants in activation locations. The first analysis stage characterizes the convergence in activations across the set of control participants by applying an analysis technique typically used for characterizing activations across studies: Activation Likelihood Estimate (ALE) (Turkeltaub et al., 2002). The second stage evaluates the degree to which the single individual's activations correspond to the control group pattern identified in Stage 1. This involves performing a Mahalanobis distance statistics analysis (Tsapkini, et al., 2011) that compares each of the control group's peak activation locations to the nearest peak generated by the individual. The third stage evaluates the extent to which the individual's peak foci are typical/atypical relative to the control participants. This includes a comparison of the locations of an individual's activation peaks to a control Peak Probability Map that reports the consistency of individual participant activations. The results of the IPPC analysis indicated that DPT demonstrated both normal and abnormal patterns of spelling activation. First, DPT demonstrated perilesional activation anterior/superior to his lesion, suggesting restructuring of the original left VOT network. Second, DPT demonstrated activation in atypical regions for spelling including the left anterior temporal pole, as well as specific areas within the inferior frontal gyrus and the superior temporal gyrus. These areas may serve compensatory functions in the face of left VOT damage. Third, DPT demonstrated normal activations in left inferior gyrus (BA 44) indicating a portion of the normal spelling network remained intact. Overall, these results indicated that damage to left VOT cortex can result in recruitment of regions typically associated with spelling as well as functional reorganization involving novel regions. IPPC Analysis allows for a quantifiable, unbiased method for comparing an individual's activation pattern to the activations of a set of control individuals in a way that considers individual variability in peak activation locations. In this way the IPPC analysis provides a valuable tool for identifying functional reorganization in brain-damaged individuals and has broader applications to situations that require the comparison of the functional activity of a single individual to that of a set of individuals.

D71 Characteristics of language dysfunction and cortical degeneration in patients with early stage amytrophic lateral sclerosis (ALS) *Noriyo Komori[1], Ikuyo Fujita[2], Shinya Uchida[3], Ritso Hashimoto[1]; [1]International University of Health and Welfare Hospital, [2]International University of Health and Welfare, [3]International University of Health and Welfare Graduate School*

INTRODUCTION: It is well known that a proportion of patients with ALS show cognitive deficits including language disturbance. However, the relationship between the characteristics of these language disorders and cortical degeneration is unclear. PURPOSE: In the present study, we investigated characteristics of ALS patients' language deficits using neuropsychological tests coupled with regional cerebral blood flow (rCBF) using single photon emission computed tomography (SPECT). METHODS: Participants were 11 intellectually-normal sporadic ALS cases (male=7, female=4; type: bulbar=5, upper=4, lower=2; age: 62.6±5.8; duration of disease: 21.9±15.2 months; MMSE: 26.6±2.7). Control participants were 13 volunteers matched in age and education. Various aspects of writing, syntax, semantics, and naming were evaluated. In Japanese, there are two qualitatively different writing systems: kana (Japanese phonograms) and kanji (Japanese morphograms). Kana writing and Kanji writing were evaluated with dictation tasks in each writing form. Syntactic functions were evaluated in sentence comprehension with the Syntax Test for Aphasia in Japanese (STA), that included two types of reversible sentences: one was necessary to understand grammatical markers, while the other was not. Semantic memory was evaluated with the semantic discrimination test (discriminating semantic similarity of kanji words). Naming was evaluated using the naming test of the Standard Language Test for Aphasia in Japanese. rCBF was measured with 99mTc-ECD SPECT and translated into voxel-based Z-scores based on a normal data base with a Z-score imaging system (e-ZIS). To identify brain regions showing hypoperfusion associated with language disturbance, correlational analyses using SPM2 were conducted with rCBF and the number of errors on each measure. The number of subjects was different for each test due to weakness of upper limbs or bad physical condition. RESULTS: Six out of six patients showed kana agraphia characterized by omissions and substitutions of kana letters in irregular words. Five of eight patients also demonstrated kanji agraphia with most errors phonetically similar but semantically incorrect. Four of nine patients demonstrated disruptions with sentence comprehension where it was necessary to understand grammatical markers. Only one of eleven patients showed naming deficits characterized by loss of word knowledge and substitution errors. Correlation mapping revealed that hypoperfusion of the left premotor/posterior middle frontal cortex, and left

supramarginal gyrus/angular gyrus were associated with kana agraphia, while bilateral temporal poles were associated with kanji agraphia. The left inferior frontal gyrus (pars triangularis), left insula/putamen, and left posterior superior frontal gyrus were associated with syntactic deficits. CONCLUSION: In patients with ALS, language deficits occur by cerebral cortical hypoperfusion even in the early stage. Kana agraphia may be explained by a disturbance of the moraic segmentation of words and by a deficit in translating phonemes into kana letters which is associated with dysfunction of the left posterior frontal and left inferior parietal lobes. Kanji agraphia may stem from deficits of the semantic system associated with dysfunction of bilateral temporal poles. Sentence comprehension deficits were explained by difficulty in understanding grammatical markers associated with dysfunction of the left posterior inferior frontal gyrus and left posterior superior frontal gyrus.

D72 Automatic neural discrimination of changes in complex spoken words in dyslexic children *Lilli Kimppa[1,2], Eino Partanen[1,2], Kimmo Alho[1,3], Synnöve Carlson[4], Teija Kujala[1,2,5]; [1]University of Helsinki, Finland, [2]Cognitive Brain Research Unit, [3]General Psychology Division, [4]O.V. Lounasmaa Laboratory, Aalto University School of Science, Finland, [5]CICERO Learning*

Spoken words are recognized in a temporal manner from the acoustic sound stream and further processed for their phonemic and lexical properties. In previous studies, impairments of auditory processing as well as phoneme discrimination difficulties have formed the core of neural impairment in dyslexia. Many times these abilities have been studied with simple stimuli, lacking the complexity of natural spoken words. In the current study we investigated the discrimination ability of dyslexic children for changes in duration increment, vowel identity and frequency in the context of a three-syllabic spoken Finnish pseudoword. Participants were 9-12 -year-old children with dyslexia and an age- and sex-matched control group with no reading or writing difficulties. Participants' cognitive performance was examined with tests of visual IQ, memory and linguistic processing as well as reading and writing skills. Event-related potentials, especially the mismatch negativity (MMN) response was used as a measure of discrimination for sound change occurring either at the second or third syllable of the pseudoword /tatata/. Stimuli were presented in a passive oddball design where participants were watching a silent movie and ignoring the auditory stimuli. This way we were able to tap the automatic neural processing for spoken words. Furthermore, we measured the behavioral discrimination accuracy with a task where participants were asked to decide on which of the syllables there was a deviation. Results show an early MMN-response and a late discriminative negativity (LDN) for all sound changes in both groups. The early MMN occurred at ~150 ms after deviation point whereas LDN followed ~200ms later. MMN response was largest for vowel identity change and smallest for frequency change in both groups. The later response showed a prolonged processing for duration change, slightly emphasized in dyslexics. Scalp distributions revealed a right-lateralized fronto-central MMN activation pattern for duration and frequency, and a bilateral distribution for vowel change. Differences were not observed in either response magnitudes or distributions between the groups. In the behavioral level, however, controls were more accurate in locating the deviant syllable. These data suggest that the phoneme discrimination difficulties in the context of words does not seem to differ in the early, preattentive level of processing in dyslexic children. Interestingly, however, dyslexic children show impairment in the behavioral level of discrimination. This discrimination entails additionally the attentive component of processing, which plays a crucial role in reading and writing. Previous findings from a study of adult dyslexics in word context showed a pattern of unimpaired preattentive discrimination of duration but aberrant behavioral and neural patterns in an attentive condition. The current results imply that the preattentive neural processing is indeed intact also in the developing brain of dyslexics.

Poster Session E

Friday, November 8, 4:15 - 6:15 pm, Emerald Ballroom

Gesture, Prosody, Social and Emotional Processes

E1 Translating foreign language vocabulary activates visual and motor areas after learning with enrichment *Katja Martina Mayer[1], Izzet Burak Yildiz[1,2], Manuela Macedonia[1,3], Katharina von Kriegstein[1,4]; [1]Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany, [2]College de France, Paris, [3]Johannes Kepler University Linz, Austria, [4]Humboldt University of Berlin, Germany*

The outcome of learning foreign languages in adulthood can be improved when information in addition to the standard verbal information is provided. Previous studies showed that enriching foreign language learning material with visual or motor information (e.g. pictures or self-performed gestures) leads to significantly better learning outcome than exclusively verbal learning. Currently, there are two theories that describe the neural correlates underlying the benefit of enrichment. One attributes the benefits of enrichment to enhanced activation in areas processing semantics. The other one attributes the benefits of enrichment to enhanced activation in areas that are specialized in processing enrichment. We conducted two behavioural and two fMRI studies to test the two theories. We taught adults vocabulary in an artificial language with verbal as well as enriched learning materials. Over the course of teaching, we monitored learning progress with vocabulary tests. Furthermore, we conducted a

vocabulary test during fMRI after vocabulary learning was completed. Behaviourally, we found beneficial effects of both self-performed gestures and pictures. Two and six months after learning participants were able to translate significantly more of the artificial words that were learned with self-performed gestures and pictures than words learned verbally or with other types of enrichment. We used multivariate pattern classifiers to analyse the fMRI data. The classifier revealed that the BOLD responses in visual and motor areas contained information about the enrichment that was provided during learning. Our findings support the theory that attributes enrichment effects to enhanced activation in areas specialized in processing enrichment.

E2 Influence of Word Stress Sensitivity on a Visual Lexical Decision Task *Cyrille Magne[1], Michael Pridmore[1], Nicole Brunas[1]; [1]Middle Tennessee State University*

Language-specific rhythm and meter play important roles in the speech perception. A growing body of evidence highlights the role of speech rhythm sensitivity in the acquisition of good reading skills and suggests a link between poor sensitivity to speech rhythm and dyslexia. In addition, recent eye-tracking studies (e.g. Ashby & Clifton, 2005; Ashby & Clifton, 2006; Breen & Clifton, 2010) and ERP studies (Magne, Gordon, & Midha, 2010) suggest that information regarding speech rhythm is implicitly reactivated during silent reading. The purpose of the present study was to extend those previous findings by investigating which acoustical correlates of stress (duration vs intensity) contribute to rhythm sensitivity during reading. EEG was recorded in native English speakers while they performed a visual lexical decision task. Stimuli were composed of an auditory prime followed by a visual target. The auditory prime consisted of a two-tone pattern of same frequencies, but systematically varying in either duration or amplitude (long-short, short-long, loud-soft, soft-loud). The visual target was either a real word or a pseudoword. In addition, half the real words were trochaic (i.e., stressed on the first syllable when spoken), while the other half were iambic (i.e., stressed on the second syllable). The tone-patterns and real words were combined so that the tone pattern either matched or mismatched the expected stress pattern of the visual words. Participants were asked to ignore the tone-word pairs and decide whether the words presented on a computer screen were real English words. Behavioral data showed lower accuracy rates for mismatching tone-word pairs. Analysis of the ERP data showed an increased negativity, starting around 250 ms post-word onset, when the word stress pattern did not match the expectancy set by the prime tone pattern. In addition, this negative effect was larger for visual words whose stress pattern mismatched the durational pattern vs intensity pattern of the auditory prime. In line with previous findings, the present study suggests that a word's metrical structure is part of its phonological representation. Implications will be discussed for the current cognitive models of reading as well as ongoing research exploring neural markers of reading disorders.

E3 A Common Functional Network for Overt Production of Speech and Gesture *Lars Marstaller[1,2], Hana Burianová[1,2,3]; [1]Department of Cognitive Science, Macquarie University, Sydney, Australia, [2]ARC Centre of Excellence in Cognition and its Disorders, Macquarie University, Sydney, Australia, [3]Centre for Advanced Imaging, University of Queensland, Brisbane, Australia*

Recent studies have found that the perception of co-speech gestures engaged a core set of fronto-temporal and fronto-parietal areas (e.g., Dick et al., 2012; Holle et al., 2008; Willems et al., 2007). However, no study has yet investigated the neural processes underlying the production of speech and gesture, and the combination thereof, i.e., co-speech gesture. Specifically, it remains an open question whether Broca's area is central to the coordination of speech and gesture as has been suggested previously (Gentilucci & Dalla Volta, 2008). The objective of this study was to use fMRI to (i) investigate the regional activations underlying overt production of speech, gestures, and co-speech gestures, and (ii) examine functional connectivity with Broca's area. We hypothesized that co-speech gesture production would engage fronto-temporal and fronto-parietal regions and that both would be mediated by Broca's area. Whole-brain analysis showed that co-speech gesturing did engage fronto-temporal and fronto-parietal brain areas that form part of known networks for language and gesture. Functional connectivity analysis revealed a functional network common to speech, gesture, and co-speech gesture production. This network consists of brain areas that play essential roles in motor control, suggesting that the coordination of speech and gesture is mediated by a shared motor control network. Our findings lend support to the idea that the relationship between language and action is primarily motoric, rather than semantic.

E4 Non-linear dynamics of speech and voice in schizophrenia *Riccardo Fusaroli[1,2,3], Ethan Weed[2,3,4], Arndis Simonsen[2,5], Vibeke Bliksted[2,5]; [1]Center for Semiotics, Aarhus University, [2]Interacting Minds Center, Aarhus University, [3]Center of Functionally Integrative Neuroscience, Aarhus University, [4]Linguistics, Aarhus University, [5]Department of General Psychiatry, Aarhus University Hospital*

Background: Patients with schizophrenia are often described as speaking monotonously and without emotion. Such anomalous speech and voice patterns are assessed in the diagnostic process and deeply impact the quality of everyday social interactions. It is therefore crucial to quantify these patterns and relate them to other symptoms. Objectives: In this project, we quantify how the speech patterns of people with schizophrenia differ from that of matched controls and how they relate to positive and

negative symptoms. To do so, we employed non-linear measures of the structure (variability, regularity and complexity) of prosody and speech behavior. Our aims were (1) to achieve a more fine-grained understanding of the speech patterns in schizophrenia than has previously been achieved using traditional acoustic measures, and (2) to employ the results in a supervised machine-learning process to classify speech production as either belonging to the control or the schizophrenia group, and to assess the severity of positive and negative symptoms based solely on voice dynamics. Methods: Our analysis was based on previously acquired narratives of the Frith-Happé triangles by 57 people with first-diagnosis of schizophrenia (23F 34M, Mean Age=22.93 SD=3.46) and 57 matched controls, with 8 narratives per subject. We extracted basic measures of pause behavior (Number of Pauses, Average Length) and fundamental frequency (Minimum, Maximum, Mean, and Range) as well as measures of stability and regularity for both (Recurrence Rate, Det, L, LMax, Entr, Lam, Vmax, T1, T2, Trend). The most relevant features were selected via ElasticNet (10-fold cross-validation, Alpha=.5). Diagnosis was predicted using in a 10-fold cross-validated discriminant function (Mahalanobis rule). Accuracy was balanced using Variational Bayesian mixed-effects inference. SANS and SAPS scores were predicted using a 10-fold cross-validated multiple linear regression. Both analyses were iterated 1000 times to test for stability of results. Results: Voice dynamics allowed discriminating patients with schizophrenia from healthy controls with a balanced accuracy of 85.68% (p=4.97e-42, Confidence Intervals: 82.50% – 86.97%), a sensitivity of 81.27% and a specificity of 86.97%. Voice dynamics explained 26.76% (measured as Adjusted R Square, SD=.23%, p=1.8730e-09) of the variance of SANS scores and 20.33% (SD=.19 %, p=2.9732e-06) of SAPS scores. When comparing them to healthy controls, schizophrenics' voice was characterized as: (1) Slower and with longer pauses; (2) Less structured, that is, with fewer repetitions of f0 sequences; (3) More "stable", that is, the same low level of regularity is kept constant over time, while the controls tend to increase and decrease the amount of regularities and repetitions over time. Conclusions: The study points toward the usefulness of non- linear time series analyses techniques in picking out the subtle differences that characterize the unusual voice characteristics of people with schizophrenia and in relating them to the symptoms. Automated analysis of voice dynamics thus reveals potential for the assessment and monitoring of the disorder.

E5 Neural correlates of gesture-syntax interaction.

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In a communicative situation, gestures are an important source of information which also impacts speech processing. Gesture can for instance help when speech perception is troubled by noise (Obermeier et al., 2012) or when speech is ambiguous (Holle et al., 2007). Recently, we have shown that not only meaning, but also structural information (syntax) used during language comprehension is influenced by gestures (Holle et al., 2012). Beat gestures, which highlight particular words in a sentence, seem to be able to disambiguate sentences that are temporarily ambiguous with respect to their syntactic structure. Here we explored the underlying neural substrates of the gesture-syntax interaction with fMRI using similar ambiguous sentence material as Holle et al. (2012). Participants were presented with two types of sentence structures which were either easy (Subject-Object-Verb) or more difficult (Object-Subject-Verb) in their syntactic complexity. A beat gesture was shown either at the first or the second noun phrase (NP). Activations related to syntactic complexity were primarily lateralized to the left (IFG, pre-SMA, pre-central gyrus, and MTG) and bilateral for the Insula. A ROI-based analysis showed interactions of syntax and gesture in the left MTG, left pre-SMA, and in the bilateral Insula activations. The pattern of the interaction suggests that a beat on NP1 facilitates the easy SOV structure and inhibits the more difficult OSV structure and vise versa for a beat on NP2. Because the IFG was unaffected by beat gestures it seems to play an independent/isolated role in syntax processing.

E6 Size matters: Graded influence of prosodic boundaries on sentence processing

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Prosodic boundaries have been consistently demonstrated to have an immediate influence on parsing in a variety of syntactic structures as well as cross-linguistically [1]. For example, in temporary ambiguities such as Early versus Late (EC/LC) closure, which contain two potential boundary positions – the first (#1) compatible with EC and the second (#2) compatible with LC (e.g., Whenever the bear was approaching #1 the people #2 (EC): …would run away; (LC): …the dogs would run away), without the benefit of prosodic information, the preferred (or default) interpretation is LC, which consequently leads to processing difficulties (garden-path effects) in EC structures [2]. The majority of studies on spoken sentence processing has focused on the impact of a single boundary on the closure or attachment preference of a specific phrase or clause. However, more recently, several influential theories have emerged that aim to account for the interplay between two boundaries in a sentence, specifically in terms of size and location [3]. Although different in their approaches, these theories agree that listeners process boundary information at the sentence level in a categorical manner, as defined by the ToBI annotation system of American English [4]. The two assumed categories are (i) the larger intonational phrase boundary (IPh) and (ii) the smaller intermediate boundary (ip). An implication of this distinction is that no differences in processing are expected between variants of a specific category [5]. Contrary to

this assumption, a few behavioral studies have found that boundaries can differ in a gradient quantitative manner [6], showing that listeners can detect and process a wide range of boundary sizes, leading in turn to more subtle patterns of language comprehension. The aim of the current study was to test whether gradient differences in boundary size impact listeners' parsing decisions in a gradient manner, or whether they exhibit strictly categorical effects, both behaviorally and using Event-Related Potentials (ERPs). We conducted 2 behavioral experiments (Exp1: N=12; Exp2: N=20) and one ERP experiment (N=40), where listeners were presented with highly controlled digitally-manipulated EC/LC sentences, each containing two prosodic boundaries (as in the example above), which differed only in terms on their relative sizes (3-4 levels per boundary). The task required an acceptability judgment on a (5 or 7 point) scale. Results showed that (i) even small early boundaries biased listeners towards EC, with much larger second boundaries required to override this bias; (ii) surprisingly, only the strength of the incompatible boundary (1st in LC, 2nd in EC) drove acceptability ratings – a finding predicted only by the Boundary Deletion Hypothesis (BDH) [7]; (iii) most importantly, we found a gradient pattern for both CPS components and the garden path effects, as well as the behavioral ratings (in all three experiments). The findings demonstrate that subtle differences between prosodic boundaries are detected by the brain and affect the degree of processing difficulty. These outcomes cannot be explained by a purely categorical account. Moreover, they cast serious doubts on most current models of prosodic online processing and strongly support the BDH.

E7 Continuous fMRI of multimodal conversation with high functioning autistic individuals. *Kyle Jasmin[1,3], Siyuan Liu[2], Yisheng Xu[2], Bako Orionzi[1], Ian Eisenberg[1], Nuria Abdulasabur[2], Meghan Healey[2], John Ingeholm[1], Allen R. Braun[2], Alex Martin[1]; [1]National Institute of Mental Health, NIH, [2]National Institute on Deafness and Other Communication Disorders, NIH, [3]UCL Institute of Cognitive Neuroscience*

Language use in the real world occurs mainly as two-person conversation. People with Autism Spectrum Disorders (ASDs), even those with appropriate use of syntax, semantics and phonology, and normal or above average intelligence, often have difficulty with social aspects of conversation. Little is known about the neural bases for these deficits because they tend to arise spontaneously in face-to-face conversation, which, because of technical challenges, are difficult to study with fMRI: conversation necessarily involves continuous movement of the speech articulators, which causes motion artifacts. Additionally, the enclosed environment of the MRI scanner makes face-to-face interaction difficult. Here we present a new paradigm for studying the neural basis of social language deficits in ASD in a naturalistic setting that simulates face-to-face interaction using live video and audio feeds between conversation partners, and copes with motion artifacts using a new de-noising technique. ASDs and neurotypical participants engaged in free conversation with an experimenter while being scanned with continuous fMRI. The participant, who was lying in the scanner, and the experimenter, who was seated in front of a blue screen in the control room, could see and hear each other using cameras, microphones and headphones. This approach allowed us to record vocal prosody, facial expressions and hand gestures – behaviors known to be related to social deficits in ASD. Each experiment consisted of 3 six-minute conversation runs. Because ASD subjects often have a restricted range of interests, the topics for two of these conversations were chosen from those reported on a self-reported Interest Scale questionnaire, which participants filled out before the experiment (e.g., "video games"). The topic of the final conversation of each was always "work and school", and served as a standardized topic across groups. Additionally, the subject and experimenter engaged in a control task in which they took turns reciting memorized nursery rhymes, for two runs of 3 minutes each. FMRI data were collected continuously during all runs. Noise from physiology and motion was removed with a novel technique that used a dual-mask spatial independent component analysis, and automatically classified and removed speech-related noise components and restored task-related signal (Xu, et al., submitted). In a preliminary analysis of the de-noised data (N=16, 9 NT, 7 ASD), we used GIFT software for independent component analysis to identify sets of co-activating brain areas (components) that were consistent across all subjects during conversation runs. We then compared the mean weights of the components for neurotypical participants to those with ASD. Significantly higher weights for the NT than ASD participants were found for a network of regions associated with language and social processes: temporo-parietal junction, dorso- and ventro-medial prefrontal cortex, posterior cingulate and precuneus, posterior superior temporal sulcus, and inferior frontal gyrus. These preliminary findings provide support for the use of fMRI in an ecologically valid setting that simulates the context where social language deficits in ASD occur – face-to-face interaction – while mitigating the motion-related artifacts that accompany speech during continuous fMRI.

Auditory Perception, Speech Perception, Audiovisual Integration

E8 Temporally dynamic cortical processing of spoken words: evidence from intracranial recordings *Ariane E. Rhone[1], Bob McMurray[1], Hiroyuki Oya[1], Kirill V. Nourski[1], Hiroto Kawasaki[1], Matthew A. Howard III[1]; [1]University of Iowa*

Spoken word recognition is characterized by periods of temporary ambiguity. For example, when a listener hears "manatee," the input is initially consistent with multiple words (e.g., "manicure," "man," "mandarin").

Behavioral and electrophysiological studies show that listeners activate many words (and associated meanings) on the basis of this partial match and then narrow down candidates from the activated cohort as disambiguating input arrives. Neuroimaging and lesion studies implicate a broad network of cortical structures involved in auditory word recognition. However, little is known about the time course of these processes in auditory and language-related cortical areas. In this study, we measured electrocorticographic (ECoG) responses to isolated real word stimuli and used single-trial support vector machine (SVM) classification to investigate the time course of spoken word disambiguation. Participants were neurosurgical patients (N = 4) undergoing chronic ECoG monitoring for diagnosis and treatment for medically intractable epilepsy. All participants were left hemisphere language-dominant. Stimuli were three sets of English words produced by an adult female native speaker of English; words varied on degree of overlap within cohort set: dinosaur/dynamite/diary; manicure/manatee/mandarin; caliber/calorie/calculate. Five repetitions of ten unique tokens per word type were randomized and presented diotically via insert earphones in a passive listening paradigm. ECoG recordings were simultaneously obtained from Heschl's gyrus and perisylvian cortex using multicontact depth electrodes and subdural grid electrodes, respectively. Two participants had right hemisphere and two had left hemisphere coverage. Averaged evoked potentials and event related band power in the high gamma band (70-150 Hz) were measured at each recording site. In all participants, responses were localized to auditory and auditory-related areas, including the supratemporal plane, lateral superior temporal gyrus (STG), inferior frontal gyrus (IFG), and supramarginal gyrus (SMG). For classification analysis, sites were grouped according to anatomical location in each participant. SVMs were used to determine discrimination of word types and cohorts within each area. High gamma power and ECoG voltage, averaged over 50 ms windows with 50% overlap, were used as input features. In Heschl's gyrus and lateral STG, cohort set classification (man- vs. di- vs. cal-) deflected from baseline early (50-150 ms post-stimulus onset), peaked near 80% correct classification at approximately 250 ms and gradually declined to baseline by 1s. Deflection from baseline and best classification for item within cohort set (manatee vs. manicure vs. mandarin) occurred later (approximately 300 and 600 ms post stimulus, respectively), potentially reflecting differences in the acoustic-phonetic properties of the non-overlapping offsets. In other areas (IFG, SMG), cohort classification performance was above chance but reduced, showed later deflection from baseline and peak than auditory areas, and declined to baseline sharply around 500-600 ms. Item classification did not differ from baseline for these regions. The results suggest that higher-order language-related areas are less sensitive to the acoustic properties of the stimuli, but do contain information relating to more global word-form properties that distinguish between sets.

E9 Word and pseudoword processing in the left ventral stream *Emily Cibelli[1], Matthew Leonard[2], Keith Johnson[1], Edward Chang[2]; [1]University of California, Berkeley, [2]University of California, San Francisco*

Pseudowords - phonologically legal novel forms like "blick" and "piteretion" - are commonly used as controls for real words in lexical processing studies. However, it is not always clear what levels of processing they activate and what is being controlled. To address this, two competing theories of pseudoword processing have emerged. In one, a dual-route approach, word processing relies on stored lexical representations, while pseudowords are processed through sub-lexical routes with no access to stored lexical information (Coltheart et al. 1993, 2001; Marshall and Newcombe 1973). By another account, words and pseudowords use the same processing streams, and differences between them are a function of magnitude, not of kind (Seidenberg and McClelland 1989). There has been evidence in the neuroimaging literature for both the dual-route theory (Jodel et al. 2003, Helm et al. 2005) and the shared streams account (e.g. Price et al. 1996, Newman and Twieg 2001). This study investigates words and pseudoword auditory processing along the ventral stream (Hickok and Poeppel 2007, Rauschecker and Scott 2009), including sites of phonetic, phonological and lexical processing, using data from electrocortographic recordings. The high temporal and spatial resolution of ECoG data has the potential to distinguish between the two processing models under consideration. Recordings from left-hemisphere electrodes were taken from two patients performing a listen-and-repeat task. Stimuli included real words (e.g. "federation", "minority") and pseudowords created by rearranging the phonemes in the real words (e.g. "reifadetion", "tomeereneye", Wilson and Gorno-Tempini). High-gamma (HG) responses (70-150 Hz) from time points during the listening phase were analyzed in temporal lobe electrodes. Spectrotemporal receptive fields (STRFs) were used to generate a predicted response for each electrode based on the acoustic tuning of that channel. The STRF predicted response was subtracted from the single-trial HG signal; regression models were then fit to the residualized data in each electrode. Growth curve analysis (GCA, Mirman et al. 2008) was used to construct time-varying models with the following lexical predictors: lexicality, cohort size (number of competitors in the lexicon, given a series of phonemes), and cohort frequency (average frequency of those cohorts at each time point). Model R2s showed a wide range (min: 0.01, max: 0.60), but electrodes where lexical factors had the greatest predictive power were concentrated in mid- and anterior-STG. On average, HG amplitude was stronger in response to pseudowords than words; however, the response in several electrodes showed the opposite effect. A strong effect of cohort size

was found in several channels. Cohort frequency also modulated HG amplitude, but this effect was minimal. The time course of activity was roughly equivalent between words and pseudowords; in general, responses peaked early in posterior superior temporal electrodes and propagated forward to mid and anterior-channels, consistent with Gow et al. (2009). The data are consistent with a shared streams account: along the ventral stream, words and pseudowords share processing in acoustic, phonetic, phonological, and lexical regions. Significant effects of cohort size and frequency suggest that stored lexical information is available along this stream.

E10 Interactive activation models simulate phoneme restoration with appropriate linking hypotheses *James Magnuson[1,2]; [1]University of Connecticut, [2]Haskins Laboratories*

One of the most challenging unsolved problems in neuroscience is sequence encoding and processing. The problem is particularly acute in the case of speech, where transient, overlapping acoustic events must be mapped onto phonological and lexical categories at a rapid rate. The TRACE model (McClelland & Elman, 1986) applied the interactive activation computational framework to speech. To handle sequence encoding, the model reduplicates feature, phoneme, and word representations over a memory bank, converting the problem of temporal encoding to one of spatial encoding: detectors aligned with a particular time slice can be activated by bottom-up input at that time. The model can distinguish sequences that include embedded words (e.g., the phonology of ADD is embedded within DAD) or repeated elements (e.g., repeated phonemes, as in DAD, or words, as in DOG EATS DOG). Repeated elements can be encoded because the model literally treats them as independent events (there is no connection between the first and second /d/ in DAD in the model). Grossberg and Kazerounian (2011) reject this approach as psychologically and biologically unrealistic, and present an alternative approach to sequence representation for spoken word recognition, the cARTWORD model. They demonstrate that cARTWORD can account for phoneme restoration effects (subjective reports that a phoneme replaced with noise was still heard, whereas a phoneme replaced by silence is clearly perceived as missing), and present TRACE simulations that seem to show that TRACE fails to simulate these effects. In their TRACE simulations, greater phoneme activation is observed when the phoneme is replaced with silence than noise. However, their simulations were flawed; they introduced noise by creating a new "noise phoneme" that could compete with other phonemes. Here, I demonstrate that when noise appropriately simulated (by replacing featural inputs with noise values, rather than adding a noise phoneme to the model), TRACE accurately predicts greater phoneme activation when a phoneme is replaced with noise rather than silence. I also refute Grossberg's & Kazerounian's (2011) claims (a) that TRACE's scheme of transforming temporal encoding into spatial encoding is not biologically possible (in fact, with slight modifications, the TRACE architecture provides a plausible basis for echoic memory) and (b) that non-modulatory feedback (i.e., feedback in the absence of bottom-up input) leads to inherent instability. In light of these demonstrations and rebuttals, I conclude that cARTWORD provides an intriguing promissory note; however, in the absence of evidence that cARTWORD captures a similar range and detail of human spoken language processing as alternative models, one cannot even claim cARTWORD is comparable to extant models like TRACE, let alone superior.

E11 Pattern specific adaptation to speech and non-speech sounds in human auditory cortex *Colin Humphries[1], Merav Sabri[1], Nicholas Heugel[2], Kimberly Lewis[1], Einat Liebenthal[1]; [1]Medical College of Wisconsin, [2]Marquette University*

Speech perception relies on the identification of specific spectral-temporal patterns in the auditory signal. A typical consonant-vowel (CV) syllable consists of an initial period of fast spectral change, providing information about the consonant, followed by a relatively unchanging period providing information about the vowel. We used an adaptation paradigm in fMRI to investigate differences in the response of auditory cortex to these two parts of the speech signal. Stimuli were CV syllables (ba,ga,bi,gi,bae,gae) synthesized in Praat consisting of two formants (F1, F2) divided into an initial spectrally changing transition (T) period followed by a spectrally flat steady-state (SS) period. Three sets of stimuli were used. Speech stimuli were generated with F1 and F2 in their canonical orientation. Non-speech stimuli were generated by spectrally rotating the F1 formant. Single-formant stimuli only included either the F1 or F2 formant. FMRI was recorded while 14 subjects listened to trials of six stimuli, in which the last two stimuli either (1) matched the first four, (2) differed in the T period, (3) differed in the SS period, or (4) differed in both the T and SS periods. During the scan subjects were required to identify trials (p=.1) that were missing one of the six stimuli. The results showed that speech stimuli elicited greater activation in the middle superior temporal sulcus (STS) bilaterally than non-speech or single-formant stimuli. A larger adaptation effect for T and SS was observed for speech over non-speech stimuli in bilateral auditory cortex and STS. This effect was stronger for adaptation differences in SS than for T. The results suggest that neurons in auditory cortex and STS are specifically tuned towards processing spectral-temporal patterns related to speech.

E12 Processing phonological stem variants of complex words: a neurolinguistic perspective *Natalia Bekemeier[1], Aditi Lahiri[2], Carsten Eulitz[1]; [1]University of Konstanz, [2]University of Oxford*

How much phonological detail of morphemes is stored in the mental lexicon? Do allomorphs derived by regular stem vowel alternations share one lexical entry or do they have separate entries (e.g., is the stem morpheme of sanity the same as sane). To answer this question we investigated the recognition process of morphologically complex words in German by means of event-related brain potentials (ERP), the key issue being error-sensitivity to certain types of phonological violations. We hypothesized that for semantically transparent derived words there should be a single underlying morpheme with a set of morphophonological and morphosyntactic rules defining its surface phonetic form. To test this hypothesis, we examined the brain's violation responses to reparable (Related Derived (RD)) and non-reparable pseudowords (Unrelated Derived (UD)) in a series of auditory ERP experiments with gradually modified experimental settings (lexical decision and memory tasks using word lists as well as sentences). If regular stem allomorphs have a single entry, the reparable pseudowords should elicit error-detection responses different from those evoked by non-reparable pseudowords depending on the experimental task and design. However, if these stem allomorphs have separate lexical entries, both types of pseudowords should evoke similar violation responses. A set of 21 German nouns (W) derived from an adjectival stem by phonological fronting of the stem vowel and attaching a nominalizing suffix {-ung } (e.g. stark [a] 'strong' > Stärkung [□] 'strengthening') were used to create two types of pseudowords. For the RD condition, the original adjectival stem was used, omitting the vowel change but adding the suffix, thus keeping the morphological structure legal: e.g. *Starkung. For the UD condition, we added the suffix to a form where the vowel was changed enough to make the stem non-existent, e.g. *Sturkung. Thus, the RD words, though altered and non-existent could still be traced back to the original morphemes and extract the composite meaning of the morphemes. The meaning of the UD words could not be recovered, but they still had a legal morphological structure. In the word list experiment with a lexical decision task the violated items elicited a gradual N400 effect: Stärkung (W) < *Starkung (RD) < *Sturkung (UD), showing that the lexical integration of reparable pseudowords is easier than the integration of non-reparable pseudowords. During the memory task (same lists) where lexical access is not obligatory, the N400 effect vanished, but a Left Anterior Negativity (LAN) effect was observed in the RD condition only. This pattern of results supports the idea of obligatory prelexical morphological decomposition of semantically transparent items, along with the detection of the violation of the morphophonological structure for the reparable pseudowords. During a memory task in a sentence experiment with the critical words being highly predictable and in final position, RD and UD pseudowords evoked differential N400-P600 effects. Across all experiments, reparable and non-reparable pseudowords elicited different error-detection responses. RD but not UD pseudowords were treated as items violating morphophonological rules. One reasonable explanation is that regular stem allomorphs do indeed share a single lexical entry.

E13 Mapping the timecourse of visual interference on auditory speech perception: A novel application of the McGurk effect

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Previous studies have utilized McGurk stimuli to measure a "window of integration" for audiovisual speech information. In particular, this window (150-200ms in length) can be reliably estimated from tolerance of McGurk fusion to temporal displacement of the auditory speech signal. However, this method fails to specify which features of the visual stimulus contribute to integration, how these features relate to one another, and exactly when they unfold in time. Here, we present a method that allows for such specification. Twelve participants were presented with 1.3s McGurk videos (60fps; 78 total frames). An audio recording of the VCV /apa/ was dubbed onto a video recording of /aka/. Over 256 trials, participants were asked to report whether they heard /apa/. A visual masker was placed over the mouth of the speaker in the videos – the masker was a square matrix of spatially and temporally correlated alpha transparency values – such that different pixels from each frame of the video were obscured at random on each trial (leading to 46% /apa/ responses versus 7% /apa/ with no mask). High spatial and temporal correlation values were chosen to give the masker a smooth, shutter-like effect that minimally disturbed the underlying video. For each participant, reverse correlation was performed by separating trials into /apa/ (no interference; NI) and not-/apa/ (interference; IN) responses and tabulating a weighted sum over all trials (NI = negative weight; IN = positive weight) of the alpha values at each pixel of the masker. The result was a classification mask that revealed which pixels of the video contributed significantly to visual interference. A mean timecourse (78 timepoints; 16.667ms resolution) was also calculated by averaging across all pixels in each frame of the classification mask. We carried out second-level analysis by averaging the classification masks and mean timecourses from all 12 subjects and performing FDR-corrected one-sample t-tests ($P<0.05$). Significant positive values indicated a contribution to visual interference. The thresholded group classification mask, which is similar to an fMRI spatial activation map, showed significant clusters of pixels frame-by-frame. The group mean timecourse gave a frame-by-frame representation of the degree of visual interference on auditory speech perception. Two peaks were observed in the group mean timecourse, one at the offset of the initial auditory vowel, and one at the onset of the subsequent stop. Only the second peak was significant

– 7 frames (116.67ms) composing this peak survived thresholding, matching well with previous estimates of the audiovisual window of integration. The first peak was not significant due to large individual variability (only 6 of 12 subjects displayed local maxima within +/- 2 frames of this peak, versus 11 of 12 subjects at the second peak). However, significant clusters of pixels in the group classification mask could be observed for the frames surrounding the first peak. The first peak preceded the second peak by 11 frames (183.33ms), meaning that visual information outside the traditional window of integration may influence auditory perception. This information would not be available using other methods.

E14 The Effects of Attention on the Speech Perception of Infants

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This study examined how attention affects the speech perception skills of 4-to 8-month old infants. Specifically, we explored the role of attention in the development of tone and vowel perception skills in infants through the use of auditory and visual associative learning and explored the functional nature of the brain discrimination responses in infants. Researchers have proposed that infants learn to automatically weigh critical features that are needed for making semantic distinctions between words (Jusczyk, 1997). Lack of automaticity in selecting relevant features in the environment appears to be a causal or contributing factor in language impairment (Shafer, et al. 2005). It is possible that poor selective attention to speech information contributes to this speech perception deficit and, possibly, language delays seen in language impairment. However, direct evidence of the role of attention has not been obtained. This study uses brain discrimination measures (Mismatch Responses (MMRs)), to compare auditory discrimination of CVC words and tones in two different tasks designed to focus attention differently. MMRs have been shown to index discrimination of fine-grained differences in auditory stimuli in infants, children and adults. A repeating standard stimulus forms a sensory memory trace against which incoming stimuli are compared. The sensory input from the deviant stimulus is registered as a mismatch, and indexed by a change in electrical firing. Two different infant MMR responses have been observed to speech sound changes, one positive and the other negative in polarity. Current evidence suggests that the negative MMR is the precursor of the adult MMN, whereas the positive MMR reflects lower-level discrimination (Shafer, et al., 2012). In addition, presence of a robust negative MMR, when attention is focused elsewhere, is hypothesized to indicate robust preattentive representations. This study further examined these claims. ERPs were collected from 64 scalp sites to tones (1000Hz vs. 1200 Hz) and Consonant-Vowel-Consonant (CVC) words ([bIp] vs. [bep]) under two different task conditions. In the contingent condition, a picture of a smiling woman's face always followed occasional deviant auditory stimuli. In the non-contingent condition, the face followed 100% of the time in the tone experiment and randomly followed the standard [bep] on half the occasions, and the deviant [bIp] on the other half in the speech experiment. The woman's face was designed to draw the infant's attention to the stimulus change in the contingent condition. Results showed that negative MMRs were present when attention was focused to the change in the Contingent condition, peaking around 200 ms. A significant difference was seen in the amplitude of the MMR to the deviant in the Contingent vs. Noncontingent conditions ($F(20, 180) = 2.67$, $p = 0.001$) in the speech contrast. The difference was greatest at left and midline frontocentral sites. These results suggest that elicitation of the negative MMR, which is probably the precursor of the adult MMN, to this fine-grained phonetic difference requires attention in the first year of life, because robust representations have not yet been constructed to allow for automatic, preattentive discrimination.

E15 Time course of phonological activation in processing spoken Chinese disyllabic words: evidence from eye movements

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Introduction:One issue of spoken word recognition is whether processing phonological unit is in a sequential fashion and whether different parts of phonological representation play a different role in word processing. In Chinese, the majority of words are disyllabic compounds and their constituent characters usually map to morpheme and syllable acting as units for words. It is unclear whether the constituent syllables at different position has the effect on spoken word recognition, especially when the morphemic influence is controlled. The present eye movement experiment used the visual world paradigm to investigate the time course of phonological processing of different syllables in spoken word recognition of Chinese disyllabic words. Methods:1.Participants:Thirty-two Chinese native speakers of university students were paid for participating in the experiment. They had normal or corrected-to-normal vision. 2.Stimuli:Thirty-two sets of Chinese two-character words were chosen from a corpus. Each set comprised of 5 words including a target word (/li3/-/mɑw4/[禮貌]), a cohort competitor sharing the first syllable but visually dissimilar with the target (/li3/-/ fa3/[理髮]), a rhyme competitor sharing the second syllable but visually dissimilar with the target(/tɛiŋ1/-/mɑw4/[經貿]), and two unrelated controls(/ɛjɑŋ1/-/jɛ3/[鄉野];/pʰiŋ2/-/ʂən3/[評審]). Word frequency, neighborhood size, number of strokes, and homophone density of constituent characters were matched within each set. 3.Apparatus : EYELINK 1000 tracking system running at 1000 Hz. Procedure : On each trial, the participants fixated at a central cross and a spoken instruction (e.g. "please click on the word /li3/-/mɑw4/") was delivered over headphone.

An array of four two-character words was displayed on the screen at 200ms before the acoustic onset of the target word. The array included the target, one competitor(cohort or rhyme), and two unrelated words. The trial ended after the participants clicked on the target word. Results : Fixation proportions on targets and cohort competitors were similar in the beginning and started to diverge from those on unrelated words at 300 msec after the acoustic onset of the target. Around 600 msec, fixations on cohort competitors decreased and dropped to the baseline level at 800 msec. For rhyme competitors, fixation proportion was similar to the unrelated words in all time periods and diverged from targets at 300 msec. Conclusion : The similar pattern of targets and cohort competitors from acoustic onset of targets lasting for 600 msec indicates that, homophones of the first syllable of word compounds are activated when processing the auditory stream. Since the cohort competitors shared no visual form or morpheme with targets, this effect was obtained clearly at the phonological level and it occurred early. In contrast, the rhyme competitors that shared the second syllable with targets obtained no additional fixations than the unrelated baseline in all time periods. The results of cohort competitor and rhyme competitor effects suggest that initial word information is more important in processing spoken disyllabic words. It is more compatible with the Cohort model assuming that mapping from auditory inputs to words is sequential and continuous.

E16 Long-term memory traces for language sounds are highly context-sensitive: an MEG/ERF study *Andreas Højlund Nielsen[1,2], Line Gebauer[1], William B. McGregor[2], Mikkel Wallentin[1,3]; [1]Center of Functionally Integrative Neuroscience, Aarhus University, [2]Linguistics, Aarhus University, [3]Center for Semiotics, Aarhus University*

Introduction: An early component of the auditory event-related potential (ERP), the mismatch negativity (MMN), has been shown to be sensitive to native phonemic language sound contrasts compared to non-native or allophonic language sound contrasts. So far this has not been attested for different phonetic contexts. In the present study we investigated the mismatch field (MMF) response (the magnetic counterpart of the MMN) of native Danish speakers to the Danish phonetic contrast of [t]-[d] in two different phonetic contexts: One in which the sound contrast was phonemic ([tæ] versus [dæ]), and one in which the sound contrast was allophonic ([æt] versus [æd]), i.e. its phonemic status was neutralized. Methods: The stimuli consisted of the four Danish syllables: [tæ] and [dæ] (meaning 'take' and 'then', respectively), and [æt] and [æd] (both meaning 'that'). These were presented in a passive listening MMN paradigm while participants' MEG was recorded. [tæ] and [æt] acted as standards, and [dæ] and [æd] thus as deviants, respectively. Results: Comparing brain responses to the deviants and the standards, only the phonemic [tæ]-[dæ] contrast showed significant effects (FWE-corrected at $p<0.05$ at the cluster-level) within the typical MMN time range (100 to 300 ms after deviance onset) and over both hemispheres. Comparing the differences between the two contrasts ([dæ]-[tæ] minus [æd]-[æt]), the phonemic context elicited significantly larger MMF responses than the allophonic context (FWE-corrected at $p<0.05$ at the cluster-level), again over both hemispheres and within the typical MMN time range. Conclusion: By manipulating the immediate phonetic context in an oddball paradigm, we demonstrate that the human brain's MMF response to language sounds is highly context-sensitive. This has important impact on the proposed long-term memory traces for native phonological categories. In order to generate different MMF responses to the same language sound contrast depending on the phonetic context, these long-term memory traces must thus be context-sensitive themselves or exist as separate traces for the context-dependent allophones of the phonological categories.

E17 Effects of phase- and amplitude-spectrum decorrelation on speech intelligibility *Sierra Broussard[1], Gregory Hickok[1], Kourosh Saberi[1]; [1]University of California, Irvine*

The effects of temporal envelope cues on speech intelligibility, and in particular the role of the phase spectrum, have been the topic of significant recent interest. In an earlier study we showed that vocoded speech, which largely distorts amplitude-spectrum cues while preserving temporal information, activates the posterior superior temporal sulcus, providing evidence that this area selectively codes for speech intelligibility and not for variations in acoustic features (e.g., temporal or spectral cues). The current study parametrically investigated the joint effects of amplitude and phase information on intelligibility of spoken sentences by independently decorrelating their amplitude and phase spectra relative to those of the original sentence. We found that when phase spectra are decorrelated to 0.4 or lower, speech becomes completely unintelligible even when the amplitude spectrum is unaltered ($r=1$). Conversely, when the original amplitude spectrum is decorrelated to 0, speech remains intelligible as long as phase correlation is at least equal to 0.8. These results support recent findings that phase information is more critical to intelligibility than amplitude-spectrum cues, and delineate the range of amplitude and phase correlations necessary for maintaining intelligible speech.

E18 Representation of spectro-temporal features of fricative and stop-consonant word onsets within the sensory auditory-evoked potentials (AEPs), the P1-N1-P2 and T-complex, in individual listeners *Monica Wagner[1], Arindam RoyChoudhury[2], Valerie L Shafer[3], Brett Martin[3], Mitchell Steinschneider[4]; [1]St. John's University, [2]Columbia University, [3]CUNY-Graduate School and University Center, [4]Albert Einstein College of Medicine*

The phoneme sequence that constitutes a spoken word consists of a unique set of acoustic features that change over time. The P1-N1-P2 and T-complex of auditory evoked potentials (AEPs) reflect these time-varying spectral and temporal features (Wunderlich & Cone-Wesson, 2001; Wagner et al., 2013) and can be used to index cortical level processing of the spoken word (Giraud et al., 2005; Martin et al., 2007; 2008; Wagner et al., 2013). It is unclear, however, whether spectro-temporal features of words can be consistently identified within the P1-N1-P2 and T-complex in individual subjects having normal language abilities. Aberrant P1-N1-P2 and T-complex patterns have been demonstrated in individuals with language impairment and related disorders including dyslexia (Bishop et al., 2007; Ceponiene et al., 2009; Giraud et al., 2005; Giraud et al., 2008; McArthur & Bishop, 2005; Purdy et al., 2002; Shafer et al., 2011; Shafer et al., 2004). Also, cortical sensory AEPs predict later language impairment in at-risk infants (Guttorm et al., 2013), suggesting these waveforms may have potential for identification of auditory processing impairment. While aberrant P1-N1-P2 and T-complex patterns have been identified in individuals having auditory processing impairment, the patterns have rarely been interpreted relative to spectral and temporal feature processing of the acoustic stimuli used within the experiments. Currently, we investigate whether spectro-temporal features of words beginning with fricative /s/ and stop consonant /p/ are represented within the P1-N1-P2 and T-complex waveforms in individual participant data. Forty-eight adult participants listened to pairs of nonsense words and performed a syllable identification task to the second word in the pairs. A 65 channel net (Electrical Geodesic Inc.) was used to record the AEP and epochs were time-locked to the first word in the words pairs. Stimuli presented in the experiment were naturally recorded to approximate cortical recognition of phoneme sequences within the natural environment (Makela et al., 2002). Nonsense words began with the fricative /s/ or the stop consonant /p/ phoneme (e. g., "petisa", "setisa"). These phonemes are highly contrastive in both spectral and temporal features (Bordon et al., 2003; Rosen, 2013) facilitating identification of speech contrasts within the sensory AEPs. Single trial AEP responses from each participant were analyzed to assess synchrony of the neural response (Michalewski, Prasher & Starr, 1986). This research will be of value for future work with clinical populations as asynchrony of response may, in some cases, underlie auditory processing impairment (Gilley & Sharma, 2010). The P1-N1-P2 and T-complex patterns for individual participants were found to index spectral and temporal feature processing for words having fricative /s/ and stop consonant /p/ onsets. Results are discussed in terms of clinical significance.

Motor Control, Speech Production, Sensorimotor Integration

E19 Left Hemisphere Spatio-temporal Correlates of Unconstrained Complex Picture Naming: An MEG Study

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Current neurological models of speech production are the product of merging the information gleaned from chronometric, ERP, and fMRI data in an effort to extrapolate the flow of activation through time between regions of the brain thought to support language processing. When merging such disparate information, however, one necessarily makes assumptions that are not directly backed-up by empirical data. In the present study, we determine the time course of activation of 30 left hemisphere brain areas identified in the meta-analysis of Vigneau and colleagues (2006) as involved in language processing in a single MEG experiment. We recorded magneto-encephalographic data from 21 healthy participants recruited from the population at large while they were performing an unconstrained picture naming task. MRI-guided beamformer time courses of activation were analyzed using a conditional inference tree. The results of the statistical analysis indicated that activation began in the fusiform gyrus, middle lateral temporal gyrus, and posterior middle temporal gyrus 119 ms after the onset of a picture (cluster 1). Activation then moved to a cluster of regions comprised of supramarginal gyrus, Rolandic sulcus, dorsal pars triangularis of the left inferior frontal gyrus, and anterior superior temporal gyrus 767 ms after stimulus onset (cluster 2). It subsequently moved to superior temporal gyrus 23 ms later (cluster 3), and flowed anteriorly 1789 ms after picture presentation to a cluster of regions encompassing anterior superior temporal gyrus, Rolandic operculum, and pars orbitalis of the left inferior frontal gyrus/middle frontal gyrus (cluster 4). 2253 ms after stimulus onset, activation proceeded to pars orbitalis of the left inferior frontal gyrus, temporal pole, middle temporal gyrus, and angular gyrus (cluster 5). Finally, it shifted to posterior superior temporal sulcus, precentral gyrus, and posterior middle frontal gyrus 2255 ms after stimulus onset (cluster 6). We characterize the functional interpretation of each of these subnetworks involved in the naming process in light of a follow-up analysis using a conditional inference random forest, where we assessed the effect of a number of lexical variables (such as lexical frequency, number of phonemes and syllables, number of orthographic and phonetic neighbours, as well as voice onset time) on the magnitude of activation in each one of of these six clusters.

E20 The response of posterior perisylvian cortex during overt and covert speech production *Anna J Simmonds[1], Robert Leech[1], Catherine Collins[1], Ozlem Redjep[1], Richard J S Wise[1]; [1]Imperial College London, UK*

Initiating speech in left frontal cortex is thought to result in parallel feedforward signals. One, directed to bilateral motor cortex, results in sequences of co-ordinated movements that form the intended utterance. Simultaneously, signals are directed to auditory and somatosensory fields that encode the intended sensory consequences of that motor plan, to allow comparison with the actual post-articulatory sensory experiences. The cortical target for the merging of feedforward motor and feedback sensory signals is thought to lie at the junction of the posterior supratemporal plane, the planum temporale, with the adjacent parietal operculum. The present functional magnetic resonance imaging (fMRI) study investigated both overt and covert internally generated speech. Seventeen right-handed native speakers of English were scanned in a single run with four experimental language conditions and a rest baseline. The four language conditions involved propositional and non-propositional speech with two response types, overt and covert speech. The propositional speech tasks required participants to describe nouns presented visually and the non-propositional speech task was counting upwards from one. A whole-brain 2 (Overt and Covert) x 2 (Speaking and Counting) ANOVA revealed a main effect of response type and a main effect of task but no interaction. Four theoretically motivated regions of interest (ROIs) were defined on an individual basis, separately for each hemisphere, using Freesurfer's autosegmentation. Three ROIs were around the temporo-parietal junction (anterior and posterior planum temporale, and parietal operculum) and the fourth was the frontal operculum. Activity in response to overt speech alone was present in the left and right anterior plana temporale, with no increased activity observed in the posterior plana temporale or parietal opercula for either overt or covert speech. Therefore, the left and right anterior plana temporale fulfill the function of sensory target and state maps for normal speech. This interpretation is strengthened by recent studies in non-human primates that have demonstrated that cortex immediately posterior to primary auditory cortex receives both auditory and somatosensory input. Other speech-related studies that have observed activity in the left posterior planum temporale have relied on covert responses to stimuli (heard or written words or non-words, or pictures). This response seems, therefore, to originate from pre-articulatory mapping of external stimuli on to representations of their associated phonology, a system that is not active during normal speech production.

E21 Intra-cranial recordings of brain activity during language production: A brief review. *Anais Llorens[1,2,3], Agnès Trébuchon[1,2], Catherine Liégeois-Chauvel[1,2], F.-Xavier Alario[1,3]; [1]Aix-Marseille Université, [2]INSERM, [3]CNRS*

Introduction: Recent findings in the neurophysiology of language production have provided a detailed description of the brain network underlying this behavior, as well as some indications about the timing of operations. Despite their invaluable utility, these data generally suffer from limitations either in terms of temporal resolution, or in terms of spatial localization. In addition, studying the neural basis of speech is complicated by the presence of articulation artifacts such as electro-myographic activity that interferes with the neural signal. These difficulties are virtually absent in a powerful albeit much less frequent methodology, namely the recording of intra-cranial brain activity (intra-cranial electroencephalography). Such recordings are only possible under very specific clinical circumstances requiring functional mapping before brain surgery, most notably in patients that suffer from pharmaco-resistant epilepsy. Method: We reviewed the research conducted with this methodology in the field of language production, with explicit consideration of its advantages and drawbacks. Two inclusion criteria were used to select the relevant published articles. First, the article had to report intra-cranial activities, either electro-corticography or stereotactic electro-encephalography. Second, this activity had to be recorded while participants produced language or performed very related cognitive tasks. Results: The available evidence is shown to be diverse, both in terms of the tasks and the cognitive processes tested and in terms of the brain localizations being studied. Following modality specific activities (in auditory or visual cortices), there is a convergence of activity in superior temporal sulcus, which is a plausible neural correlate of phonological encoding processes. Later, between 500 and 800 ms, inferior frontal gyrus (around Broca's area) is involved. Peri-rolandic areas are recruited in the two modalities relatively early (200–500 ms window), suggesting a very early involvement of (pre-) motor processes. Summary: The review provides patchy yet valuable information for characterizing the dynamics of the neural events occurring in the language production network. Some of these findings may be at odds with conclusions drawn from available meta-analysis of language production studies, for example the spatio-temporal dynamics of the activity recorded from temporal gyrus, or the relatively early recruitment of peri-rolandic areas. Many specific aspects of word production remain largely unexplored with intra-cranial recordings. It is clear however, that combining specific cognitive hypotheses with the temporal and spatial resolution of this technique can provide a powerful tool to uncover the dynamics of language production.

E22 The neural basis of phonological influence on lexical access *Megan Reilly[1], Sara Guediche[1], Sheila Blumstein[1,2]; [1]Brown University, [2]Brown Institute for Brain Science*

Spoken word production research has shown that phonological information influences lexical access: a speaker is more likely to access 'balcony' rather than 'veranda' following the production of 'balance' than following an unrelated utterance. It has been shown that this shared phonological information increases lexical access regardless of whether that information matches in word position or acoustic realization: 'balance' and 'cannibal' equally prime 'balcony' (Reilly & Blumstein, submitted). The results support models of spoken word production which include context-independent phonological representations. What is unclear are the neural systems underlying these effects. In an fMRI experiment, ten subjects produced lexical targets (e.g., 'balcony') in response to the target's definition ('deck higher than a building's first floor') after reading a series of prime stimuli in one of three conditions: Match (three of six primes contained the same initial, middle, or final syllable as the target, overlapping in word position and acoustic realization: e.g., 'ballast', 'reconcile', 'villainy'), Mismatch (three of the primes contained the initial, middle, and final syllable of the target word in a different word position, neither overlapping in word position nor acoustic realization: 'cannibal', 'contagion', 'needle'), or Control (all primes were phonologically unrelated). Two regions showed changes in neural activation that corresponded with the behavioral pattern observed in Reilly & Blumstein (submitted). The left temporal gyrus (extending from Heschl's gyrus to the superior temporal gyrus, or STG) and the left supramarginal gyrus (SMG) showed a significant reduction in percent signal change during the Match and Mismatch conditions compared to the Control condition. Additionally, the Match and Mismatch conditions did not differ from each other. The STG has been associated with phonological processing during production (Buchsbaum, Hickok, & Humphries, 2001) and the SMG has been associated with phonological processing during visual word recognition (Stoeckel et al., 2009), suggesting that these two areas form a network sensitive to the relationship between perception and production. While the role of the STG in phonological and lexical processing has been established, the current findings also suggest a role for the SMG. The SMG has been implicated in lexical access processes during both speech production (Peramunage et al. 2011) and perception (Righi et al, 2010). Thus, activation in the SMG may reflect lexical access processes in speech production that rely on position-independent phonological representations. The left inferior frontal gyrus (LIFG) showed significant deactivation in the Control condition relative to the Match condition but not relative to the Mismatch condition. This suggests that the LIFG is only sensitive to position-matched phonological overlap between the prime and target, compatible with a role in articulation and motor planning during production for this area. Taken together, these results support a neural architecture in which temporal and parietal areas govern abstract, position-independent phonological information that interface with lexical information, whereas frontal areas are involved in position-dependent phonological processes involved in phonetic sequencing and motor planning.

E23 Low frequency long range coherence during speech sensory motor processing *Gregory B Cogan[1], Thomas Thesen[2], Daniel Friedman[3], Werner K Doyle[4], Orrin Devinsky[3], Bijan Pesaran[1]; [1]Center for Neural Science, NYU, [2]Department of Neurology, NYU Langone Medical Center, [3]Comprehensive Epilepsy Center, NYU Langone Medical Center, [4]Department of Neurosurgery, NYU Langone Medical Center*

The study of speech processing has placed a strong emphasis on the link between speech perception (auditory) and speech production (motor). Investigating the neural underpinnings of this linkage has previously been difficult as non-invasive imaging techniques display strong signal contamination due to movement artifacts. To overcome this issue and to study the linkage between sensory and motor processes during speech, we used intracranial electroencephalography (iEEG) on seven patients with pharmacologically resistant epilepsy. These patients were sub-durally implanted with an 8 x 8 electrode array (1 cm spacing; Adtech) in the parietal-temporal-frontal region. This technique allowed us to investigate neural processing associated with both auditory perception and articulator movement with limited/no movement artifacts. Coherence was analyzed between electrodes that were locally referenced to two adjacent channels that did not overlap between electrodes. Four regions of interest (ROIs) were selected based on previous literature in both speech perception and speech production: motor/premotor cortex, prefrontal cortex, inferior parietal cortex and superior temporal cortex. Subjects performed a task in which consonant-vowel-consonant (CVC) syllables were presented auditorily and after a short delay, they were instructed to either repeat the syllable or repeat the syllable without any overt sound. These two conditions were collapsed for the present analysis. A control condition in which the syllables were presented auditorily but not repeated was also performed but not included in this analysis. The task analyzed therefore links auditory (sensory) and production (motor) processing during speech. Results indicate that significant coherence occurs between electrodes in each area and occurs at low frequencies (4-12 Hz) in all subjects, between all four ROIs. This coherence was particularly prominent both during a delay period between sensory and motor processing as well as leading up to and during the actual production itself. The timescale of this coherence also corresponds to the average syllabic rate of speech, suggesting that activity between these areas is coordinated on the same time scale as both the incoming sensory signal and output motor act. Taken together, this indicates the existence of a common timescale for brain area coordination and sensory and motor processing.

Phonology, Phonological Working Memory

E24 The duration of auditory sensory memory for vowel processing: Mismatch negativity and late negativity *Yan Yu[1,2], Margaret Shakibai[3], Carly Marut[2], Valerie L. Shafer[1]; [1]The Graduate Center, City University of New York, [2]William Paterson University of New Jersey, [3]Marymount Manhattan College*

Speech perception behavioral research suggests that rates of sensory memory decay are dependent on stimulus properties at more than one level (e.g., acoustic level, phonemic level). The neurophysiology of sensory memory decay has rarely been examined in the context of speech processing. In a lexical tone study, we showed that long-term memory representation of lexical tone modulates the decay rate of sensory memory for these tones. Here, we tested the hypothesis that long-term memory representation of vowel modulates the rate of auditory sensory memory decay in a similar way to that of lexical tone. We measured auditory sensory memory using an oddball paradigm involving electrophysiological components called the mismatch negativity (MMN) and late negativity (LN). Sensory memory effects were assessed by varying the inter-stimulus interval (ISI) between the standard and deviant. Event-related potential (ERP) responses were recorded from native Mandarin and native American English participants under short and long ISI conditions (short ISI: an average of 575 ms, long: an average of 2675 ms). The standard (/gupa/) and deviant (/gipa/ and /gypa/) stimuli are multiple bisyllabic natural speech nonwords containing two vowel contrasts, one which is phonemic for both English and Mandarin listeners, and a second which is phonemic only for Mandarin listeners. Behavioral discrimination and identification tasks followed the ERP measures. We found that the Mandarin group showed larger MMN than the English group regardless of ISI for the /gypa/ deviant condition. There was no language group difference in terms of the MMN peak amplitude or latency for the /gipa/ condition. Increasing the ISI to 3 s did not change the LN responses in Mandarin listeners, but the LN for both deviant types became larger in the nonnative/English listeners. Behavioral discrimination results showed that there was a steep decrement in performance for English listeners in discriminating the non-native contrast, /gypa-gupa/, especially in the long ISI condition. This study provided new evidence that native language experience affects different ERP components (here, MMN and LN) in different ways. By using different ISIs, we demonstrated that native language experience plays a role in echoic sensory memory trace maintenance.

E25 Using Long Distance Harmony to Probe Prediction in Speech Perception: ERP Evidence from Basque *Philip Monahan[1,2]; [1]University of Toronto, [2]Basque Center on Cognition, Brain and Language (BCBL)*

Our understanding of how humans extract meaningful linguistic content from the speech signal remains incomplete. Recent approaches reemphasize the importance of predictive mechanisms during perception, wherein listeners generate online expectations of the incoming signal predicated upon their linguistic knowledge (Poeppel & Monahan, 2011). Here, we concentrate on predictions at the phonological level. Basque sibilant harmony is the test-case to determine whether listeners tap into abstract properties of their phonological knowledge during online auditory perception. In two behavioral experiments and one EEG experiment, Basque listeners show sensitivity to violations of sibilant harmony and this sensitivity is evident in early electrophysiological responses. Basque, a linguistic isolate primarily spoken in Northeastern Spain, has three contrastive places of articulation (PoA) for sibilant fricatives and affricates (orthographically: dental z,tz; apical s,ts; palatal x,tx). Morpheme-internal sibilants agree in PoA. Consequently, given one sibilant, it is hypothesized that listeners reliably predict the PoA of an upcoming sibilant. In the first behavioral phoneme-monitoring experiment, participants (n = 30) listened to Basque pseudowords (i.e., consistent with Basque phonology) and responded when they heard the sound being monitored (three conditions: Match (same PoA, e.g., usatsu), Mismatch (different PoA, e.g., uzatsu) and Control (non-sibilant /f/, e.g., ufatsu)). To determine the time-course of phonological predictions, each condition also had two different lengths: in the Short condition, sibilants were the onset of adjacent syllables, and in the Long condition, there was an intervening syllable. Mismatch items showed reliably longer reaction times compared to Control and Match items. There was no main effect of length, suggesting that the strength of these predictions does not dissipate at longer phonological distances. Experiment 2 (n = 30) showed that the facilitation seen in the Match condition in Experiment 1 is not due to phonological priming of the second sibilant given the first. To determine the temporal dynamics of phonological prediction, a subsequent EEG experiment was conducted. Participants (n = 34) passively listened to the same Basque pseudowords as in Experiment 1 and responded via button press when they heard a distractor sinusoid. A reliable increase in positivity over central-parietal electrodes was observed in the Mismatch condition compared to the Match and Control conditions. This positivity was observed beginning 75 ms post-onset of the second sibilant indicating that these phonological predictions are exerted early in the electrophysiological response. Taken together, these results demonstrate that listeners use abstract properties of their phonological knowledge to generate predictions about the content of the upcoming speech signal and that these predictions are reflected early in the neurophysiological response.

E26 On the role of the supramarginal gyrus in phonological processing and verbal working memory: evidence from rTMS studies. *Isabelle Deschamps[1,2], Shari Baum[1,2], Vincent Gracco[1,2,3]; [1]McGill University, Faculty of Medicine, School of Communication Sciences and Disorders, Montreal, Quebec, Canada, [2]Centre for Research on Brain, Language and Music, Rabinovitch House, McGill University, Montreal, Quebec, Canada, [3]Haskins Laboratories, New Haven, Connecticut*

The supramarginal gyrus (SMG), a region located within the inferior parietal lobule is activated during both language and verbal working memory tasks. The activation within this region during these two types of tasks is typically attributed to phonological processing. However, the contribution of the SMG to phonological processing during both language and verbal working memory tasks has yet to be established. The difficulty in defining the contribution of the SMG to phonological processing can be attributed to the fact that during experimental manipulations, phonological and verbal working memory processes are often confounded. Using rTMS, we investigated whether the contribution of the SMG to phonological processing is domain-specific (specific to phonology) or more domain-general (attributable to verbal working memory). A measure of phonological complexity was developed based on sonority profiles. The manipulation of sonority differences between consonant clusters can access phonological processes without increasing verbal working memory demands. Subjects were tested after low frequency rTMS on a same/different judgment task and an n-back verbal memory task in which the same phonological manipulation was used (e.g. sonority differences). It was reasoned that if the SMG activation in prior studies was domain general, i.e., related to verbal working memory demands, performance would be more affected by the rTMS during the n-back task than during the same/different judgment task. However, if the activation in the SMG is truly domain specific i.e. related to phonological properties of the stimuli, performance during the n-back task and the same/different task should be equally affected by the rTMS. Two auditory experiments were conducted. The first experiment demonstrated that under conditions where working memory demands are minimized (i.e. same/different judgment), repetitive stimulation had no effect on performance, although performance varied as a function of phonological complexity. More specifically, rTMS to the left and right SMG had no effect on reaction time or accuracy data. The second experiment demonstrated that during a verbal working memory task (n-back task), where phonological complexity was also manipulated, subjects were less accurate and slower at performing the task after stimulation to the left and the right SMG but the effect of phonology remained. In addition, a complex interaction between rTMS stimulation and hemisphere emerged. The results confirm that the SMG is involved in verbal working memory but not in the encoding of sonority differences and that the contributions of the left and right SMG to verbal working memory differ.

E27 Charting the functional relevance of Broca's area for visual word recognition in English using fMRI-guided TMS *Katherine L. Wheat[1], Piers L. Cornelissen[2], Peter C. Hansen[3], Teresa Schuhmann[1], Alexander T. Sack[1]; [1]Maastricht University, [2]Northumbria University, [3]University of Birmingham*

Background: Broca's area has long been known as a critical area for language production; however its contribution to visual word recognition is less clear. Mounting evidence from MEG and EEG studies suggests that Broca's area (specifically, pars opercularis of left inferior frontal gyrus, LIFGpo) may play a role in visual word recognition as early as ~100 ms after viewing a word and that early LIFGpo activity may involve direct feedforward and feedback connections to occipitotemporal cortex. Such early involvement of LIFGpo would have significant implications for models of the visual word recognition network. Therefore, we used a chronometric, event-related TMS design to chart the functional relevance of LIFGpo for reading over time. Method: We applied online TMS at 8 latencies from word presentation in order to test the hypothesis that LIFGpo is necessary for visual word recognition within 100 ms of viewing a word, as shown by slowed reaction times during reading aloud. Based on previous fMRI data, we predicted that disruption at 100 ms would be stronger for inconsistent, low-frequency, low-imageability (IncLoLo) words than for consistent, high-frequency, high-imageability (ConHiHi) words. Based on previous TMS data, we predicted that both types of words would be disrupted by pulses at 250-350 ms. Ten right-handed, native English-speaking adults first underwent an fMRI localizer to define their individual LIFGpo target site for TMS (pseudowords > real words). Then, in a 2x2x8 repeated-measures design, event-related, double-pulse TMS (40 Hz) was applied to two sites (LIFGpo and a vertex control; separate sessions), for two word types, and at eight different latencies from word onset; 0-25, 50-75, 100-125, 150-175, 200-225, 250-275, 350-375, and 500-525 ms. Vocal reaction times (VRTs) were measured. Results: Linear mixed effects models were performed in R. Consistency (ConHiHi vs. IncLoLo words), TMSTime (8 levels), and Site (LIFGpo vs. Vertex) were included as fixed effects, with Subjects and Items as random effects. Likelihood ratio tests revealed significant main effects of Consistency ($p<0.001$), TMSTime ($p<0.001$), and Site ($p<0.001$) and significant interactions of TMSTime*Site ($p<0.001$) and Consistency*Site ($p<0.05$). Disruption to word reading performance (VRT) is apparent within 50-100 ms of word onset. Later disruption is also apparent at around 250-350 ms. Conclusion: The current results indicate an early and necessary role for LIFGpo during visual word recognition, as shown by slower word reading performance when TMS stimulation is given at 50-100 ms. Later TMS stimulation,

at 250-350 ms, is interpreted as disrupting speech-motor output processes. This suggests that the LIFGpo speech-motor region is important, not just for later motor planning and output, but also for rapid, feed-forward visual word recognition processes, such as orthographic-to-phonological mapping.

E28 Is fMRI the optimal method for identifying TMS stimulation sites? *Magdalena W. Sliwinska[1], Manali Khadilkar[1,2], Keith Kawabata-Duncan[1,3], Joseph T. Devlin[1]; [1]Cognitive, Perceptual & Brain Sciences, UCL, London, UK, [2]Department of Neurology, University of California Irvine, [3]Department of Cognitive Neuroscience, Graduate School of Medicine, University of Tokyo, Japan*

Successful TMS experiments require an effective and robust method of targeting the stimulation site. Although it is possible to use a "one size fits all" approach, it is sub-optimal due to inter-subject variability in functional anatomy. Instead, a method for functionally localizing the testing site is typically required. There is a common misperception that fMRI scanning of individual participants prior to TMS represents the "gold standard," however, there are both theoretical and practical reasons to question this assumption. fMRI and TMS are subject to different spatial biases (e.g. draining veins vs. the orientation of axons in the magnetic field) that can result in different localization of the same neural generator across the two techniques. Moreover, fMRI-based localization suffers from less-than-ideal reproducibility of peak responses typically used to target TMS stimulation, calling into question its suitability for identifying a TMS target site. Here we empirically assessed the accuracy of fMRI-based functional localization for TMS and compared it to TMS-based functional localization. In the first experiment, 18 participants performed a one-back task in the scanner to localize a region of ventral occipito-temporal cortex engaged by visual words. The peak activation within this region was then targeted with repetitive TMS (10 Hz, 500 msec) during a visual lexical decision task. Only 11 out of 18 participants (61%) had slower responses on trials with rTMS than on trials without TMS (mean effect of +40msec); the remaining 7 showed no effect of TMS. A second experiment investigated the consistency of a TMS-guided functional localization procedure that was designed to identify an area within supramarginal gyrus (SMG) involved in phonological processing. Fifteen participants performed a rhyme judgement task and rTMS (10 Hz, 500 msec) was applied to three separate stimulation sites in the left SMG. Each of these sites was tested on two separate occasions to identify the site that produced longer responses in rhyme judgments. In 12 out of 15 participants (80%), this localization procedure identified the same SMG site in both sessions. On average in those sites, stimulation in the first session produced an inhibitory effect of +59 msec while in the second session, an inhibitory effect was +37 msec. In the remaining 3 participants, the localization procedure worked but identified two different stimulation sites for the two sessions. These findings demonstrate that both fMRI- and TMS-based functional localization are appropriate methods for identifying TMS testing sites in individual participants. Indeed, TMS-based functional localization may be more robust than fMRI-based localization, as well as being more efficient in terms of both time and money. In other words, the use of TMS-based "localizer tasks" may be an optimal method for targeting TMS in individuals under normal circumstances. In less typical cases where stimulation involves some discomfort to participants or where the anatomical search space is large, fMRI-based localization may represent the most efficient method for targeting stimulation. Key words: TMS, fMRI, functional localization

E29 Using functional transcranial Doppler sonography (fTCD) to examine hemispheric lateralisation during rhyme judgement *Heather Payne[1,2], Eva Gutierrez-Sigut[2], Joanna Subik[3], Mairead MacSweeney[1,2]; [1]Institute of Cognitive Neuroscience, University College London, [2]Deafness, Cognition & Language Research Centre, University College London, [3]University College London*

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 event related changes in blood flow velocity in left and right middle cerebral arteries. Differences in velocity increases between left and right arteries are used to calculate a laterality index. These indices show high concordance with other methods of measuring functional lateralisation, such as the Wada test (Knecht et al., 2001) and fMRI (Somers et al., 2011). Typical fTCD paradigms adopt word generation and are reliable indicators of hemispheric lateralisation, showing high test-retest reliability (Vingerhoets & Stroobant, 1999; Knecht et al., 2000; Bishop et al., 2009). Word generation usually requires participants to generate words covertly and later report some of their generated words to ensure compliance. However, we have recently demonstrated that whilst the extent of lateralisation is comparable during overt and covert generation, the number of words produced in the overt condition positively correlated with the extent of lateralisation (Gutierrez et al., submitted). This result indicates that it is important to take into account the volume of material that participants generate. In light of this, the purpose of the current study was to investigate an alternative paradigm for fTCD which allows tighter control on the amount of material being manipulated. We employed a written word rhyme judgment task which does not require mental generation of words, but, we reason, involves pre-motor processing. During rhyme judgement of orthographically dissimilar word pairs, participants must subvocally rehearse items in order to make a judgement, thus likely recruiting pre-motor systems. By using judgement tasks, we are able to control the amount of stimuli presented and, to some extent therefore, the amount of pre-motor processing. An additional question

we addressed was how verbal and non-verbal processing are lateralised within participants when tested using a non-verbal paradigm with similar task and timing requirements: line judgement. Twenty right handed adults were tested on two well matched judgement tasks. Word pairs or pairs of line patterns were presented and participants had to judge whether the words rhymed or the line patterns matched. At a group level, the laterality index of the rhyme task was significantly left lateralised ($t(19) = 3.54$, $p = .002$), and the line task was right lateralised ($t(19) = -3.32$, $p = .004$). This significant hemispheric dominance for each task is in agreement with fMRI literature using similar stimuli (Lurito et al., 2000) and demonstrates that fTCD can be used to assess language lateralisation in tasks that do not require word generation. This highlights the possibility of using fTCD to assess language lateralisation in populations for whom speech production is difficult to assess, such as children born profoundly deaf.

Orthographic Processing, Writing, Spelling

E30 Reading Houses: A House-Based Orthography Elicits Left Fusiform Activation

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A left lateralized fusiform area, the visual word form area (VWFA), is active when English readers view words, but is less robustly active for consonant letter strings and non-orthographic stimuli (Cohen & Dehaene, 2004). In our previous work, we studied the role of the VWFA in reading a novel alphabetic orthography comprising faces as graphemes, called FaceFont. Behavioral, neuroimaging, and neuropsychological results indicated that normal readers were able to learn FaceFont, the VWFA was sensitive to face stimuli, and injury to the VWFA seemed to impair one's ability to learn and decode FaceFont due to its grapheme-phoneme correspondences (Moore, Durisko, Perfetti, & Fiez, Under review; Moore, Brendel, & Fiez, Under review). These findings suggest that there is flexibility in the range of stimuli that can function as units in a writing system. However, because face processing can also elicit activation changes at or near the VWFA, alternative interpretations cannot be ruled out. The purpose of this study is to examine another artificial orthography in which pictures of houses are used as graphemes, called HouseFont. Since houses are most associated with parahippocampal activation and marginal (if any) VWFA activation, HouseFont provides another way to test the limits of the VWFA's flexibility. Twelve participants completed a two-week HouseFont training, first learning grapheme-phoneme associations and then progressing to reading words and stories. Neuroimaging sessions were completed before and after the training. Behavioral results indicate that HouseFont learning proceeded similarly to FaceFont. HouseFont-trained participants had similar reading latencies on daily single-word reading tests and their reading latencies improved at a similar rate throughout training as compared to the FaceFont-trained participants in our previous work. HouseFont-trained participants also demonstrated nearly identical reading rates compared to FaceFont-trained participants across the early reader stories used in training; as measured by number of words read per minute, they showed similar sensitivity to the fluctuations in text style and complexity. Preliminary neuroimaging results indicate a significant HouseFont training effect at or near the typical locus of the VWFA – i.e., participants showed significantly more activation for houses versus patterns (baseline) after training compared to before training. This region's sensitivity to house stimuli in the HouseFont-trained group provides evidence that functional localization within the fusiform is not purely driven by the perceptual qualities of a stimulus. Furthermore, the results from this study further demonstrate the VWFA's flexibility to utilize a broad range of stimuli to function as units in a writing system. References: Cohen, L. & Dehaene, S. (2004). Specialization within the ventral stream: the case for the visual word form area, NeuroImage, 22(1), 466-476; Moore, M.W., Durisko, C., Perfetti, C.A., and Fiez, J.A. (Under review). Learning to read an alphabet of human faces produces left-lateralized training effects in the fusiform gyrus; Moore, M.W., Brendel, P.C., and Fiez, J.A. (Under review). Reading faces: Investigating the use of a novel face-based orthography in acquired alexia.

E31 The role of the left middle frontal gyrus in visual-orthographic on top of phonological analysis in Chinese readers

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Introduction Chinese reading has become an area of great interest especially in the past few years. Chinese characters map onto a morpheme (meaning) and a monosyllable and cannot be pronounced with recourse to grapheme-phoneme correspondence rules. Thus, a Chinese character has a more direct association with its meaning than a written word in English does (Wang, 1973). Brain imaging studies have generally found that reading Chinese is served by a distinct neural system involving the left middle frontal gyrus (LMFG), and functional and anatomical disruption of the LMFG is associated with impaired reading of the Chinese language (Siok et al., 2004, 2008). This is in contrast with dyslexia in alphabetic languages that is found to be associated with neural deficits in the more posterior temporoparietal regions. Although it has been speculated that the LMFG functions as a center for fluent Chinese reading that coordinates and integrates phonological, orthographic and semantic information of written characters, the exact functions of the LMFG that underlie Chinese reading are actually not clear. Here

we set out to testify if the LMFG is involved in visuo-orthographic processing besides phonological analysis. The squarish configuration of Chinese characters, which consist of a number of intricate strokes and correspond more to meanings than to pronunciation, is likely to require a more elaborated and intensive analysis of visual-orthographic information. Methods Task 1: Visual-orthographic Discrimination In this fMRI study, nineteen normal adult Chinese readers were asked to decide (1) whether two pseudocharacters presented sequentially were visually the same (pseudocharacter condition), (2) whether two complex figures presented sequentially were visually the same (figure condition) and (3) whether two lines presented simultaneously were the same (baseline condition). Task 2: Homophone Judgment The same group of subjects had to decide (1) whether two Chinese characters presented simultaneously shared the same pronunciation, (2) whether two characters presented sequentially shared the same pronunciation and (3) whether two characters viewed simultaneously had the same physical size (baseline condition). Results Task 1: Visual-orthographic Discrimination Direct comparisons of BOLD contrast activity between the experimental (pseudocharacter and figure) and baseline conditions showed that the LMFG is involved in these visual-orthographic tasks. More importantly, direct contrast between the pseudocharacter and figure conditions show that the LMFG is more involved in the pseudocharacter processing. Task 2: Homophone Judgment Both contrasts – simultaneous homophone judgment (contrasted with font size decision) and sequential homophone judgment (contrasted with font size decision) – elicited activations mainly in left mid-inferior frontal gyrus including the LMFG and occipital regions, although the activities were shown to be weaker for the latter contrast. Conclusion The current study supports the hypothesis that the LMFG has a role in both phonological and visual-orthographic analysis. This contributes to a better understanding of the functions of the LMFG and why it is associated with Chinese reading. Reading in nonalphabetic Chinese is likely to be involved in cognitive processing components and neural activations not completely shared by those necessitated by alphabetic reading.

E32 The orthographic consistency shapes Chinese spoken word recognition in the rhyming task *Pei-Chun Chao[1], Wei-Fan Chen[2], Jie-Li Tsai[3], Chia-Ying Lee[1,2]; [1]National Yang-Ming University, Taiwan, [2]Academia Sinica, Taiwan, [3]National Chengchi University, Taiwan*

In studies of alphabetic languages, orthographic consistency is defined as the degree of mapping consistency from phonology to orthography (whether words had onsets or rimes that can be spelled in multiple ways, e.g., /ip/ in heap and deep). Studies have demonstrated the orthographic consistency effect, in which the auditory lexical decision to orthographic inconsistent words took longer and yielded more errors than did those to the consistent words. This effect implies that the orthographic knowledge would be automatically activated to affect the spoken words processing. In Mandarin Chinese, there are around 1100 syllables can map onto 5,000 characters. Based on our corpus, 82% of Mandarin syllables can be mapped onto more than one character. The largest set is /yi4/, which has 56 homophones, such as 易, 亦, 意, 義, 異, 議, 億 , 憶…. etc. The pervasive homophony of Chinese suggests the orthographic form is particularly important for achieving the semantic knowledge and escaping homophony in Chinese spoken word recognition. Therefore, one might expect a greater impact from orthography during spoken word recognition in Chinese than that in the alphabetic writing system. There are two ways to measure the mapping consistency from phonology to orthography in Chinese. The first one is homophone density (HD), which is defined as the number of characters sharing exactly the same pronunciation (including tonal differences). The second one is phonology to orthography mapping consistency (P-O consistency), which is defined as whether a set of homophones can be subdivided into subgroups based on their sub-lexical orthographic units (phonetic radical). The present study aimed to differentiate these two types of orthographic consistency in Chinese spoken word processing and to characterize their temporal dynamic with the event-related potentials (ERPs) measurement. Participants would hear 90 monosyllabic Chinese spoken words, which were sub-divided into three conditions based on their homophone density and P-O consistency, as following: (1) low HD/ high P-O consistency; (2) high HD/high P-O consistency; (3) high HD/low P-O consistency. Each critical stimulus was paired with a probe that rhymed with the target stimuli. Participants were asked to perform the rhyming judgment task. The ERP data on the critical stimuli revealed that the P-O consistency effect in the N400 time window with frontal central distribution. This finding is congruent with the orthographic consistency effect found in English. Moreover, the ERPs to the probe showed the rhyming effect would be modulated by the orthographic consistency. The rhyming effect was mainly found in high P-O consistent condition and the High HD/high P-O consistent condition evoked an earlier and bigger rhyming effect than the low HD/high P-O condition did. Our findings suggest that the orthographic information is automatically activated during Chinese spoken word recognition, even in the metaphonological task, and support the bi-directional mappings between phonology and orthography.

E33 Functionally distinct contributions of the anterior and posterior putamen during reading *Marion Oberhuber[1], Susan Prejawa[1], Tom Hope[1], ʻŌiwi Parker Jones[1,2], Mohamed L. Seghier[1], David W. Green[3], Cathy J. Price[1]; [1]Wellcome Trust Centre for Neuroimaging, University*

College London, UK., [2]Wolfson College, University of Oxford, UK., [3]Cognitive, Perceptual and Brain Sciences, University College London, UK.

Introduction: Reading involves the mapping of visual features (orthography) to meaning (semantics) and articulatory codes (phonology) that will generate the corresponding speech sounds (phonetics). The non-semantic mapping between orthography and phonology at the sublexical level can facilitate, or interfere, with the production of the whole word at the lexical level. Previous studies have investigated the influence of sublexical orthographic-phonological mapping by comparing brain activation for (1) reading words to object naming or (2) reading pseudowords (e.g. "prume") to words (e.g. "plume"). In this fMRI study, we combined both approaches to provide new insights into sublexical reading. Methods: In 25 healthy native English speakers, fMRI activation was measured for 8 speech conditions: reading words, reading pseudowords, naming objects in pictures, color naming, auditory repetition of words and pseudowords, naming objects from sounds and naming the gender of someone humming. The stimuli from these 8 conditions were also presented during 8 one-back matching tasks that did not involve a speech production response. This allowed us to segregate sensory input and motor effects in the areas associated with sublexical reading. SPM was used to analyse the data with standard procedures. First we compared reading words and pseudowords to picture and color naming to identify areas involved in orthographic-to-phonological mapping while controlling for semantics. Within the identified areas, we compared words and pseudowords during reading and auditory repetition. Results: Greater activation for reading words and pseudowords compared to object and color naming only reached significance in the left putamen ($p<0.05$ corrected). Within this region of interest, the anterior segment was more activated for reading pseudowords than all other conditions; whereas the posterior segment was more activated for reading and auditory repetition of words than all other conditions. The contrasting responses to reading words and pseudowords in the anterior and posterior putamen was confirmed by a significant region by condition interaction ($F(1,24)=25.4$; $p=.000$), with greater activation for pseudoword than word reading in the anterior putamen but greater activation for word than pseudoword reading in the posterior putamen. Examination of the responses across all 16 conditions indicated that both the anterior and posterior putamen were activated by all speech conditions relative to one-back matching on the same stimuli. We therefore interpret our effects in terms of articulatory responses that were influenced by (1) sublexical orthographic processing in the anterior putamen; and (2) a combination of both lexical and sublexical influences in the posterior putamen. Conclusion: Our results indicate a functional dissociation between the anterior and posterior putamen. The pseudoword effect in the anterior putamen is consistent with prior studies that associated this region with "the initiation of unskilled difficult movements". In contrast, the heightened word response in the posterior putamen is consistent with prior studies that associated this region with "memory guided movement" [2]. References: [1] Aramaki et al. (2011) J Neurosci. 6;31(27):9819-23. [2] Tricomi et al. (2009) Eur J Neurosci.;29(11):2225-32.

E34 Title: Visual recognition of upright, inverted and rotated words. *Bethany L Sussman[1], Sharlene D Newman[1]; [1]Indiana University*

In typical development, visual word recognition becomes an expert ability and argued to be similar to face perception. One similarity is that the features of both are better perceived from within a whole legal word or face and familiar and legal words or faces are more easily recognized than non-words or scrambled faces. Likewise, the visual word form area (VWFA) is often seen as analogous to the fusiform face area (FFA), both of which are more sensitive to legal words and faces, respectively. Furthermore, inverting faces appears to disrupt the advantages and configurality of viewing an entire face and the FFA responds less to inverted than upright faces. While a face inversion effect has been well documented, there is little investigation on how a vertical word inversion affects word perception and if it is analogous to face inversion. We used fMRI to investigate the effect of stimulus orientation on word recognition. During a lexical decision task pseudowords and words were presented upright, rotated 180°, or mirrored vertically. We expected a graded effect in the VWFA with upright words showing more activation than rotated and inverted words and possibly greater activation for rotated than inverted words. Preliminary data showed that, while there was activation in VFWA for all orientations, inverted actually revealed greater activation than upright. This was contrary to our expectations. However, inverted words also showed greater inferior frontal gyrus activation than both rotated and upright words. This may be indicative of increased phonological and/or orthographic processing in order to identify words and that an increase in phonological processing was not needed in the rotated condition.

Language Development, Plasticity, Multilingualism

E35 Two distinct forms of functional lateralization in the human brain *Stephen J. Gotts[1], Hang Joon Jo[2], Gregory L. Wallace[1], Ziad S. Saad[2], Robert W. Cox[2], Alex Martin[1]; [1]Laboratory of Brain and Cognition, NIMH/NIH, Bethesda, MD, US, [2]Scientific and Statistical Computing Core, NIMH/NIH, Bethesda, MD, US*

The hemispheric lateralization of certain faculties in the human brain has long been held to be beneficial for functioning. However, quantitative relationships between the degree of lateralization in particular brain regions and

the level of functioning have yet to be established. In the current study, we used BOLD fMRI in 62 right-handed male participants to examine correlations among pairs of voxels in resting brain activity, assessing lateralization of cortico-cortical interactions by comparing within- and between-hemisphere correlations at homotopic locations on the unfolded cortical surface. We first demonstrate that two distinct forms of functional lateralization are present in the left versus right hemispheres, with the left hemisphere showing a preference to interact more exclusively with itself, particularly for cortical regions involved in language and fine motor coordination. In contrast, right-hemisphere cortical regions involved in visuospatial and attentional processing interact in a more integrative fashion with both hemispheres. When evaluating the interdependence of lateralization within language, motor, and visuospatial brain regions across participants, the magnitude of lateralization was found to be highly interrelated among left hemisphere language and motor regions, whereas these were relatively independent of lateralization magnitude in right-hemisphere visuospatial regions. Behavioral measures of verbal versus visuospatial ability acquired in a separate testing session (Vocabulary and Block Design subtests of the Wechsler Abbreviated Scale of Intelligence; N=44 participants) were selectively predicted by the degree of lateralization observed in left-hemisphere language regions versus the degree observed in right-hemisphere superior parietal and ventral temporal regions associated with visuospatial processing. Taken together, these results provide direct evidence of qualitatively distinct forms of functional lateralization in the left versus right cerebral hemispheres, with the magnitude of lateralization in distinct subsystems associated with enhancements of the related cognitive ability.

E36 Speech Motor Activation When Speaking a Non-Native Language: Support for a Sensitive Period in Second Language Acquisition

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The age at which a second language (L2) is learned has been shown to have consequences for the development of native-like speech. In this regard, research has supported the notion of a biologically optimal window, or sensitive period, for second language acquisition. Here, we take advantage of the bilingual environment of Québec to investigate the functional patterns of native and nonnative language processing in subjects grouped according to language experience: French-English simultaneous bilinguals who acquired two languages from birth, sequential bilinguals who learned their L2 after the age of 5 years, and English-speaking monolinguals. Simultaneous and sequential bilinguals were highly proficient in both languages, while monolinguals were only proficient in their native language. Subjects were scanned using functional magnetic resonance imaging (fMRI) while they read sentences aloud in English and French. Native-language reading across all groups revealed comparable brain activation that included frontal and temporal regions as well as the cerebellum. A similar functional pattern was also observed for L2 speech in sequential bilinguals. However, although simultaneous bilinguals showed no activation differences in a direct subtraction of overt sentence reading in their two languages, sequential bilinguals showed more robust recruitment of several cortical areas including the left premotor cortex, left inferior frontal gyrus, and right cerebellum when reading in their non-native language. Similarly, a between-group analysis revealed sequential bilinguals to activate speech motor areas more substantially when reading in English, their L2, compared to simultaneous bilinguals and monolinguals for whom English is a native-language. The results suggest less efficient processing of articulation for non-native speech production in late L2 learners and indicate that acquiring a language from birth minimizes the neural resources required for speaking, perhaps due to greater expertise. While our observations are consistent with the notion of a sensitive period for articulatory processing in a late-acquired L2, further research will clarify whether age of acquisition or a simultaneous or sequential bilingual language experience is most critical for native-like speech development.

E37 Second language age of acquisition but not language proficiency predicts differential brain activation patterns during a picture-naming task in bilinguals

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Previous literature has discussed how factors such as second language age of acquisition (AoA) and proficiency influence bilinguals' brain activity during picture-naming in single language tasks. However, a consensus as to which of these two factors has the most influence on brain activity during task performance has not been reached. The purpose of the present study was to investigate how language proficiency and AoA modulate brain activity during a picture-naming task. Forty-seven right-handed Spanish-English bilingual adults who learned English as a second language (L2) between birth and age 17 performed a picture-naming task inside an fMRI scanner. Participants named objects in three conditions: Spanish only, English only and mixed (alternating between Spanish and English). Before scanning, bilinguals were given a language history questionnaire to determine L2 AoA and subtests of the Woodcock Language Proficiency Battery-Revised test to examine L1 and L2 proficiencies. Analyses using the general linear model were performed on brain activity during the three conditions using SPM8. Regression analyses using L2 AoA and proficiency as predictors of brain activity were also performed. Regression analyses

revealed that language proficiency was not associated with brain activity during the three conditions. However, L2 AoA was correlated with brain activity while naming in English and Spanish. Learning L2 later was associated with increased activity in the left inferior parietal lobule (IPL), postcentral gyrus, inferior frontal gyrus (IFG), right superior temporal gyrus (STG), and bilateral middle temporal gyrus (MTG) while naming in English (uncorrected $p < .001$). Learning L2 earlier was correlated with increased activity in the right supramarginal gyrus and IPL, bilateral STG (FWE corrected, $p < .05$), right MTG (FWE corrected, $p < .05$), left supplementary motor area (SMA), right postcentral gyrus, and right rolandic operculum, as well as cognitive control areas such as bilateral cingulate cortex and left superior frontal gyrus (uncorrected $p < .001$) when naming in Spanish. These results demonstrate that the age at which a second language is acquired influences brain activity when naming in both L1 and L2. Learning L2 later is mostly parasitic with some increased activity in areas devoted to motor planning such as the left IFG. However, learning L2 earlier leads to significantly increased activity while naming in L1 in areas devoted to auditory language processing and cognitive control. The plasticity of the neural system early in life allows for the acquisition of an L2 with the caveat that L1 processing will require a more distributed system due to the lower dominance of this language. These findings are consistent with interactive activation models of bilingualism.

E38 A Functional Investigation of the RAN-Reading Relationship in University Students with and Without Dyslexia

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Rapid Automatized Naming (RAN), defined as the ability to name as quickly as possible visually presented symbols such as letters, digits, and objects, has been found to be a strong predictor of reading ability (Kirby, Georgiou, Martinussen, & Parrila, 2010). However, the mechanism underlying the RAN-reading relationship remains unclear. We sought to investigate how RAN and reading are related by combining evidence from behavioural measures and functional magnetic resonance imaging (fMRI). University students with and without dyslexia were recruited. Participants completed RAN letters, digits, and objects as well as reading of familiar and unfamiliar words in the behavioural lab and while in the MRI. Consistent with previous research, the participant with dyslexia had increased response times for each of the RAN and reading tasks in comparison to the individuals without dyslexia, and the participant with dyslexia showed more activation overall during the RAN and reading tasks. Contrary to our expectation, however, fMRI results showed minimal overlap between RAN tasks and reading for both the participant with dyslexia and the controls. Although the results should be interpreted with caution due to the small sample size, preliminary results show that RAN and reading do not rely on the same neural networks in either controls or individuals with reading disability.

E39 Phonological Working Memory in the Brain: International Adoptees, Bilinguals, and Monolinguals

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International adoptees (IA) experience a unique language learning environment due to the fact that they cease acquiring their first language (L1) at the time of adoption in favor of of the language spoken by their adopted family. Because of this, their second language (L2) is acquired similarly to an L1 in the sense that they receive input exclusively in that language from that point on. However, like L2-learners, they also experience both a delay in exposure to that language, as well as previous exposure to another language. We investigated whether the neurocognitive processes elicited by IA children using their adopted language are similar to those elicited by L1- or early L2-learners, or whether they exhibit a unique pattern. In particular, we examined the processes involved during phonological working memory (PWM) in their L2. Behaviourally, IA children have shown deficits on tasks assessing L2 PWM, such as sentence repetition (Gauthier & Genesee, 2011) and non-word repetition (e.g., Scott, Roberts, & Krakow, 2008). This deficit may be based on a disruption or delay in the development of phonological representations during early language acquisition. However, this has not been examined neurocognitively. To assess this we used BOLD fMRI to scan three groups of 10 – 16 year old female participants: (1) 10 IA children from China, adopted into French-speaking families before age three, who now speak only French; 2) 10 L1-Chinese children who began learning French as a second language by age three; and 3) 10 monolingual French-speaking children. Participants were matched for current age, as well as the age that they began acquiring French in the case of IA children and bilinguals. While in the scanner, participants completed an auditory n-back task, shown to assess PWM, using French pseudo-words (e.g., Chee et al., 2004). Participants listened to series of bisyllabic pseudo-words and were required to respond when a target word was presented. The target word was one that matched a word occurring in either a 0-back, 1-back, or 2-back position, depending on the condition. Thus, participants were required to hold phonological information in working memory while performing the task. Differences in activity patterns between bilinguals and monolinguals would suggest that delay or divided language exposure affects the processing of an L2. If a monolingual language-learning environment compensates for an early delay, we expect IA children to show patterns similar to monolinguals. If, in contrast, this early experience has an effect, we expect IA children to show patterns similar to bilinguals. Results show that bilinguals and IA children exhibited a different

pattern of activity as compared to monolinguals, despite the fact that both the bilingual and IA groups began learning French prior to three years of age. These results suggest that even short delays in language acquisition onset lead to differences in neurocognitive processing.

E40 Dynamic neural network reorganization associated with second language vocabulary acquisition: a multimodal imaging study *Chihiro Hosoda[1,2,3,4], Kanji Tanaka[5], Tadashi Nariai[3], Manabu Honda[1], Takashi Hanakawa[1,2,6]; [1]Department of Functional Brain Research, National Institute of Neuroscience, National Center of Neurology and Psychiatry, [2]Department of Advanced Neuroimging, Integrative Brain Imaging Center, National Center of Neurology and Psychiatry, [3]Department of Neurosurgery, Tokyo Medical and Dental University, [4]Department of Motor Control and Rehabilitation, ATR Computational Neuroscience Laboratories, [5]Research Center for Advanced Science and Technology, The University of Tokyo, [6]PRESTO, Japan Science and Technology Agency*

It remains unsettled whether human language relies exclusively on innately privileged brain structure in the left hemisphere or is more flexibly shaped through experiences, which induce neuroplastic changes in potentially relevant neural circuits. Here we show that learning of second language (L2) vocabulary and its cessation can induce bidirectional changes in the mirror-reverse of the traditional language areas. In the cross-sectional study, 137 native Japanese speakers (71 males and 66 females) with a mean age of 24.0 years [standard deviation (SD) = 5.3, range 18-42] were participated. All subjects were university students or graduates whose self-reported English (L2) proficiencies varied from low to very high to the level of Japanese-English bilinguals. The structural magnetic resonance imaging (MRI), multi-angular diffusion-weighted magnetic resonance images (DWI), and the Test of English Vocabulary tests were obtained. We identified that grey matter volume in the inferior frontal gyrus pars opercularis (IFGop) and connectivity of the IFGop with the caudate nucleus and the supramarginal/superior temporal gyrus (SMG/STG), predominantly in the right hemisphere, were positively correlated with L2 vocabulary competence. In the cohort study, we recruited 43 native Japanese speakers who were assigned to L2 training (n=23) and 20 matched control groups (n=20). We obtained structural MRI, DWI, and the Test of English for International Communication (TOEIC) before and after L2 training intervention. Participants in the training group participated in a 16-week L2 e-learning program. Brain structure before training did not predict the later gain in L2 ability. However, training intervention did increase IFGop volume and reorganization of white matter including the IFGop-caudate and -SMG/STG pathways in the right hemisphere. These 'positive' plastic changes were correlated with the gain in L2 ability in the trained group, but were not observed in the control group. We propose that the right hemispheric network can be reorganized into language-related areas through use-dependent plasticity in young adults, reflecting a repertoire of flexible reorganization of the neural substrates responding to linguistic experiences.

E41 Individual Differences in Declarative and Procedural Memory and Changes in L2 ERP Signatures Over Time *Mandy Faretta-Stutenberg[1], Darren Tanner[2,3], Kara Morgan-Short[1]; [1]University of Illinois at Chicago, [2]Penn State University, [3]University of Illinois*

Investigations into the neurocognitive mechanisms underlying linguistic processing among late second language (L2) learners reveal significant variability. 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 and empirical work suggest that L2 development may be mediated by domain-general cognitive factors, such as individual differences in declarative and procedural memory (Morgan-Short, et al., 2013; Ullman, 2001), and that the contributions of these systems may vary by linguistic structure, L2 proficiency, and even training type (Carpenter, 2008; Morgan-Short, et al., 2013; Ullman, 2001). The current study examines the complex relationships between the neurocognitve mechanisms underlying L2 lexical and morphosyntactic development and individual differences in declarative and procedural memory in order to provide explanatory insight into issues of L2 variability. Fourteen native English speakers enrolled in intermediate-level university Spanish classes participated in a longitudinal investigation over the course of one semester. Learners first completed a cognitive assessment session that included two measures of declarative memory and two measures of procedural memory; composite scores for declarative and procedural memory were calculated. Participants also completed pre- and post-semester language assessment sessions to measure potential changes in electrophysiological processing and behavioral performance. During these sessions, event-related potential (ERP) data were collected while participants judged Spanish sentences (half correct) designed to assess processing of lexical (semantic) and morphosyntactic (noun-determiner gender agreement) violations. Composite scores for declarative and procedural memory were calculated. ERP data were examined in a classic "N400" time window (400-600ms) as well as in a later "P600" time window (800-1000ms). At pre-testing, learners showed an N400 response to both lexical and morphosyntactic violations. At post-testing, however, learners were divided between N400 and P600-like responses for both conditions. In order to further investigate individual differences in ERP responses, pre- and post-testing effect magnitudes were calculated using a mean amplitude for correct and violation items in a nine-electrode central-parietal region of interest in the time windows mentioned. Change in N400/P600 effect magnitudes from pre- to post-testing were also calculated

for each participant. Results of correlational analyses reveal a relationship between procedural memory and ERP responses to morphosyntactic, but not lexical, violations: higher procedural memory was related to greater positivity in the P600 time window during pre-testing, and reduced P600 from pre- to post-testing, potentially reflecting a reduced processing cost for higher procedural memory learners at more advanced stages of proficiency. Declarative memory, on the other hand, was significantly related to lexical, but not morphosyntactic, processing signatures: higher declarative memory correlated with increased N400 to lexical violations from pre- to post-testing. Consistent with theoretical claims, it appears that for the intermediate-level learners in this study, declarative memory subserves processing of lexical violations, whereas procedural memory subserves processing of basic morphosyntactic violations. These results suggest that declarative and procedural memory play a role in adult L2 development and serve as individual difference factors that account for variation in L2 processing.

E42 Emerging Sensitivity to Morphosyntax at the Earliest Stages of Development: ERP Evidence for the Role of the L1

Robert Fiorentino[1], Alison Gabriele[1], José Alemán Bañón[1]; [1]University of Kansas

Previous studies have demonstrated the advantage of using event related potentials (ERPs) to examine development in L2 processing (Osterhout et al., 2006; McLaughlin et al., 2010). Different ERP components have been argued to index distinct aspects of language processing and thus can be used to track qualitative changes in processing over time: the N400 has been argued to index the strength of lexical associations while the P600 has been argued to index grammatical processing (e.g. Kutas et al., 2006). In a longitudinal study, Osterhout et al. (2006) found that for constructions that are similar between the L1/L2, novice learners of L2 French showed a shift in processing from an N400 at the first testing session to a P600 at the final session. In contrast, constructions which differed between the L1/L2 did not elicit reliable effects at any point. Building on this approach, the present study examines the role of the L1 and individual differences in the processing of gender and number agreement in English-speaking learners of Spanish, tracking development at three points during their first year of university Spanish. Learners were tested after two months, six months, and eight months of exposure. The experiment targeted three types of agreement: number agreement on verbs, which is similar in Spanish and English (1); number agreement on adjectives, a context in which agreement is not realized in English (2a,b), and gender agreement on adjectives, which is unique to Spanish (2a,c). (1) Subject-Verb Agreement La pasajera(sg) brasileña (a)desembarca(sg)/ (b)*desembarcan(pl) en San Diego. 'The Brazilian passenger disembarks at San Diego.' (2) Noun-Adjective Number/Gender Agreement La biblioteca(fem.sg) es (a) moderna(fem.sg)/ (b)*modernas(pl)/ (c)*moderno(masc) y la escuela también. 'The library is modern and the school too.' The role of individual differences was investigated by testing learners on a range of verbal and nonverbal cognitive measures, including verbal aptitude (Llama, MLAT), processing speed, working memory, and inductive and spatial reasoning (WAIS IV). Results for the Spanish native controls (n=12) revealed reliable P600s for all violation types. For learners (n=23), a small positivity emerged in midline electrodes for number violations on both verbs (1b) and adjectives (2b) across sessions. However, after six and eight months, this positivity evolved into a more broadly distributed, canonical P600, which was significant at both the midline and lateral regions (although the effect was only numerical for number violations on adjectives after eight months). Gender violations did not yield any effects at any point. Results also revealed significant correlations between verbal aptitude (MLAT) and behavioral sensitivity to all three types of agreement violations in all three sessions. The fact that sensitivity emerges only for number agreement and emerges both in contexts that English does (1b) and does not instantiate agreement (2b) suggests that at very early stages of development, processing is modulated by the similarity in the inventory of features in the L1/L2 (Schwartz and Sprouse, 1996; Hawkins, 2001). Our results also suggest that from the earliest stages of development, verbal aptitude (MLAT) is a strong and consistent predictor of sensitivity to agreement overall.

E43 Predicting and Processing Ellipsis in Native and L2 Readers

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A current hypothesis about the difference between native and L2 sentence processing is that L2 speakers do not actively predict upcoming information, or are slower to form predictions on the basis of the preceding structure (e.g., Kaan et al., 2010; Lew-Williams & Fernald, 2010). We further tested this hypothesis, building upon a paradigm used by Lau, et al. (2006). EEG was recorded from 21 native English speakers and 28 advanced Dutch learners of English (AoA ~10yrs) while they completed a grammaticality judgment task in which they read sentences in the following conditions. (1 a/b) Ellipsis possible: "Although John met Max's surgeon, he did not meet Bill's {*of / before} the operation." (1 c/d) Ellipsis impossible: "Although the surgeon met Max, he did not meet Bill's {*of / *before} the operation." In (a) and (b), the sentence can end at "Bill's", whereas in (c) and (d) a noun is expected to follow the possessive. The critical word was "of" (ungrammatical in (a) and (c)), or a different preposition that formed a grammatical (b) or ungrammatical (d) continuation. Lau et al. found that native speakers' ERP ungrammaticality response (LAN) at "of" was weaker for (a) than (c) sentences. If L2 speakers are less able to predict upcoming words on the basis of the preceding structure, early ERP effects of ungrammaticality are expected to be smaller and not modulated by ellipsis in the L2 group

compared with native English speakers. The L2 group did not differ from the English group in terms of acceptability judgments. Contrary to Lau et al. (2006), there was no significant LAN effect at "of" in the (c) vs. (a) comparison for either group. Both groups showed a positivity for the non-ellipsis (c, d) vs. ellipsis (a, b) conditions starting at the onset of critical word. This effect may reflect the difference in predictability of upcoming information at the possessive ("Bill's"). Both groups also showed a central negativity for the ungrammatical ellipsis (a) versus non-ellipsis (c) conditions, 400-600 ms after onset of "of". The negativity was not seen in (b) vs. (d), which suggests that the effect is related to the retrieval of a previously mentioned noun that "of" can modify. The only difference between the L2 and native groups was that the L2 speakers showed a larger late frontal negativity and larger P600 at "of" for the ungrammatical non-ellipsis (c) versus ellipsis (a) conditions than the native speakers. Our results suggest that advanced L2 learners do not differ from native speakers in the prediction of upcoming syntactic-semantic categories, but differ from native speakers in some aspects of integrating information and accommodating ungrammatical structures. Kaan, et al. (2010). In Zwart & de Vries (eds.), Structure preserved. John Benjamins. Lau, et al. (2006) Brain and Language, 98, 74-88. Lew-Williams & Fernald, (2010). Journal of Memory and Language, 63, 447-464.

E44 Quantitative biological measurements of white matter development *Jason Yeatman[1], Brian Wandell[1], Aviv Mezer[1]; [1]Stanford University*

Due to rapid advances in diffusion-weighted imaging (DWI), spatially resolved measurements of specific white matter pathways in the living human brain have become routine. There is now a substantial literature documenting changes in white matter diffusion properties in developing children and relating these changes to cognitive development. DWI is extremely sensitive to changes in tissue organization, but it does not specify which biological processes drive the diffusion signal change. Here we capitalize on novel quantitative MRI measurements to model the biological source of developmental changes in white matter tissue with the goal of understanding the coupling between biological and cognitive development. We measured 50 subjects between the ages of 8 and 40 years. In each subject we collected high angular resolution DWI data and employed a novel technique to quantitatively map Macromolecule Tissue Volume (MTV) and T1 relaxation rate. MTV quantifies the volume within a voxel that is occupied by tissue (macromolecules) rather than water molecules. T1 values are driven by the amount and composition of tissue within a voxel. Changes in the molecular composition of tissue (such as myelin) can be inferred by quantifying the extent to which T1 values deviate from what is predicted by the MTV of that voxel. We identified 25 major fiber tracts from each subject's DWI data with the Automated Fiber Quantification (AFQ) software package and then calculated tract profiles of MTV and T1 along each tract. MTV increases significantly from childhood to adulthood within most tracts and the rate of change varies significantly among tracts. For example, between age 8 years and adulthood MTV in the arcuate and superior longitudinal fasciculus (SLF) increases by roughly 25%. However MTV in the anterior thalamic radiations (ATR) does not change substantially. The molecular composition also changes over development. T1 values for the arcuate and SLF changed significantly more than was predicted by the change in MTV confirming developmental changes in the molecular composition of the tissue in these pathways. Adult T1 values could be accurately predicted from child T1 values for the ATR demonstrating that molecular properties that affect T1, such as myelination, develop prior to age 8 years for this pathway. Quantitative MRI measurements of diffusion, MTV and T1 can be combined to model the biological processes that underlie child development. Developmental processes create additional tissue that displaces water, leading to higher MTV within the white matter. In some cases the molecular composition of the tissue also changes which likely reflects increases in myelin content. The timing of these processes differs between tracts: some tracts have adult-like MTV by age 8 and others continue to develop through adolescence. By combining these in vivo biological measurements with behavioral measurements of reading skills we hope to better understand the neurobiological basis of reading development.

Lexical Semantics

E45 Early automaticity in neural processing of unattended written words: MEG evidence *Francesca Carota[1,2], Clare Cook[2], Lucy MacGregor[2], Yury Shtyrov[3]; [1]Neurolex, Department of Psychology, University of Cambridge, UK, [2]MRC, Cognition and Brain Science Unit, [3]Department of Clinical Medicine, Center for Functionally Integrative Neuroscience, Aarhus University, DK*

Previous work has shown that initial stages of neural processing of spoken language are largely automatic and can take place even when the linguistic input is not in the focus of the individual's attention. This is indexed by a lexically-specific increase of the brain's EEG and MEG responses to words over matched pseudo-words, which has been hypothesised to reflect activation of pre-existing long-term memory traces for words in the brain. Most often (but not exclusively), this has been seen in auditory oddball paradigm (see Shtyrov, Mental Lexicon 2010, for review). As language is a multi-modal function, similar automaticity may also be hypothesised for the processing of visually presented words; its evidence, however, has been scarce to date. A recent EEG experiment (Shtyrov et al, Front Hum Neurosci, 2013) suggested a lexical enhancement of brain responses to visual words early on, but failed to identify neuroanatomical underpinnings of this effect and could not reproduce some of the earlier auditory findings. Here, we set you to investigate the processing of unattended

lexical stimuli in the visual modality using high-resolution MEG recordings in combination with distributed minimum-norm source localisation technique. We used a non-linguistic visual dual task, during which 20 English native speakers had to continuously track combinations of 2 geometric shapes in the centre of their visual field, while visually and psycholinguistically matched words and pseudo-words were briefly presented outside the foveal focus of attention (at ~1.5° from the centre) in an oddball sequence. Event-related MEG responses revealed a complex spatio-temporal dynamics of neural activity underlying lexical processing of unattended visual words. Visual mismatch negativity (vMMN) to unexpected orthographic stimuli arose over left fronto-temporal sensors early on, from around 90 ms, and persisted over a few hundred milliseconds. Furthermore, a lexicality effect distinguishing parafoveally presented words from pseudo-words emerged over a set of temporal, parietal and occipital sensors. Sources of neural activity specific to the orthographic vMMN were detected in left inferior frontal (BA44-45) and motor regions around 100 ms, shifting to the superior and posterior temporal regions from 150 to 240 ms. The lexicality effect was found most significant in cortical sources located in left inferior frontal (BA 45-47) and orbitofrontal regions around 180 ms, shifting to a set of more dorsal left inferior frontal (BA44) and precentral regions around 250 ms. These results indicate that the brain can differentiate unattended orthographic stimuli very rapidly after stimulus onset. Even more importantly, we show the brain dissociates meaningful written words from meaningless pseudo-words early on, even when they are not attended and the experimental task does not encourage linguistic processing. A distributed occipito-temporo-frontal network appears to underpin this automatic word recognition process. Combined with the previous studies, our current results suggest that the automatic processing of lexical information may be a supra-modal neural mechanism, shared by the auditory and visual word recognition processes. Neural activity associated with unattended lexical stimuli may index the first processing stages of linguistic information in the brain, well before task-dependent attentional neural resources come into play.

E46 Putting an end to the motor cortex representations of action words *Greig de Zubicaray[1], Joanne Arciuli[2], Katie McMahon[3]; [1]University of Queensland, School of Psychology, [2]University of Sydney, Faculty of Health Sciences, [3]University of Queensland, Centre for Advanced Imaging*

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 involving large-scale corpus analyses and behavioural measurements demonstrating that verbs tend to show distinct, non-morphologically derived ortho-phonological properties that are different from those exhibited by nouns. Moreover, it has been shown that these probabilistic cues can affect both word and sentence level processing. We therefore investigated whether motor cortex activity evoked by manual action words (e.g, caress) might reflect sensitivity to probabilistic orthographic-phonological cues to grammatical category embedded within individual words. We first review neuroimaging data demonstrating that nonwords evoke activity much more reliably than action words along the entire motor strip, encompassing regions proposed to be action category specific. Using fMRI in healthy participants (N=21), we found that disyllabic words denoting manual actions evoked increased motor cortex activity compared to non-body-part-related words (e.g, canyon), activity which overlaps that evoked by observing and executing hand movements. This result is typically interpreted in support of language embodiment. Crucially, we also found that disyllabic nonwords containing endings with probabilistic cues predictive of verb status (e.g, -eve) evoked increased activity compared to nonwords with endings predictive of noun status (e.g, -age) in the identical motor area. 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 ortho-phonological statistical regularities that help to distinguish a word's grammatical class.

E47 Effects of multiple tasks and variables on EEG/MEG responses in visual word recognition *Olaf Hauk[1], Yuanyuan Chen[1,2], Friedemann Pulvermüller[3], Matthew H Davis[1]; [1]MRC Cognition and Brain Sciences Unit, Cambridge, [2]Neuroscience and Aphasia Research Unit, University of Manchester, [3]Brain Language Laboratory, Freie Universität Berlin*

Neither behavioral nor metabolic neuroimaging studies have been able to answer the question as to what degree early visual word recognition is "automatic" or "flexible", i.e. modulated by task demands. Do task demands modulate the way the brain retrieves word-specific information at earliest stages of processing? Or do task demands operate on the output of an automatic word recognition process? The most direct way to address this issue is to compare the spatio-temporal brain dynamics of word processing for specific psycholinguistic variables under different task demands. Here, we employed multiple linear regression analysis of combined EEG/MEG data to study the effects of three different tasks (lexical decision, LD; semantic decision, SD; silent reading, SR) on four psycholinguistic variables (word length, bi/trigram frequency, word and lemma frequency, imageability). We performed ROI analysis in source space and focused on left-hemispheric ventral stream areas which are most

likely involved in early visual word processing, following previous fMRI results (Vinckier et al., Neuron 2007, 55(1)). Thus, we analyzed a chain of ROIs from posterior to anterior left inferior temporal lobe. EEG and MEG data were combined for MNE source estimation on individual cortical surfaces. Multiple linear regression was applied to EEG/MEG data in order to create event-related regression coefficients (ERRCs) for each participant, task, variable and sensor separately. ERRCs were subjected to source estimation, and statistically analyzed in an ROI approach. Task effects on event-related responses for the average across all words occurred around 150 ms (recently reported in http://www.frontiersin.org/Human_Neuroscience/10.3389/fnhum.2013.00376/abstract). Word length was positively correlated with brain activity in occipital brain regions across tasks around 100 ms, in line with previous findings, thus validating our regression procedure. Bi/trigram frequency showed positive correlation in a posterior ROI around 100 ms only in LD. Frequency was negatively correlated in a middle ROI around 150 ms, but only for LD. Between 200-300 and 300-400 ms, a positive correlation occurred in anterior ROIs across tasks. Imageability produced positive correlations between 200-300 ms in mid-posterior ROIs, and between 300-400 ms in anterior ROIs across tasks, but only at lenient statistical thresholds. A number of previous behavioral and neuroimaging studies have shown that the lexical decision task enhances processing relying on "wordlikeness" or orthographic familiarity. We have shown here that this is already manifest in ventral temporal cortex before 200 ms after word onset, likely to reflect top-down modulation of ventral stream processes. Silent reading may resemble semantic decision in the sense that natural reading usually aims at retrieving meaning, and therefore produces a similar pattern of brain activation. Our finding that brain activity was more similar across tasks at later latencies, and occurred in anterior temporal brain areas, suggests that word recognition under different task demands eventually leads to the activation of word meaning, even for tasks that do not necessarily require it. However, significant task modulation of effects for specific psycholinguistic variables before 200 ms demonstrates that early word recognition processes are flexible and susceptible to top-down control.

E48 The relationship between orthographic phonological and semantic representations in the two cerebral hemispheres

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Previous studies show that while both hemispheres can extract meaning from print, the timing of semantic activation is different (Burgess & Simpson 1988). We have recently suggested (Peleg & Eviatar, 2012) that these asymmetries can be explained by hypothesizing hemispheric differences in the connectivity between orthographic, phonological, and semantic representations. Specifically, we propose that while orthographic, phonological and semantic representations are fully interconnected in the left hemisphere (LH) there is no direct link between orthographic and phonological representations in the right hemisphere (RH). To test this proposal, the present study investigated hemispheric asymmetries in accessing multiple meanings of two types of Hebrew homographs: homophonic homographs (e.g., bank); and heterophonic homographs (e.g., tear). Both types of homographs have one orthographic representation associated with multiple meanings. They are different however in terms of the relationship between orthography and phonology. Given the asymmetries described above (direct orthographic-phonological connections in the LH versus no such connections in the RH), we predicted that differences between heterophonic and homophonic homographs will be more pronounced in the LH than in the RH. Forty participants saw pairs of words and decided if the two words in each pair are semantically related. The first word in each pair was presented centrally. The second word was presented either to the LH (right visual field RVF), to the RH, (left visual field LVF), or to both hemispheres (central visual field CVF). We compared response latencies for related pairs in two conditions: In the ambiguous condition, the first word in each pair was a homograph (either heterophonic or homophonic) and the second word was related either to its dominant (bank-money) or subordinate meaning (bank-river). In the unambiguous condition, homographs (bank-river) were replaced with unambiguous control words (boat-river). The ambiguity effect is the difference between these conditions, and reveals the automatic excitation of the alternative meaning of the homograph. Overall, both hemispheres revealed sensitivity to frequency; Irrespective of VF or homograph type, response times for ambiguous pairs were significantly longer than for unambiguous pairs, only when targets were related to the subordinate meaning of the homograph. Importantly, as predicted by our proposal, homophonic and heterophonic homographs, which diverge on how their meanings are related to phonology, were processed differently in the LH, whereas, in the RH, similar patterns were obtained for both types of homographs. Finally, performance patterns in the CVF revealed the same patterns as those in the RVF (LH), and were different from those in the LVF (RH). Thus, when words are presented to both hemispheres (in CVF), performance is dominated by the LH. Burgess, C. & Simpson, G. B., (1988). Cerebral hemispheric mechanisms in the retrieval of ambiguous word meanings. Brain and Language, 33, 86-103. Peleg., O. & Eviatar, Z. (2012). Understanding written words: phonological, lexical and contextual effects in the cerebral hemispheres. (pp. 59-76) In M. Faust (Ed.), Handbook of the neuropsychology of language. John Wiley & Sons, New York.

E49 The neural correlates of phonological, semantic and causal verbal fluency in patients with schizophrenia *Kim Wende[1], Straube Benjamin[1], Stratmann Mirjam[1], Sommer Jens[1], Kircher Tilo[1], Nagels Arne[1]; [1]Philipps-University Marburg*

Schizophrenia spectrum disorders are associated with language production deficits as pronounced in impaired performance of word fluency (continuous single word production) tasks. At a neural level, patients show altered response patterns in frontal and prefrontal regions crucial to executive function and language production. Whether patients show specific differences in behavioural and neural response patterns with respect to distinct requirements of verbal fluency, is yet unknown. Within the present study, fMRI was used to investigate the neural correlates of three overt verbal fluency paradigms (semantic, phonological, and a newly developed causal verbal fluency task) in patients with schizophrenia and healthy subjects. A group of 17 patients with schizophrenia spectrum disorder and 17 matched controls performed three alternating overt verbal fluency tasks (subjects were instructed to generate as many different single words as possible within 10 seconds in response to identical cue words), while BOLD-responses were measured with fMRI: causal verbal fluency (CVF), requiring the continuous production of reasons for a cue (e.g. for HEAT, reasons are fire, sun, etc.), one semantic control task (free association, FA, e.g. associations with HEAT are fire, sun, sweat, shower etc.) and one phonological control task (phonological verbal fluency, i.e. rhyming, PVF, e.g. rhymes with HEAT are meat, wheat etc.; see e.g.). Behavioural group differences (number of correctly generated words) were found in all three conditions; patients produced significantly less correct words than controls in all conditions. Preliminary fMRI-analyses showed common activation for patients and controls across the three word production tasks in a bilateral temporo-cerebellar language production network. Furthermore patients activated the same brain regions as controls for both semantic word production conditions (FA, CVF) compared to phonological verbal fluency PVF, i.e. the left inferior and middle frontal gyrus, the left angular gyrus and supplementary motor area. However, in addition to these commonalities we found that controls showed greater activity compared to patients during both semantic conditions (CVF and FA) in the bilateral cerebellum and the precentral gyrus (area 6/44) bilaterally. Similar clusters of greater BOLD-response in healthy subjects resulted from the interaction of FA and CVF, contrasted to PVF, showing content-(semantic>non-semantic)-specific engagement of these areas in healthy subjects. On the other hand, patients showed increased activations as compared to controls, specifically during CVF, located in the right middle frontal gyrus, the left inferior parietal cortex and the right angular gyrus. Higher demands during CVF, as well as specific impairments in patients with respect to causality and reasoning may account for patients' additional neural activity during continuous causal word generation. Further analyses will aim at assessing effects of word content (social, as well as non-social stimuli were used) on neural response in patients and controls, as well as possible between-group differences in functional connectivity within the task-related ("semantic") network.

E50 A Hierarchical Predictive Coding Approach to Conceptualizing the Neurobiology of Language Comprehension *Gina Kuperberg[1,2]; [1]Tufts University, [2]Massachusetts General Hospital/Harvard Medical School*

An adult brain stores vast amounts of information about real-world events. The challenge for our language comprehension systems is to make maximal use of this stored information, but still be flexible enough to respond to changing and unpredictable linguistic input. Here, I suggest that we meet this challenge by engaging in successive word-by-word cycles of probabilistic prediction and belief updating, and that comprehension can be understood within a hierarchical Bayesian framework of neural predictive coding (e.g. Friston, 05). Here, I focus on how this framework informs the functional interpretation of several ERP components: the N400 and the LAN, each between 300-500ms, as well as prolonged negativities and the P600, past 500ms. Prior to encountering any word within a sentence, we have some degree of uncertainty about its semantic features and syntactic properties. Actually encountering this word entails a shift from uncertainty to near-certainty: 'surprise' (cf Hale 03, Levy, 08). I suggest that surprise for a set of semantic features is reflected by the amplitude of the N400, and for a particular syntactic category by the LAN. Encountering this new word puts us in a better position to construct a new probability distribution of the semantic-syntactic mappings that best explain the underlying event---those that are most likely to have generated the complement of words encountered thus far. If this redistribution of probabilistic mappings is large, the N400 or LAN are prolonged past 500ms. Having now settled on these new mappings, we are able to generate a new set of probabilistic predictions for the likely semantic and syntactic features of the following word, thereby beginning a new cycle. In this way, we are able to incrementally home in on the specific set of semantic-structural mappings that best describes the event(s) the speaker intended to communicate. In most situations, we will home in on this interpretation with increasing certainty and our predictions about upcoming words will be correct. However, there are situations in which we may be quite certain about a particular semantic-syntactic mapping, using this to constrain our predictions of an incoming word, but this word's semantic features or syntactic properties are completely inconsistent with these predictions. This forces a full re-evaluation of the model (the set of semantic-syntactic mappings) used to generate these predictions ('unexpected surprise', Yu & Dyan, 05). I suggest that this re-evaluation manifests as the posteriorly-

distributed late positivity: the P600. This framework can explain many observations in the ERP literature, including why the N400 is sometimes paradoxically reduced to words in implausible sentences, and why the P600 is produced by some, but not all, semantic violations. Most importantly, it explains how we meet the challenges outlined above: it suggests that we make maximal use of stored material by predicting semantic features and syntactic properties of upcoming words, without necessarily committing to fine-grained predictions of specific lexical form. And, by casting comprehension as inherently tied up with Bayesian learning, it explains how our comprehension systems are dynamic and flexible enough to respond to ever-changing task and environmental demands.

E51 ERP evidence of unconstrained lexical access to meaning specified by gender *Cheryl Frenck-Mestre[1], Elisa Sneed-German[2]; [1]Centre National de Recherche Scientifique, Aix-Marseille Université, [2]SIM University, , English Language & Literature Programme,*

Many languages, in addition to marking biological sex, also divide nouns into two or more arbitrary classes of grammatical gender. Grammatical gender allows for (and requires) cohesion of elements in a sentence and in some cases, can even disambiguate the meaning of lexical items. A number of behavioural studies have examined whether grammatical gender plays a role in lexical access (eg., Grosjean et al., 1994; Bölte & Connine, 2004; Spinelli & Alario, 2002; Spinelli, Meunier & Seigneuric, 2006; Frenck-Mestre, Bueno & Sampo, 2012); however, the results are inconclusive, particularly with regard to when in the process of lexical activation gender contributes, as well as to what extent the frequency of the primed meaning plays a role. Following recent research on the priming of subordinate (ie., less frequent) word meanings by Frenck-Mestre, Bueno and Sampo (2012), we used ERPs, which have shown differences in the time course of lexical access as a function of target word properties (eg., Van Petten & Kutas, 1987) to investigate the role of grammatical gender in lexical access for dominant (ie., more frequent) meanings of French homophones. Our findings provide further support for the claim that grammatical gender does not constrain lexical access. In this study, primes were auditorily presented non-homographic French homophones preceded by a definite determiner (eg., le sel /løs□l/ "the salt" and la selle /las□l/ "the saddle"). All homophones had a dominant and a subordinate meaning but only the dominant meaning was presented, as specified by the gender of the determiner (eg. /løs□l/). A 2 x 2 design was used: auditory Primes were either the dominant homophone or a frequency-matched control (/løs□l/ vs. /løg□up/ "the salt" vs. "the group") and visual Targets were associated to either the dominant or subordinate meaning of the homophone (poivre/cheval "pepper/horse"). Targets were presented at Prime offset and Prime-Target ISI was zero milliseconds. ERPs were recorded while participants engaged in a go/no-go task responding to probe items (city names). Preliminary results suggest activation of both the dominant and subordinate meaning of the homophone following the gender-specified dominant homophone Prime as evidenced by a significant reduction in the N400 component for related Targets. The onset of the N400 was not delayed for the gender-context inappropriate meaning, which suggests that there was no difference in the time course of meaning activation. No interactions were found. Our results support the findings of studies showing that grammatical gender does not constrain lexical access. We find that independent of gender congruence, both meanings of homophonic primes are immediately activated and affect the cortical response to subsequent targets. Our ERP results also contradict previous findings from ERP work, which showed that in sentential contexts, the N400 effect to the contextually inappropriate meaning of a homophone is delayed (Van Petten & Kutas, 1987). Our results support models that propose an exhaustive account of lexical access and they provide unequivocal evidence from complementary techniques that grammatical gender does not play a role in the early stages of lexical access in French.

E52 Effects of syntactic structure on concept grounding *Wessel van Dam[1], Rutvik Desai[1]; [1]University of South Carolina*

Support for motor simulation in language processing comes from behavioral studies showing that action words modulate the execution of congruent and incongruent motor responses, and from imaging studies showing that comprehension of action words and sentences recruits sensory-motor brain areas. However, the role of syntactic structures in conceptual grounding is unclear. There is evidence from imaging studies that action observation of transitive and intransitive actions recruit different regions of the fronto-parietal perception-action system. Much less is known about processing of actions described in transitive and intransitive linguistic structures. It is unclear whether these structures themselves are associated with actions, and whether sensory-motor activations observed in the processing of these sentences reflect semantic resonance or resonance at the level of syntactic constructions. The present fMRI study was designed to investigate these questions using a 2x3 design. We used transitive (T) and intransitive (I) structures for literal action (LT, LI), abstract (AT, AI) and nonword sentences (NT, NI), with 35 sentences in each condition. A slow event-related design with visually presented sentences was used to scan 12 right-handed participants, with each participant being scanned twice on separate days. Subjects were instructed to read all sentences in preparation for answering yes/no questions posed after some of the trials. Contrasting Literal Transitive with Intransitive sentences (LT>LI) led to stronger activation within the right IPL, whereas the opposite contrast (LI<LT) elicited stronger activation within bilateral anterior MTG/STG. Similar transitivity effect was obtained for Abstract sentences: Abstract

Transitive sentences (AT>AI) elicited stronger activation within the right IPS, whereas Abstract Intransitive sentences (AI<AT) elicited stronger activation within the right anterior MTG/STG. These results support a neural dissociation between transitive and intransitive abstract and concrete language. Interestingly, we obtained a significant transitivity (T, I) x word (L, N) interaction in the right IPL, left posterior MTG/STG and right anterior MTG. For the Abstract sentences, the transitivity (T, I) x word (A, N) interaction led to significant activation in the right IPL, left anterior MTG/STG and left posterior MTG/STG. These findings suggest a neural dissociation between transitive and intransitive language after controlling for differences that might arise at the level of their syntactic constructions. Finally, we obtained a significant transitivity (T, I) x abstractness (L, A) interaction in the left posterior STG, left STS and the right IPL. These results provide evidence that the syntactic structure of a sentence is associated with sensory-motor activation independent of the linguistic content of the sentence, and these structures affect the processing of action and abstract semantic content differently. These findings underline the importance of taking into account both lexical and constructional representations in generating theories of conceptual processing.

E53 Cross Language Influences in Bilingual Speakers: The Effect of a Partial Shared Translation *Zohar Eviatar[1], Tamar Degani[1]; [1]University of Haifa, Israel*

The current study seeks to examine semantic organization of multiple languages within one system. Cross-language influences can point to integration and dependence among the different languages of bilingual speakers. Previous work has shown that when two words in one language (e.g., map and tablecloth in English) share a translation in another language (e.g., MAPA in Hebrew), bilingual speakers tend to rate these words as more similar in meaning than pairs of words that do not share a translation, in comparison to monolingual English speakers with no knowledge of Hebrew (Degani, Prior, & Tokowicz, 2011). Thus a shared form in one of the languages influences semantic relatedness in another language. The present study extends these findings and asks whether partial overlap in form is sufficient to cause increased semantic relatedness. We manipulated both the degree and the content of the overlap: Complete overlap: pairs of English words that were unrelated in meaning (e.g., 'beak' and 'source'), but translated into Hebrew into the identical form (a homophonic homograph-'MAKOR'); Phonological overlap: pairs of words (e.g., 'yes' and 'nest') that translate into heterographic homophones (like 'plain' and 'plane'); Orthographic overlap: pairs of words whose translations are identical orthographically but phonologically different (heterophonic homographs such as 'tear'). The two English words were presented one after the other, at either 300 or 750 SOA. In an all English task, participants were asked to judge as quickly and accurately as possible whether the two words were related in meaning. Results from 42 Hebrew-English bilinguals were compared to those of 48 monolingual English speakers to reveal substantial cross-language influences for bilinguals. In particular, pairs with complete overlap in translation were judged as more related in meaning irrespective of SOA, such that bilinguals but not monolinguals tended to judge these pairs as related more often than control pairs, and further made faster related responses and slower unrelated responses on such pairs. In addition, at short SOA, pairs of English words with translations that overlap in phonology but not orthography were also judged as related more often than controls. This effect diminished somewhat at the longer SOA, at which point it was the pairs with translations that overlap in orthography but not phonology that diverged from control. The results suggest that words in one language of bilingual speakers automatically activate both the phonological and the orthographic form of the translations, and that this form activation influences semantic decisions. This automatic activation is present even when the two languages differ in script (such as English and Hebrew). The effect of form overlap in one language on semantic representations in another language highlights the interconnected nature of the bilingual lexicon across phonology, orthography, and meaning representations. In additional to the implications for the multilingual semantic lexicon, the results emphasize the primacy of orthographic knowledge in adults, in that a non-presented orthography affected responses independently of phonology. References Degani, T, Prior, A., & Tokowicz, N. (2011). Bidirectional transfer: The effect of sharing a translation. Journal of Cognitive Psychology, 23, 18-28.

Syntax, Morphology

E54 Multiple routes for complex word comprehension: Novel neurophysiological paradigm dissociating whole-form and combinatorial morphosyntactic processing in the brain *Yury Shtyrov[1,2,3]; [1]Center for Functionally Integrative Neuroscience (CFIN), Aarhus University, Denmark, [2]Centre for Languages & Literature, Lund University, Sweden, [3]MRC Cognition & Brain Sciences Unit, Cambridge, UK*

Are complex words real mental objects or are they best described as combinations of morphemes held together by rules similar to the rules of syntax? For example, is inflectional form such as 'worked' segmented into two morphemes ('work+ed'), as proposed by a range of dual-route accounts, or stored holistically as predicted by single-route models? Are these mechanisms the same or different for derivational forms ('work-er',) and do they depend on other word properties such as its lexical frequency and semantic transparency? Similarly, are compound words, comprised of e.g. 2 nouns ('home-work'), processed as word combinations, guided by combinatorial rules similar to those linking 2 separate

words in phrases, or do they form higher-order unified lexical representations in the mental lexicon? As we show in a series of studies, such questions hotly debated in (psycho)linguistic literature can be straightforwardly addressed using neurophysiology. Using MEG and EEG, we have established a distinct double dissociation pattern in neurophysiological responses to spoken language, which can reflect lexical ("representational") vs. syntactic ("combinatorial") processes in the brain. These are manifest as: (1) a larger passive (i.e. obtained without any stimulus-related task) brain response to meaningful words relative to matched meaningless pseudowords, reflecting stronger activation of pre-existing lexical memory traces for monomorphemic words (= lexical ERP/ERF pattern), (2) a smaller ERP/ERF amplitude for congruous word combinations (reflecting priming via syntactic links), relative to incongruous combinations where no priming is possible (= syntactic/combinatorial pattern). This double dissociation – larger response for simple holistic representations vs. smaller response for well-formed combinatorial sequences – allows, in turn, for clear predictions for neurobiological experiments. Such experiments could test the nature of morphosyntactic processing by presenting the subjects with real complex words and incongruous morpheme combinations in passive auditory event-related designs, and comparing the relative dynamics of their brain responses. We have used this neurophysiological approach in a recent series of experiments to address a range of morphosyntactic questions: neural processing of compound words, past tense inflections, particle verbs as well as differences between inflectional and derivational morphology. We find substantial differences between neural processing of these different word-formation types, further influenced by lexical and semantic word properties. English regular past tense verbs demonstrate a pattern most compatible with combinatorial/desegmentation account: larger passive MEG response for incorrectly formed past tenses than congruous forms. Real particle verbs, on the other hand, produce larger ERFs than matched pseudo-forms, suggesting that such particle-verb units are lexicalized to form a single chunk-type representation. Compound words and derivational forms show a graded pattern suggesting the dominance of dual-route parsing-type processing for semantically transparent forms, with a stronger tendency for lexicalization for semantically opaque complex words as well as for high-frequency derivations and compounds. This body of results generally supports a flexible dual-route account of complex-word processing, with a range of strategies dynamically involved depending on exact psycholinguistic stimulus properties. As these experiments indicate, comprehension of spoken complex words is a largely automatized process underpinned by a very rapid (~100-150 ms) neural activation in bilateral perisylvian areas.

E55 Revisiting Shared Resources for Language and Music

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[INTRODUCTION] The Shared Syntactic Integration Resource Hypothesis (SSIRH; Patel 2003) proposes that while the representational systems underlying music and language involve distinct systems supported by separate underlying neurocognitive systems, structural/syntactic processing for music/language implicates shared/overlapping neural resources. Some evidence supporting the SSIRH comes from ERP studies. Violations of linguistic syntax (e.g., "He will KICKED the ball") can elicit a negative shift with a left/anterior scalp distribution ("LAN") followed by a posterior positive wave ("P600"). ERP studies of "musical syntax" (e.g., probed with violations involving out-of-key notes, incongruent chord progressions, etc.) have produced strikingly similar ERP patterns (notably, an anterior negative shift, although with a slightly right-lateralized distribution on the scalp ("RAN") and identical looking P600 effects as those elicited by linguistic stimuli (Patel et al 1998)). Furthermore, studies targeting simultaneous processing of language and music (e.g., Koelsch et al. 2005) suggest shared mechanisms underlying the anterior negative-going ERP effects. However, to our knowledge, there is no comparable work targeting the P600 (i.e., though Patel et al. 1998 were able to compare linguistic and musical P600 violations within subjects). [METHODS] In the present study, participants (N=16) were exposed to sentences displayed word-by-word in the center of a computer monitor time-locked to notes in melodies played over headphones (one musical note per syllable). This arrangement allowed a 2x2 design crossing correct/violation contrasts for language and music. Linguistic violations involved semantic anomalies in object relative clauses (e.g., "…the ball that John will KICK/*BAKE…"). Similar such violations can elicit a range of ERP responses in succession (N400 effects followed by both anterior negativities and posterior P600-like positivities, see Steinhauer et al. 2010). Music violations involved out-of-key notes, for which we expected to find RAN and P600-type responses. This design enabled us to directly contrast linguistic and musical violations against "double" violations (where the violating target word coincided with an out-of-key note). [RESULTS] Linguistic violations on their own elicited a biphasic negative/positive ERP response. Musical violations elicited RAN and P600 effects, consistent with previous findings. Importantly, simultaneous processing due to "double violation" conditions yielded an additive pattern for P600 effects, suggesting (contra the SSIRH) distinct neural resources underlying processing in these domains. Anterior negative-going effects, however, were observed to yield patterns consistent with the SSIRH. These non-additive responses included not only an early sub-additive

pattern as previously seen in the work of Koelsch et al. (2005), but also a late super-additive pattern as well. [CONCLUSION] Though the SSIRH may be correct in predicting overlapping resources for language and music, our data suggest this may only be the case for the systems underlying anterior negative-going ERP responses, and not (as had been previously suggested by Patel et al. 1998) for the systems underlying P600-type effects. We believe these data are thus also of broader relevance for efforts to understand the functional significance of LAN-/P600-type effects. In an ongoing follow-up we are testing whether P600s elicited in this paradigm for local morphosyntactic violations (e.g., ...the ball that he will KICKED...) will elicit a similar additive response profile.

E56 Sentence-level Processing in the Cerebellum: A Combined fMRI and VBM Study

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Introduction: This study used functional and structural MRI to find the brain areas that were significantly related to sentence production after controlling as closely as possible for single word production and the articulation of sentences. In the fMRI study, the sentence task required participants to overtly describe a depicted event involving two objects (e.g. "The goat is eating the hat"). Activation for this task was compared to: naming aloud two objects (e.g. "goat and hat") to control for lexical retrieval; verb naming (e.g. "eating") to control for verb retrieval; auditory sentence repetition of the same sentences to control for articulation; and semantic matching of two pictures (e.g. "hat" and "scarf") to control for semantic associations. In the structural MRI study, we identified brain regions where grey or white matter was most closely related to out-of-scanner accuracy scores on a picture description task after regressing out accuracy scores for: object naming, semantic fluency, letter fluency, word repetition comprehension, and age. Methods: The fMRI experiment included 13 healthy native English speakers. To constrain sentence production, there were only four possible verbs ("eating", "drinking", "jumping", "falling"). Visual input was controlled across conditions by presenting animals and objects depicted in the events in unrelated pairs for object naming and semantic matching. Data analyses were conducted with SPM using standard procedures. The structural imaging experiment included T1-weighted images from 34 non-aphasic patients who had very small lacunar lesions (less than 0.8cm3) caused by stroke. Patients were assessed with the Comprehensive Aphasia Test [1]. As anticipated, performance varied widely within the normal range of fluency, organisation, and sentence structure permitting an effective search for associations between grey or white matter density and performance on each task. Data were analysed with a standard voxel-based morphometry (VBM) analysis. Results: In the fMRI study, sentence production was associated with four regions: the right superior cerebellum (MNI = +39, -57, -27; Zsc = 6.8), right inferior cerebellum (MNI = +33, -60, -48; Zsc = 6.2), Broca's area (MNI = -48, +24, +27; Zsc = 5.2), and left superior parietal area (MNI = -15, -63, +63; Zsc = 5.9). In the VBM analysis, there was one white matter region that was significant after FWE correction for multiple comparisons across the whole brain in extent rather than height. This was the inferior midline cerebellum that extended laterally into the left hemisphere (MNI = -35, -52, -46; Zsc = 3.5). An additional peak was identified in the right cerebellum (MNI = +30, -66, -38; Zsc = 3.4), close to the area activated by sentences in the fMRI study. None of the patients had cerebellar lesions. Conclusions: These two experiments, using different types of data and participants, highlight the importance of the cerebellum in the production of sentences when articulation, lexical retrieval, and semantics have been controlled. We speculate that the cerebellum is involved in sequencing articulatory events prior to speech production. References: [1] Swinburn, K., Howard, D., and Porter, G. (2004). Comprehensive aphasia test CAT. Hove: Psychology Press.

E57 Grammatical categories show differential activations in convergence zones: An fMRI study

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It is an unanswered question how semantic categories are processed in the brain at the level of grammar, specifically when these are highly schematic and abstract categories and may depend on different modalities for their representation. In numeral classifier languages, nouns are enforced by grammar to be accompanied by a superordinate category marker when items are counted, specifying ontological semantic features of nouns in a taxonomic relationship to their nouns. E.g. in Chinese, when counting tigers, a grammatically correct noun phrase contains the classifier □zhī 'animal' as in Yī zhī l□oh□ 'a tiger' (literally 'one animal tiger'). Classifiers are highly schematic and can be characterized by fewer semantic features than their respective nouns. These linguistic features can again be analyzed in association with different modalities. As we see it, there are three competing theories of concept processing that attempts to explain how modal knowledge is integrated: the fully-distributed model, the distributed-plus-hub model, and the convergence areas hypothesis. In the first of these, modal areas are gated by the current cognitive task. The second presupposes an amodal semantic store in addition to a distributed modality-specific network. The third explains the blending of modalities into coherent concepts in terms of convergence zones, predicted e.g. in the angular gyri (BA39) for motor and visual knowledge, and in the anterior temporal pole for integrated semantic

categories. We carried out semantic analyses of two numeral classifiers in Chinese, the graspable object □ b□ classifier (typically containing objects like kitchen and agricultural tools, musical instruments with a 'neck' and objects with a handle), and the huge object classifier □ zuò (typically skyscrapers and tall buildings, bridges, parks, mountains and icebergs). We hypothesized that whereas the BIG classifier depended on visual knowledge for representing large size (too large for physical interaction), the GRASP classifier would depend on motor interactions in addition to visual object knowledge. We used fMRI in a rapid event-related jittered design with a final of 17 native speakers of Chinese, presenting randomized classifier – noun sequences. Consistent with the convergence zone model we found different and varying activations for BIG vs. GRASP classifier categories in the left anterior temporal pole and in the BA39 areas (i.e. bilaterally). The GRASP classifier had a greater activation for BA39, consistent with earlier lesion findings that this association area links visual and motor modalities. These results suggest that abstract semantic categories that depend on different modalities for semantic processing are represented differentially in convergence zone areas. Our results further showed that concrete nouns were activated consistently with previous research (in ventral stream), thus confirming validity of method. Additionally, BIG nouns contrasted over GRASP nouns showed precuneus activation (BA19), suggesting visuospatial processing (viewing mountains and skyscrapers from afar), and areas in the visual cortex activations suggestive of visual imagery. In conclusion, our fMRI findings on numeral classifiers allow for investigation into differences and unique activations of abstract semantic concepts in primary association regions and so lets us make justified choices between models of conceptual processing.

E58 Modulations of functional activity and connectivity in the language network during syntactic sentence production

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Sentence production is a highly complex process, in which concepts have to be transferred into a meaningful utterance. Several brain regions have been associated with syntactic planning during sentence production. In order to get to a well-formed utterance, these regions must also interact with each other. In this functional magnetic resonance imaging (fMRI) study, we examined neural activity modulations and functional interactions within the language production network. In particular, we were interested to see whether the correlations between language regions vary parametrically with increasing levels of syntactic complexity. Functional images were acquired on a 3T scanner in a group of 12 healthy participants. A standard EPI sequence covering the entire cortical volume was used [TR = 2000 ms, TE = 30 ms, 32 slices, 3.5 x 3.5 mm voxels]. During scanning, participants were instructed to either passively watch or overtly describe a visually animated scene using one of three response conditions, varying in syntactic complexity (i.e., using only words, noun phrases or a complete sentence; similar to Indefrey et al., 2001). Regions of interest (ROIs) were defined based on a group analysis [contrast: language production > passive watching; FDR-corrected at q = .05] and included bilateral posterior inferior frontal gyrus (pIFG), bilateral superior temporal gyrus (STG), bilateral premotor area (ventral part), bilateral angular gyrus, a bilateral area in superior precentral gyrus/sulcus, left SMA, a left posterior parietal area, and right insula. Within these ROIs, condition effects were evaluated. Further, using an approach similar to psychophysiological interaction (PPI; Friston et al., 1997), interactions between these selected regions were investigated per level of syntactic complexity (the preliminary analysis of 7 participants is discussed presently). The resulting correlation coefficients were fed into a repeated measure GLM to test for differences in functional correlations between conditions. Results showed that in both the left pIFG and in the left SMA, there was a linear effect of syntactic complexity (S > NP > W; lpIFG linear contrast: p = .043; lSMA linear contrast: p = .005). In addition, preliminary analysis showed clear trends of increasing functional interactions with increasing syntactic complexity in several pairs of regions: the correlation between the right pIFG and the angular gyrus (bilateral) varied as a result of syntactic complexity [linear contrast of condition left angular gyrus: p = .01; right: p = .06], as well as the correlation between right pIFG and the ventral premotor area [linear contrast: p = .08]. To conclude, complexity of syntactic planning during sentence production seems to be reflected both by modulating neural activity within specific regions of interest (left pIFG, left SMA) and by parametrically varying correlations between areas: specifically, between the pIFG (linked to syntactic processing) and angular gyrus (involved in lexical processing), and the pIFG and the ventral premotor area (associated to syntactic and phonological planning). Although analyses need to be extended and refined, these preliminary data show a first functional network involved in syntactic sentence production.

Language Disorders

E59 Cause or consequence of dyslexia? Anomalies in white matter tracts sustaining phonological processing predate reading

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Converging neuroimaging research indicates that dyslexic readers exhibit a left-lateralized neural deficit in dorsal (i.e. temporoparietal) and ventral (i.e. occipitotemporal) grey matter regions as well as in dorsal white matter connections

(i.e. arcuate fasciculus). The standard neuroanatomical model of dyslexia localizes the primary phonological decoding deficit in left dorsal regions, with a secondary deficit in building up orthographic word representations located in left ventral regions. However, this model is based on neuroimaging studies that generally involve older children and adults, hence evidence is lacking on whether a dorsal deficit indeed predates a ventral deficit and to what extent these neural deficits are a consequence or cause of reading difficulties. To fill this gap, we have set up a longitudinal study in which we aim to investigate how the dorsal (arcuate fasciculus, AF) and ventral (inferior-fronto-occipital fasciculus, IFOF) white matter tract develop during the different stages of reading acquisition and whether distorted brain connectivity in dyslexics is present already prior to reading, hence suggesting a causal influence. Using diffusion tensor imaging, we currently scanned 36 pre-readers with a family risk for dyslexia (FRD+) and 34 individually-matched pre-readers without a family risk for dyslexia (FRD-). The bilateral AF, split up in its anterior, posterior and long segment, as well as the bilateral IFOF were individually delineated. Mixed model analyses, taking into account that pairs of children attended the same class, showed abnormal white matter organization for the FRD+-group in left IFOF ($F(1,26) = 9.87$, $p = .004$) and the posterior segment of left AF ($F(1, 26) = 5.14$, $p = .032$). In addition, white matter organization in bilateral IFOF correlated with phonological awareness (left: $r = .35$, $p = .003$; right $r = .37$, $p = .002$), lexical retrieval (right: $r = .31$, $p = .009$) and letter knowledge (left: $r = .26$, $p = .031$; right $r = .26$, $p = .027$), which are known to be the most significant predictors of later reading skills. In addition, phoneme awareness correlated with the posterior ($r = .29$, $p = .016$) and long ($r = .29$, $p = .016$) segment of left AF. These relations with bilateral IFOF and left AF seem to be mainly driven by phoneme awareness as this was the only cognitive variable that could predict unique variance in white matter organization above the others. Although analyses should be reran when participants can later be classified as dyslexic, this DTI-study suggests that white matter alternations are fundamental to dyslexia and cannot solely be the result of reading failure itself. In contrast to the standard neuroanatomcial model on dyslexia and DTI-results in adults (Vandermosten et al., Brain, 2012), the primary deficit seem not to be predominantly located in dorsal connections. Furthermore, the ventral and dorsal tracts have not yet developed a specialized function for phonological versus orthographic aspects of reading. Both tracts probably closely interact with each other to achieve the complex process of reading acquisition.

E60 Neural signatures of phonological working memory and grammatical processing in autism spectrum disorders *Zhenghan Qi[1], Tyler Perrachione[1], Anne Harris[2], Irina Ostrovskaya[1], Sara Beach[1], Kelly Halverson[1], Abbie Cyr[1], Katalina Sher[1], Margaret Kjelgaard[1], John Gabrieli[1], Kenneth Wexler[1], Helen Tager-Flusberg[2]; [1]Massachusetts Institute of Technology, [2]Boston Univerisity*

Language deficits are one of the core impairments of autism spectrum disorders (ASD). Behavioral studies have documented reduced phonological working memory capacity and impaired grammatical processing in children with ASD (Kjelgaard & Tager-Flusberg, 2001). The current study is the first to probe the neural characteristics of these two key language functions in children with ASD and their typically developing (TD) counterparts. Participants were all native English-speaking children and subject groups were matched on age, non-verbal IQ, and performance on standardized language tasks (Clinical Evaluation of Language Fundamentals – Fourth Edition). In Experiment 1, 19 children (7 ASD and 12 TD, mean age 12;1) completed a non-word repetition task during fMRI. Stimuli were pseudowords designed to match the phonological and phonotactic properties as real English words and ranged from two to five syllables in length. As predicted, the ASD group performed significantly worse than the TD group in overall accuracy (78.2% vs. 90.0%, $p < .05$). Imaging results revealed that repeating nonwords activated bilateral superior temporal gyri and left prefrontal areas in both groups, but that children with ASD showed a significantly greater task-induced activation in the right temporal pole (FDR < 0.01, $q < .05$) as compared to TD children. As syllable length increased, both groups exhibited decreasing accuracy in performance ($r = 0.14$, $p < .05$) and a corresponding increased recruitment in left superior temporal gyrus as syllabic length increased (FDR < 0.01, $q < .05$). In Experiment 2, 22 children (10 ASD and 12 TD, mean age 12;0) completed an auditory grammaticality judgment task during fMRI. Children listened to short sentences, which were either grammatically correct or contained morphosyntactic errors and decided if each sentence sounded correct or not. The type of errors was characteristic of those made by TD during initial language acquisition and children with language impairments for a protracted length of time (e.g. Every day he walk to school). As compared to the TD group, the ASD group performed marginally worse (91.5% vs. 97.1%, $p = .07$) on this task, and had significantly reduced task-induced activation in left inferior frontal gyrus, superior temperal gyrus, and precentral gyrus (FDR < 0.01, $q < .05$). These preliminary results revealed an atypical hemispheric asymmetry of language processing: hyperactivation in the right temporal region during the phonological working memory task and reduced activation in the left hemisphere including those typical language areas during grammaticality judgment in the ASD group. Our work paves the way for understanding the neural characteristics underlying language phenotype in children with ASD. Future research with larger sample size will compare the

developmental trajectory of the neural recruitment across various age groups between typical developing children and those with ASD.

E61 Improved white matter integrity following naming treatment post-stroke *Sophia van Hees[1,2], Katie McMahon[3], Anthony Angwin[2], Greig de Zubicaray[4], Stephen Read[5], David Copland[1,2,6]; [1]Centre for Clinical Research, University of Queensland, Brisbane, Australia, [2]School of Rehabilitation Sciences, University of Queensland, Brisbane, Australia, [3]Centre for Advanced Imaging, University of Queensland, Brisbane, Australia, [4]School of Psychology, University of Queensland, Brisbane, Australia, [5]Royal Brisbane and Women's Hospital, Neurology, Brisbane, Australia, [6]Centre for Clinical Research Excellence in Aphasia Rehabilitation*

Background: Previous studies concerned with the neural mechanisms underlying treatment-induced recovery in aphasia have primarily focussed on the cortical regions responsible for language processing. However, integrity of the white matter tracts connecting these cortical regions may also be a critical factor in treatment outcome. Thus, this study examined the integrity of two white matter tracts associated with language processing, the arcuate fasciculus (AF) and uncinate fasciculus (UF), pre and post-treatment for anomia. Methods: Eight people with aphasia and fourteen healthy older controls completed the study. Participants with aphasia received twelve treatment sessions that aimed to improve object naming, and alternated between a phonologically-based task and a semantic-based task. High angular resolution diffusion imaging (HARDI) was conducted pre and post-treatment for participants with aphasia, and on one occasion for controls. The number of fibres and mean generalised fractional anisotropy (GFA), a measure of fibre tract integrity, in the AF and UF in both hemispheres were compared pre and post-treatment, as well as with the control group. Results: Participants with aphasia had significantly fewer fibres and lower mean GFA in the left AF pre-treatment compared to controls. A significant increase in mean GFA was found from pre- to post-treatment in the left AF, such that there was no longer a significant difference with controls. Additionally, mean GFA in the left AF pre- and post-treatment positively correlated with maintenance of the phonologically-based treatment. No significant differences were found between participants with aphasia and controls in the right AF or the UF in either hemisphere, and no significant changes were found in these tracts following treatment. Conclusions: These preliminary results suggest that the neural mechanisms underlying treatment outcome in people with aphasia may involve changes beyond activity in cortical regions. Improved integrity of the white matter pathways connecting cortical language regions may also play an important role in treatment-induced recovery. Further research with a larger cohort of participants may aid in determining predictors for treatment outcome, in order to provide more effective and targeted treatment for people with aphasia.

E62 Development of white matter in children with developmental dyslexia *Indra Kraft[1], Michael A. Skeide[1], Jens Brauer[1], Alfred Anwander[1], Angela D. Friederici[1]; [1]Max Planck Institute for Human and Cognitive Brain Sciences*

During their first years at school children learn how to read and to write. These two skills are crucial not only for educational success but also for an active participation in social life. However, one out of five school children suffer from dyslexia, a development disorder which is characterized by impairments in the domain of reading and writing, despite age-typical development of other cognitive abilities. A deficit in phonological awareness is discussed as one of the impairments underlying dyslexia. The goal of our study was to investigate the relation between white matter integrity and phonological awareness as well as reading skills in 10-year old German children. We acquired diffusion tensor imaging (DTI) data from 41 children (24 males, 17 females) in order to measure individual fractional anisotropy (FA) values within the entire white matter skeleton. In addition, we used standardized psychometric tests to assess the basic reading skills and the phonological awareness of each participant. A regression analysis revealed that the both test scores are significantly associated with FA values of the inferior longitudinal fasciculus (ILF), which is in line with previous findings from English suggesting an involvement of the ILF in reading (Rimrodt et al., 2010; Yeatman et al., 2012). Moreover, the psychometric measures are significantly related to FA values in the anterior corona radiate (ACR) suggesting an involvement of the ACR in phonological manipulation as it has been associated with working memory tasks (Nagy et al., 2004; Niogi & McCandliss, 2006; Olesen et al., 2003). Taken together, our results confirm that white matter fractional anisotropy can serve as a neurobiological marker for a developmental dyslexia also for German, and thus possibly across languages. In particular our results suggest that the ACR is not only involved in pure working memory tasks, but also in basic phonological processing, which is an important prerequisite for reading and writing. In the future, further longitudinal studies are needed to investigate the interplay of altered fiber maturation and impaired phonological awareness as well as reading skills during childhood.

E63 Atypical lateralization of phonological working memory in developmental dyslexia *Min Xu[1,2], Jing Yang[3], Wai Ting Siok[1], Li Hai Tan[1]; [1]The University of Hong Kong, [2]Massachusetts Institute of Technology, [3]Guangdong University of Foreign Studies*

Developmental dyslexia is a neurological condition characterized by unexpected low reading performance in people with normal intelligence and typical schooling. One prominent theory posits that dyslexic children

fail to establish left-hemisphere dominance of visual representations and visual-phonological/meaning integration of printed words and thus exhibit an atypical lateralization of lexical processing. Behavioral, electrophysiological, histological, and morphological imaging studies examining this hemispheric asymmetry have generated conflicting evidence; however, it remains possible that dyslexics have impaired functional lateralization of language processes without a structural correlate. Here, using functional magnetic resonance imaging (fMRI) and a phonological working memory task, we found distinct hemispheric asymmetry differences between dyslexic and normal children in brain regions subserving the storage and manipulation of phonological information in verbal working memory. Thus, the language impairments in dyslexic children appear related to a reduced dominance of the left hemisphere in phonological language functions, which offers clues into the biological dysfunction and possible remediation of developmental dyslexia.

E64 Selective Grammatical Comprehension Deficit in Non-Fluent/Agrammatic Primary Progressive Aphasia

Dorothy Charles[1], Christopher Olm[1], John Powers[1], Sharon Ash[1], David Irwin[1], Corey McMillan[1], Katya Rascovsky[1], Murray Grossman[1]; [1]University of Pennsylvania

Grammatical comprehension difficulty is a necessary characteristic of the non-fluent/agrammatic variant of primary progressive aphasia (naPPA), also known as progressive non-fluent aphasia. However, clinical measures of grammatical comprehension are few, and those available are controversial. We developed a novel, two-alternative, forced-choice sentence-picture matching task sensitive and specific for grammatical comprehension, and examined this comparatively in 39 PPA patients (naPPA=12, logopenic variant PPA (lvPPA)=15, and semantic variant PPA (svPPA)=12) 27 non-aphasic patients with behavioral-variant frontotemporal degeneration (bvFTD), and 12 healthy controls. We also assessed the neuroanatomic basis for grammatical comprehension deficits in a subset of these patients with volumetric grey matter (GM) atrophy and whole-brain fractional anisotropy (FA) in white matter (WM) tracts. We found that patients with naPPA have selective difficulty understanding cleft sentence structures (e.g. "It was girls that boys chased"), while all PPA variants and bvFTD patients were impaired with more complex, center-embedded sentences (e.g. "Girls that boys chased were tall"). All patients had more difficulty with object-relative than subject-relative sentences. We also found that bvFTD patients are selectively impaired understanding sentences involving a strategically-placed adjectival phrase stressing short-term memory. Regression analyses related grammatical comprehension difficulty in naPPA to left anterior-superior temporal GM atrophy and reduced WM FA in anterior corpus callosum and inferior frontal-occipital fasciculus. Difficulty with center-embedded sentences in other PPA variants was related to other brain regions implicated in a large-scale sentence processing network. These findings emphasize a distinct grammatical comprehension deficit in naPPA, and associate this with interruption of a frontal-temporal neural network involved in sentence processing.

E65 Patterns of brain activation predicting greater language improvement in non-fluent aphasia

Svetlana Kuptsova[1], Rosa Vlasova[2], Olga Dragoy[2], Maria Ivanova[2], Svetlana Malyutina[3], Petrushevsky Aleksey[1], Fedina Oksana[1], Gutyrchik Evgeny[4]; [1]Center for Speech Pathology and Neurorehabilitation, Moscow, Russia, [2]National Research University, Higher School of Economics, Moscow, Russia, [3]Moscow Lomonosov State University, Russia, [4]Ludwig Maximilians University, Munich, Germany

A lot remains unknown about how language is processed in the damaged brain and what the exact relationship between cerebral reorganization and language recovery is (Thompson & den Ouden, 2008). The aim of the current fMRI study was to investigate if specific brain activation patterns associated with language performance are indicative of the degree of overall language improvement. Participants included neurologically healthy individuals (n = 16) and four individuals with chronic aphasia following a left hemisphere CVA . All patients were diagnosed with moderate non-fluent aphasia. The MRI investigation showed that participants with aphasia had lesions in the left fronto-parietal areas. All participants were native speakers of Russian and were premorbidly right-handed. The fMRI investigation was conducted at the middle of a 45-day long intensive rehabilitation course. In the experimental condition a lexical-semantic task was presented to activate the classical language network – three words were visually presented, a verb at the top and two nouns below (for example, read – cat and book). The task was to match a noun to the verb by pressing an appropriate button. All words were matched on critical psycholinguistic parameters. In the control condition, three sequences of symbols were presented: one at the top and two below. Participants had to choose which of the two sequences below was identical to the one on top. Experimental trials were presented in 36 blocks, control trials – in 12 blocks. Each block lasted 18 sec and included three trial of 5.5 sec each with 0.5 sec interstimulus interval. FMRI data analysis was performed in SPM8 ($p < 0.001$, the threshold significance level of clusters $p(FWE) < 0.001$). Language improvement of participants with aphasia was indexed with the Quantitative Assessment of Speech in Aphasia (Tsvetkova et al., 1981) and was measured twice (before and after the rehabilitation course). In healthy participants, the experimental condition contrasted to the baseline, elicited the expected language-associated brain activation in the inferior frontal gyrus, superior and middle temporal areas of the left hemisphere. Two patients with minor improvement showed brain activation patterns in the right temporal area. One of them also demonstrated additional activation in the right inferior

and middle frontal gyri. Both participants with significant improvement showed similar to the healthy patterns of activation in the left inferior and middle frontal perilesional areas, left superior and middle temporal gyri. One of them showed additional activations in the right inferior frontal gyrus, right temporal area, precentral gyri and parietal areas bilaterally. The results show that re-recruitment of the left posterior frontal and temporal areas during language rehabilitation is indicative of significant improvement, while recruitment of just the right hemisphere areas associates with less improvement. This finding is in line with previous studies that demonstrated additional left hemisphere activation associated with better language performance in aphasia while additional recruitment of the right hemisphere usually reflected less efficient language processing in the chronic recovery phase (Fridriksson et al., 2009, 2010; Price & Crinion, 2005).

E66 The nature of across-task and across-structure generalization following a sentence comprehension treatment for aphasia. *Swathi Kiran[1], David Caplan[2], Sarah Villard[1], Carrie Des Roches[1], Elsa Ascenso[1], Gloria Waters[1]; [1]Boston University, [2]Massachusetts General Hospital, Boston*

Introduction: In a previous study (Kiran, Caplan, et al., 2012), we developed two treatments, one based on sentence to picture matching (SPM) and the other based on object manipulation (OM), that train patients on the relationship between syntactic structure and the meanings of sentences. We found the treatment to be effective in improving sentence comprehension of trained structures in fifteen patients with aphasia. More patients improved on the OM task than SPM task. In this study, we compare acquisition of trained structures and generalization to untrained structures and tasks across the two treatment approaches (SPM/OM). Methods: Twenty six patients with aphasia were identified on the basis of two screening tests for syntactic comprehension (SPM & OM) with sentence structures ranging from object relative to active sentences. A single subject multiple baseline design was used to examine acquisition of sentence comprehension. Sentence comprehension was trained on the affected sentence type in one task-related protocol with the order of task and structure counterbalanced across participants. The two tasks are SPM and OM and the treatment stimuli comprise two WH- movement structures (Object relatives (OR), Object clefts (OC)) and two NP movement structures (Passives (PA), Unaccusatives (UNACC)) as well as untrained control structures (Object relatives with a complex NP (OR-COMPLEX NP), active sentences with three NPs (3NP)). Both the SPM and OM treatments are similar in terms of the number of steps as well as the basic procedures involved but differ in terms of the nature of "thematic role mapping". In the picture matching task the clinician demonstrates the thematic roles to the patient, and in the object manipulation task the patient enacts the thematic roles using objects. Monitoring probes (with different sentences) are administered each week to assess treatment acquisition and generalization. Results: Of the 26 patients 15 received OM treatment, and 11 received SPM treatment. Results from a paired t-test show that treatment (independent of the task) is successful in improving comprehension accuracy of trained structures on the trained task ($t(25) = -6.34$, $p = .0001$). In addition, an ANOVA using change in percent accuracy as the dependent measure and treatment task as the independent measure shows that OM treatment is more effective at facilitating change on the trained structure than SPM treatment ($F(1,24) = 13.07$, $p = .01$). Finally, we conducted a cross-correlation analysis for each patient to examine across-structure and across task generalization. Positive correlation coefficients (r values over .5 that exceed two standard errors) between trained structure-untrained structures (between OR-PA, OR-OC, PA-UNACC, OC-UNACC) are observed for more patients trained on OM than SPM, indicating greater across-structure generalization for OM treatment than the SPM treatment. In contrast, SPM treatment results in greater across-task generalization than the OM task. Conclusions: These results show that training patients on the relationship between syntactic structure and the meanings of sentences using two different tasks is effective in improving sentence comprehension in aphasia. Generalization effects to untrained structures and tasks are marginal but appear to follow the principles of syntactic structure.

E67 Deficit Lesion Correlation for Syntactic Comprehension Differs as a Function of Task *Brad Dickerson[1], Jennifer Michaud[1], Rebecca Hufford[1], Nikos Makris[1], David Caplan[1]; [1]Massachusetts General Hospital/ Harvard Medical School*

Introduction: We investigated brain-behavior relationships in syntactic comprehension in aphasic stroke patients using multiple distinct types of tasks. Method: Thirty-eight people with aphasia (pwa) (age 62.1 + 13.0 years; education 14.9 + 3.1 years; M:F = 26:12) with single left hemisphere strokes were tested for the ability to understand 13 sentence types in a sentence-picture matching task (SPM) and object manipulation task (OM) and for immediate serial recall (STM) using five tasks (Digit Span, Word Span; Span for Phonologically Similar Words; Span for Phonologically Dissimilar Words; Span for Long Words; Span for Short Words.) and for working memory (WM) using four tasks (Alphabet Span, Backwards Digit Span, Subtract-2 Span, and Sentence Span). The ability to assign and interpret syntactic structure independent of STM and WM ability was measured as the residual of the regression of STM or WM composite scores onto the difference in accuracy on sets of experimental and baseline sentences assessing particular structures and elements. Lesions were measured as percent of the cortical Rademacher parcellation units, as in Caplan et al (2007). Results: Simple correlation analyses demonstrated that the percent lesion of the angular gyrus was associated with performance on all tasks, but

after controlling for STM its effect on complex syntactic sentences was largely limited to a subset of sentence types. In contrast, performance on complex object manipulation tasks was impaired in patients with caudal inferior frontal gyral lesions, even after controlling for comprehension of simpler sentence forms and STM. Conclusion: These results provide support for the hypothesis that the inferior parietal cortex is critical for comprehension of syntactically complex sentences, but at least some of this effect is driven by the phonologic working memory demands of the task. More importantly, the type of task employed for testing of syntactic comprehension also appears to play a critical role in lesion-behavior correlations.

E68 The auditory comprehension of Who and Which-NP questions in aphasia: Support for the Intervener Account *Shannon MacKenzie[1], Matthew Walenski[2,3], Tracy Love[1,2,3], Lewis P. Shapiro[1,2]; [1]SDSU/UCSD Joint Doctoral Program in Language and Communicative Disorders, [2]School of Speech Language and Hearing Sciences, San Diego State University, [3]Center for Research in Language, University of California, San Diego*

We investigated auditory comprehension of various types of Wh-questions in neurologically unimpaired adults and adults with Broca's aphasia. Consider the following: A mailman, a fireman, and another mailman got into a fight. 1. Which mailman pushed the fireman yesterday? 2. Which mailman did the fireman push ___ yesterday? 3. Who pushed the fireman yesterday? 4. Who did the fireman push ___ yesterday? Evidence from the linguistic and psycholinguistic literatures suggests that Which-NP and Who questions like those in (1)–(4) can be differentiated. We examined patterns of online and offline comprehension with four specific hypotheses in mind, each of which governed a distinct set of predictions: The Word Order hypothesis predicted that across the two question types, object-extracted questions ((2) & (4)) should be more difficult to understand than subject-extracted questions ((1) & (3)) because the former are in non-canonical word order. The Discourse Interface hypothesis predicted that Which-NP questions should be more difficult to process than Who questions (regardless of subject or object extraction) because they must refer to an individual taken from a set of entities previously mentioned in the discourse, an operation that is particularly resource-intensive (Donkers & Stowe, 2006; Shapiro, 2000). The Retrieval hypothesis predicted the opposite; that because Which-NP constructions contain specific information that speeds memory retrieval in relation to their Who question counterparts, Which-NP questions should be easier to process (Hofmeister, 2007). Finally, the Intervener hypothesis predicted that if a fully specified NP (e.g., one that has a DET-N structure) 'intervenes' between a filler (e.g., Which mailman in (2)) and its gap, interference occurs, rendering object-extracted Which-NP questions particularly difficult to comprehend for people with Broca's aphasia (Friedmann & Novogrodsky, 2011). Using an eye tracking-while-listening method coupled with a three-figure picture (e.g., one mailman pushing a fireman who is pushing another mailman), participants listened to 40 quads of Wh-question materials presented across four sessions in a within-subjects design. Participants responded to the question using a button box; offline accuracy and reaction time (RT) data were collected. We also collected online gaze data where gazes to each of the three referents depicted in the three-figure picture were recorded every 17ms throughout the time course of the sentence and through the offline button press response. Results for our college-age healthy controls (N=30) revealed offline support for the Word Order hypothesis – object-extracted Who and Which-NP questions took significantly longer to answer than subject-extracted versions. The gaze data revealed the same pattern across all of the four conditions, with significantly more gazes to the correct than to the incorrect referent. Unlike the neurologically unimpaired controls, data from participants with Broca's aphasia (N=7) revealed offline and some online support for the Intervener hypothesis as the object-extracted Which-NP questions took longer to answer, had lower accuracy, and yielded more gazes to the (incorrect) intervener NP compared to object-extracted Who questions. We suggest that the Intervener hypothesis can generalize to other structures, is compatible with current interference accounts of working memory, and gives a unified account of sentence comprehension in aphasia.

E69 Online processing of unaccusative verbs in individuals with aphasia *Natalie Sullivan[1], Matthew Walenski[2], Tracy Love[2], Lewis P. Shapiro[2]; [1]SDSU/UCSD Joint Doctoral Program in Language and Communicative Disorders, [2]School of Speech Language and Hearing Sciences, San Diego State University*

Individuals with Broca's aphasia exhibit delayed lexical activation in S-V-O word order sentences, and delayed reactivation of the displaced element in sentences containing syntactic dependencies (Ferrill et al., 2012; Love et al., 2008). These patterns support the Delayed Lexical Activation (DLA) hypothesis, which posits that lexical activation and syntactic operations are de-synchronized; that is, lexical access is too slow for normally fast-acting syntactic operations. This delay in lexical access leads to what appear to be syntactic comprehension deficits in aphasia. In the current study we examined lexical activation in aphasia in sentences containing unaccusative verbs: The tailor from New Jersey inappropriately disappeared __1* when it was time 2*for the tuxedos 3*and dresses to be adjusted. Unaccusative verbs like disappear are intransitive, but their single argument (the tailor…) is base-generated in object position and displaced to subject position, leaving a gap after the verb. Friedmann et al. (2008) demonstrated that unimpaired participants re-access the displaced NP (i.e., the tailor) only at a point well after the gap (at probe position 2), but not at the gap (probe position 1). This normally delayed effect

offers an opportunity to further examine lexical delays in individuals with Broca's aphasia, who are expected to delay activation of the displaced NP relative to the gap position, and who therefore may evince similar patterns as unimpaired participants. Alternatively, these participants might reveal activation even further downstream from the gap relative to control participants. Importantly, individuals with Broca's aphasia may have unaccusative verb deficits, though the evidence is equivocal (e.g., Lee & Thompson, 2004; McAllister et al., 2009). We presented 32 sentences containing unaccusative verbs (with filler sentences) to participants with Broca's aphasia (currently N=6) and age-matched neurologically healthy controls (currently N=3). We used the cross-modal picture priming task in a within-subjects design. Sentences were presented aurally and during the temporal unfolding of each sentence, a picture representing the displaced NP (e.g., tailor) or an unrelated control probe (e.g., baker) was briefly (1000ms) presented at one of three probe positions (as numbered above). Participants were required to attend to the sentences while also making a binary decision on the picture (here, animate/inanimate; note that picture animacy was balanced across the items in the study). Faster response times to the identity probe than to its control indicate lexical activation. We have completed testing probe positions 1 (gap) and 2 (750ms post- gap). Thus far we have observed priming at the post-gap position 2 for the older control group, replicating prior results. Our Broca's group revealed no priming at either probe position. We are continuing to run more participants (to yield an N of 10 for each group) and are running the probe point 3 condition (1250ms post- gap). If we observe activation at this position but not at probe point 2, it would suggest that regardless of the syntax of the sentence, lexical access and re-activation are delayed in Broca's aphasia, consistent with the hypothesis that comprehension deficits in aphasia reflect desynchronization of lexical and syntactic processing routines.

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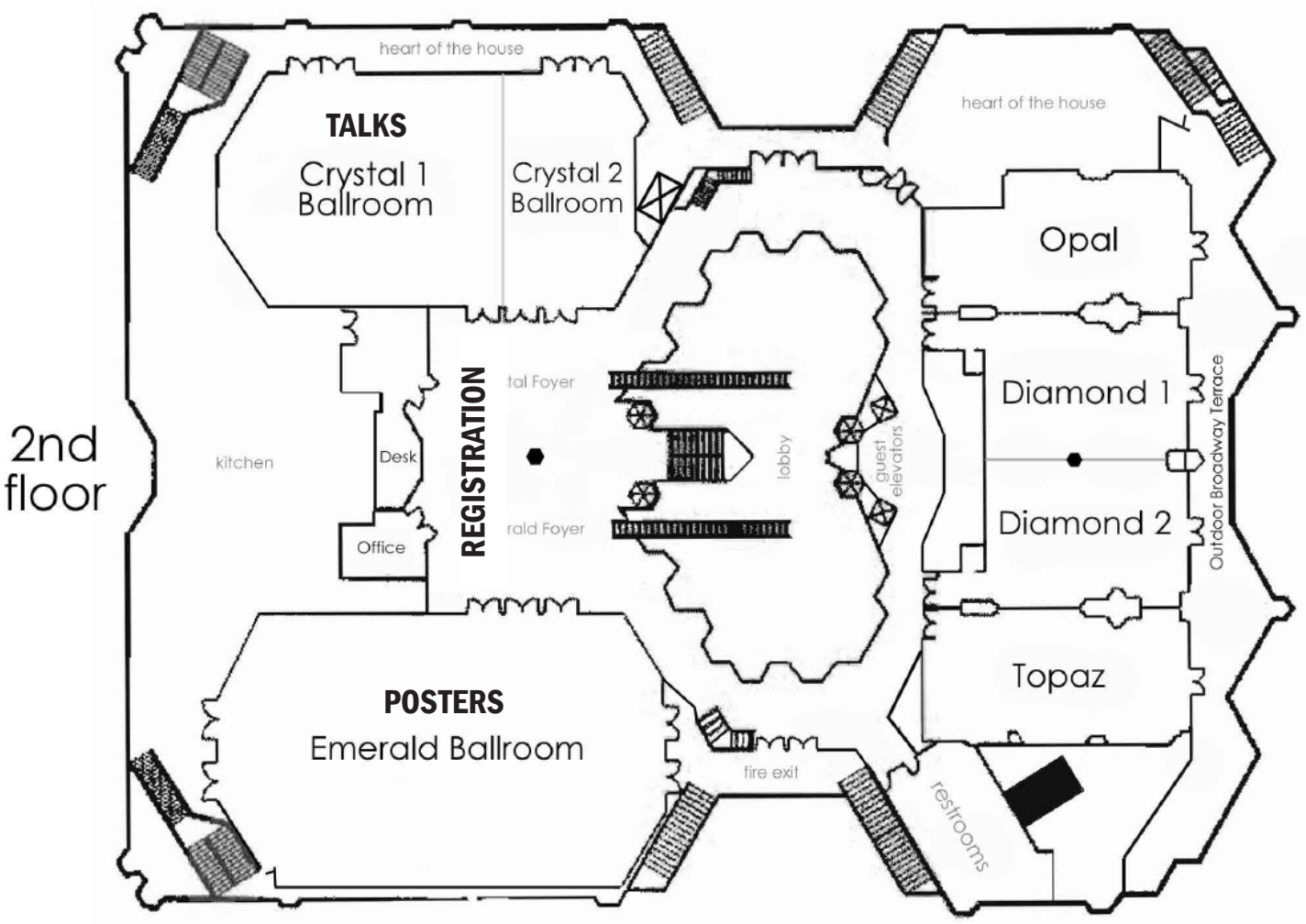

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The Sixth Annual Meeting of the Society for the Neurobiology of Language will be held at the Beurs van Berlage in Amsterdam, August 27-29, 2014